



An Efficient RFID-based Tracking System for Airport Luggage

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Abstract

The emergence of new wireless technologies opened new opportunities to develop more efficient information systems. Radio Frequency Identification (RFID) is among those technologies, which extended the potential of wireless identification and present a potential replacement to old-fashioned identification schemes such as the barcode-based system. The suggested system in this paper considers an enhanced RFID-based approach to identify and track the location of passengers' luggage. The use of an interactive bracelet that communicates with the RFID system by mean of a database application is investigated. The database application interacts with the bracelet using messages that inform the passenger about his luggage status. The proposed system design and implementation are discussed and the corresponding components are detailed with their interactions. Additionally, a draft cost analysis is presented.

Key Words

RFID, tracking, luggage, Airline system.

I. INTRODUCTION

In the light of the increasing number of airline users, many initiatives have been undertaken to enhance customers' satisfaction. These include the implementation of RFID luggage tracking system in airports. This system is still facing some challenges as it does not involve the passenger in the luggage tracking process. Consequently, an efficient luggage handling system is required. The use of an interactive RFID-based bracelet luggage tracking system would make the

process of baggage handling easier and faster as it would reduce the passenger waiting time when a mishandling error occurs.

The currently used baggage handling system causes a large number of mishandled bags. Mishandled baggage generates big losses to airline companies. The average loss behind a delayed bag is USD 21.90, USD 92.27 when the bag is damaged, and USD 348, 70 if the bag is lost. Those losses are estimated by an average value of USD 100 per bag [1].

RFID implementation in airports becomes very useful since it enhances the ability of luggage tracking and increases customer's satisfaction. Yet, many improvements were done on the RFID system to optimize its results. In [2], the implementation of an intelligent RFID reader was done to provide various computing and logging operations, but also support the deployment of real-time tasks, execution control and automatic update of check-in and check-out information. The authors in [3] discussed an RFID equipment tuning and configuration methodology developed to support baggage tracking and feed dashboards with real time status of service level agreements between the airport, the airliner and the ground operators. A passive UHF tag configuration is explained for suitcase identification and tracking in airport-handling applications in [4]. The evolving applications of RFID in airports, demonstrate a need for an enhanced system that would involve the passenger to reduce his anxiety about the location of his luggage [5].

The proposed luggage tracking system operates under three situations. The first case is when the passenger is on board and his luggage has been embarked. The second scenario is when a mishandling error occurs. The third case is concerned with a multi-stop flight. These scenarios will be further explained in a later section showing how the database system needs to react with each case.

This paper is organized as follows. Section II presents the considered RFID-based tracking system principles and components. In Section III, the interaction between these components is described. A draft cost analysis is presented in Section IV. And finally, Section V concludes the paper.

II. RFID-BASED TRACKING PRINCIPLES

The RFID system can be used to record and track the movement of a luggage in the airport through radio frequency communication. This system is composed of two parts: the reader and the transponder. This latter is also known as the tag. It is made up of an antenna and a silicon microchip. It has a unique identification number and carries information. This data would represent the personal information of the passenger as an identity code that is stored in binary format. Tags come in three general varieties namely passive, active, or semi-passive. The passive ones do not require an internal power supply, while semi-passive and active tags require a power source, usually a battery.

As illustrated in Figure 1, passive tags are powered from electromagnetic field generated by reader antenna which has to transmit enough power to provide energy to the tag that transmits back data. Passive tags simply consist of a single transponder, antenna coil, and capacitors [6].

They operate below 100 MHz frequencies and their transferred energy is carried by magnetic field. This later generates voltage in the coil which is used as power supply also as data signal.

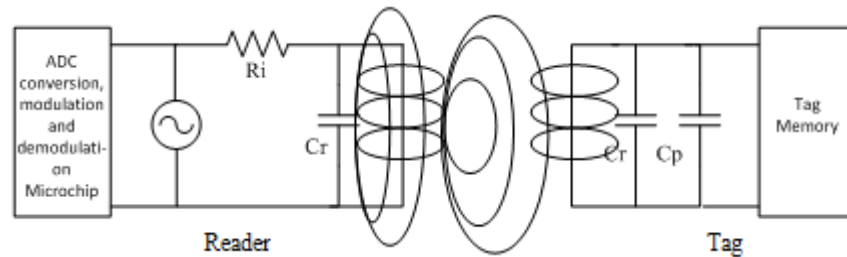


FIGURE I: RFID READER AND TAG INTERNAL DESIGN.

The RFID reader has three main functions: energizing, demodulating and decoding. The reader is composed of a coil antenna, a capacitor C_r , a resistor R_i , an alternative current source and a microchip for analog to digital conversion, modulation and demodulation. As for the tag, it is made of an antenna, capacitors C_r and C_p along with a tag memory containing the information to be communicated to the reader which coiled antenna emits a low-frequency radio wave field to power-up the tag. The antenna in both reader and tag can be shaped and sized in different ways and can be designed to adequate any situation considering the small size of the tag as considered in similar applications [7], [8].

The proposed system in this paper considers passive tags as they do not require a significant scanning range and relatively have a small size. These tags do not have a power source but rather they get power from the incident electromagnetic field. When the tag is subject to this RF field, it draws power used to get and transmit the stored information in the memory. In this way, the tag sends the traveler's information to the reader. Then, the reader converts the reflected waves sent by the tag into digital data for computer processing. Once the data is processed, the database system sends appropriate messages to the passengers.

III. SUGGESTED RFID-BASED TRACKING SYSTEM FOR AIRPORT LUGGAGE

The suggested RFID-based Tracking System for Airport Luggage (RTSAL) considers an interactive bracelet which receives luggage tracking information from a database system. Figure 2 illustrates the corresponding RTSAL overall architecture.

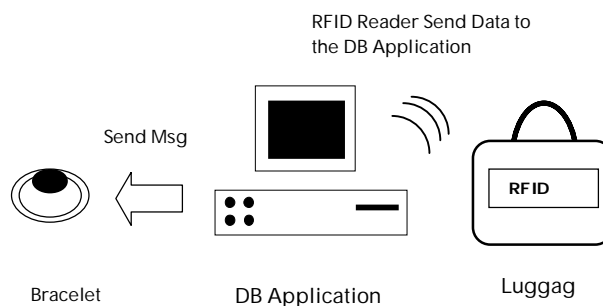


FIGURE II: BLOCK-DIAGRAM OF THE CONSIDERED RTSAL.

A. Passenger's Interactive Bracelet Description

The interactive bracelet that is used to support the RFID in luggage tracking system is worn around the passenger's arm. The bracelet is made up of silicon and has a graphical LCD display module. The cost of this bracelet is included in the flight ticket and is handed to passengers in the checking process. This bracelet has a unique ID and receives text messages from the database application. This application processes the RFID signals, and then sends text messages to the passenger's bracelet whenever the luggage moves from a station to another. The bracelet has a button that can be used by the passenger to transmit an emergency message. There are two emergency cases when the passenger can send a warning message. The first case is when the passenger is on the flight and does not receive any message. He can send an emergency message to request information from the administrators of the system. This functionality is enabled by the airline staff when the boarding finishes. The second case is when the passenger arrives to the conveyor and does not find his luggage. He can send a warning message to notify the system administrators.

At the end of the trip, passengers are required to return these bracelets back to the airline company. This interactive bracelet involves the passenger in the luggage tracking process as it informs him about the location of his baggage throughout his trip.

B. Database System for Data Processing and Tracking

The database application that is used in this system considers C Sharp as a programming language. C Sharp includes functional, object-oriented and component-oriented programming disciplines. The Database Management System (DBMS) is relational. It displays the results of data processing in tables composed of rows and columns. The system also uses Oracle9i because it is commonly used in airports.

The desktop application that tracks the RFID signals manages different functionalities which are: the management of passengers, luggage, flight, messages, and bracelet.

The passenger management would help the administrator keep track of all the passengers as well as the information about them (passenger ID, first name, last name, phone, email, class, seat, checking time).

The flight management functionality stores data about the flight (flight number, destination, company name, departure time, arrival time, number of passengers, gate number).

The luggage management functionality enables the system administrator to identify the following information about the luggage (Tag ID, color, luggage priority, weight, shape).

The bracelet management function keeps track of the attributes (bracelet ID, bracelet color, first_usage_date).

The messages management functionality is responsible for storing specific messages that

matches appropriate situations. Those situations will be explained in the next section. The attributes that defines this functionality are (Msg_ID, date and time).

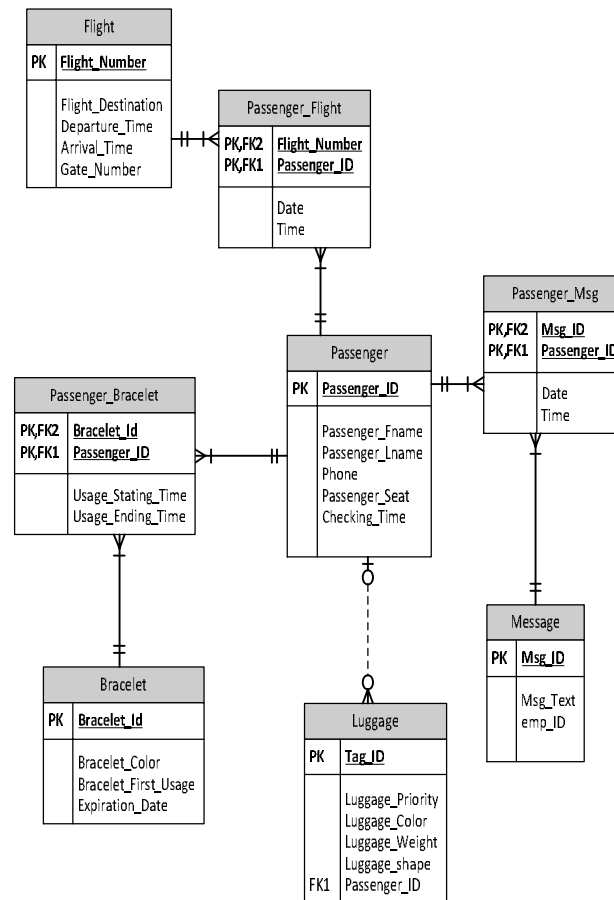


FIGURE III: ENTITY RELATIONSHIP DIAGRAM FOR THE DATABASE SYSTEM.

Figure 3 represents the entity relationship diagram using Cross Foot Model. This diagram shows the different entities along with their relationships. The relationship between a passenger and luggage (is one to many) relationship since a baggage can be owned by only one passenger while the passenger can have more than one baggage. The passenger-flight relationship is (many to many) relationship since a flight can have many passengers on board while a passenger can travel on a many flights. Thus, a bridge entity called Passenger-Flight is needed. This bridge entity contains Flight_Number and Passenger_ID as a primary key. This entity keeps record of a specific passenger along with the flight he took. The passenger-message relationship is a many to many relationship since the same message is sent to many passengers and a passenger receives many messages during his flight, so a bridge entity is required as it is called Pass_Msg. This bridge entity contains as a primary key the respective primary keys of the two entities passenger and message. Finally, the relationship between a bracelet and a passenger is (many to many) relationship since a passenger can have one to many bracelets and a bracelet can be worn by one to many passengers since these later are required to return them back to the airline company at the end of the trip.

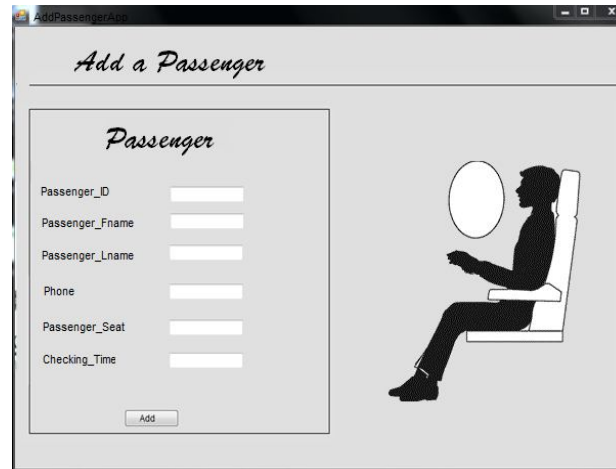


FIGURE IV: GRAPHICAL USER INTERFACE OF THE FUNCTION ADD A PASSENGER.

The administrator can perform several functions on each of the building of the database, e.g., adding a passenger to the list. Figure 4 is a Graphical User Interface that allows the user to perform this functionality. He can also modify passenger information, delete a passenger from the list, search for a specific passenger and view the list of all the passengers along with their information. These functions can be handled in flight, luggage, bracelet and messages functionalities.

Concerning the application structure, a user-friendly interface is implemented. The Graphical User Interface (GUI) is a very important component of the application since it represents the way by which the user communicates with the system. Therefore, it is important that the user interface should be friendly, clear, and easy to understand in order that the user can benefit fully from the services the system provides. Figure 5 represents the GUI for the function "Add a Flight". This functionality allows the user to enter the different attributes of a specific flight such as Flight_Number, Destination, and Departure_Time.



FIGURE V: GRAPHICAL USER INTERFACE OF THE FUNCTION ADD A FLIGHT.

C. Database System for Data Processing and Tracking

The implemented system organizes every step of the luggage handling process. In the check in process, the passenger chooses one of the two options which are to get information about his luggage either through his phone or via the bracelet that could be handed to him upon request. In case the passenger does not have a phone or have a discharged battery, he would be obliged to opt for the second option. The passenger is then informed about the bracelet operating instructions.

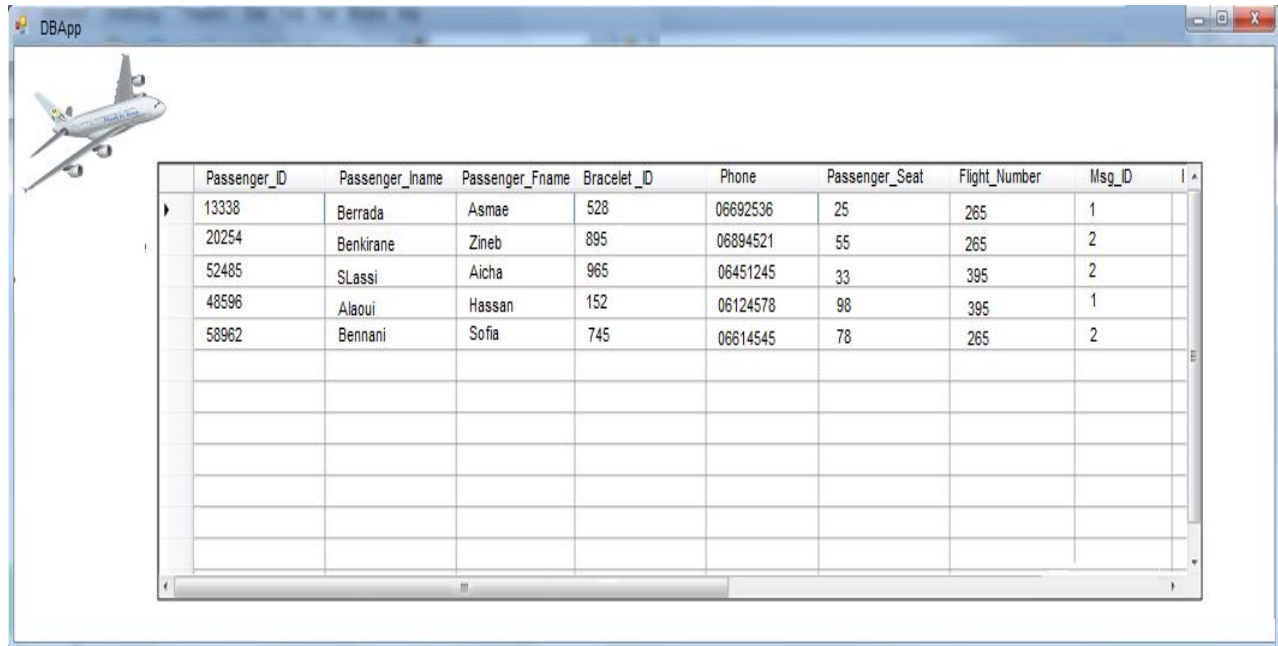
When the luggage is placed on the conveyor, the reader collects the tag data and records the beginning of the trip. As the bag moves through the conveyor, the RFID keeps track of the luggage in order to make sure that it would be delivered to the right gate and flight. At the same time, the database system processes the data sent by the RFID system and retrieves from it the passengers' information in order to know the bracelet ID and be able to send the appropriate message. As stated before, there are three scenarios where the system operates. In the first scenario, when the passenger's luggage has been embarked, the passenger should receive a message stating that "Your luggage has been embarked successfully".

The role of this system is mostly important in the delivery process as it allows the bag to be easily located and delivered to the right traveler. Again the passenger receives a message informing him that his luggage arrived to the delivery conveyor. There are two other scenarios when the database application operates differently. In the first case which is a multi-stop flight, the passenger receives a message each time his luggage arrives to a different airport. The advantage of this feature is that the passenger never worries about the location of his luggage. The second case is when a mishandling problem occurs; the passenger does not receive a message so he sends an emergency message to the system that checks the location quickly. Then, the system administrates try to fix the problem as soon as possible.

Figure 6 shows a Graphical User Interface (GUI) that presents the relationship between the entities' attributes. This table is in first normal form (1NF). The database matches each passenger who is identified by a unique ID with the corresponding flight number and bracelet to which a message is sent. For instance, the passenger whose ID is '13338' receives a text message stored in the database through the bracelet ID: '528'.

IV. COST ANALYSIS

The cost of RFID implementation has decreased significantly due to the increasing availability of RFIDs in the market as they are used in thousands of applications. This cost depends on many factors such as the size of the installation and the type of the RFID system. Table I presents a draft cost estimation (in USD) of the considered RFID system [5] along with the bracelet [9], [10]. The implementation of the proposed system in airports appears to be expensive. Considering this suggested approach of RTSAL, airlines companies would save millions of dollars related to mishandling errors and baggage losses that occur frequently.



Passenger_ID	Passenger_Lname	Passenger_Fname	Bracelet_ID	Phone	Passenger_Seat	Flight_Number	Msg_ID
13338	Berrada	Asmae	528	06692536	25	265	1
20254	Benkirane	Zineb	895	06894521	55	265	2
52485	SLassi	Aicha	965	06451245	33	395	2
48596	Alaoui	Hassan	152	06124578	98	395	1
58962	Bennani	Sofia	745	06614545	78	265	2

FIGURE VI: DATABASE TABLE FOR THE PROPOSED SYSTEM.

TABLE I: SYSTEM COMPONENTS COST

Parameter	Estimated Cost
RFID Passive Tags	Generally, \$0.07 to \$0.15
RFID Printer tags	Range from \$1,600 to \$1,800
RFID Fixed Readers	Range from \$500 to \$2,000
Silicon Bracelet	\$ 1
Graphic LCD Display Module	\$5 to \$10
Total Cost	\$2106.07 to \$3811.15

V. CONCLUSION

In this paper, an efficient RFID-based tracking system for airport luggage was proposed. The suggested system considers an interactive bracelet that involves passengers in the luggage tracking process. An analysis of the overall system's interaction was presented. Furthermore, the design and implementation of the considered system were also discussed. With this solution, customers' satisfaction in airports would be increased and mishandling cost would be lowered.

REFERENCES

- [1] AeroAssist, "RFID in Aviation: airport luggage control," AeroAssist.pt, Jun. 2008.
- [2] Y. Ouyang, Y. Hou, L. Pang, D. Wang, and Z. Xiong, "An intelligent RFID reader and its application in airport baggage handling system", 4th International Conference on Wireless Communications, Networking and Mobile Computing, pp. 1-4, Oct. 2008.
- [3] C. Jacinto, M. Romano, A. Montes, P. Sousa, M. S. Nunes, "RFID tuning methodology applied on airport baggage tracking," IEEE Conference on Emerging Technologies & Factory Automation, pp. 1-4, Sep. 2009.
- [4] C. R. Medeiros, J. R. Costa, and C. A. Fernandes, "Passive UHF RFID tag for airport suitcase tracking and identification", Antennas and Wireless Propagation Letters IEEE, Vol. 10, pp. 123-126, Feb. 2011.
- [5] A. Salssi-Sennou, A. Berrada, Y. Salih-Alj and N. Assem, "An Interactive RFID-based Bracelet for Airport Luggage Tracking System," in Proc. of IEEE 4th International Conference on Intelligent Systems Modelling and Simulation (ISMS'2013), pp. 40-44, Jan. 2013.
- [6] H. Lehpamer, "RFID Design Principles," Norwood, MA: Artech House, 2008.
- [7] L. El Alamy, S. Lhaddad, S. Maalal, Y. Taybi, and Y. Salih-Alj, "Bus Identification System for Visually Impaired Person," in Proc. of 6th International Conference on Next Generation Mobile Applications, Services and Technologies (NGMAST'2012), pp. 13-17, Sep. 2012.
- [8] A. Karmouche, Y. Salih-Alj and J. Abrache, "Distributed Aisle-Level Scanning Approach for RFID Shopping Systems," in Proc. of 2014 IEEE International Conference on Logistics Operations Management (GOL'14), pp. 1-7, Jun. 2014.
- [9] RFID Journal, "How much do RFID readers cost today ?". URL: <http://www.rfidjournal.com/faq/20/86>.
- [10] B. Chen, "price 128x64 graphic lcd module". URL: http://www.alibaba.com/product-gs/666312166/price_128x64_graphic_lcd_module.html.

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