Airline Baggage Tracking

ECE 480 Senior Design Team 1 Final Project Proposal

Brian Prange | Ziye Xing | Marwan Baraya | Emmanuel Wadieh | Henry Nguyen

Project Sponsor:
Dr. Satish Udpa, Ph.D.

Project Facilitator:
Tongtong Li, Ph.D.

10/9/2015
Executive Summary

Design team one was tasked with improving airport luggage tracking and retrieval through the use of RFID technologies. The team was given 11 weeks to integrate RFID technologies into the airline luggage tracking systems as well as a mobile app. The final design and presentation is scheduled to be demonstrated on the 11th of December. The current luggage system, involving barcodes, is prone to failure as evidenced by the 15% failed scan percentage. By replacing the barcode system with an RFID tagging and tracking procedure, successful identifying and routing of luggage would increase to a rate near 100%. The project will be centered around the ability to differentiate RFID tags attached to luggage with a mounted scanner. After being scanned, the information can be used by the airport for routing purposes and by the passenger through the app that gives real time tracking updates.
Table of Contents

1. Section 1: Introduction & Background .................................................................3
   a. 1.1 Introduction .................................................................................................3
   b. 1.2 Background ..............................................................................................3-4

2. Section 2: Design Solution ...............................................................................5
   a. 2.1 FAST Diagram ............................................................................................5
   b. 2.2 Design Parameters ....................................................................................5
   c. 2.3 Conceptual Designs Matrix .......................................................................#
   d. 2.4 Final Proposed Solution:
      Software ..........................................................................................................#
   e. 2.5 Final Proposed Solution:
      Hardware ........................................................................................................#
   f. 2.6 Risk Analysis ..............................................................................................#

3. Section 3: Management ....................................................................................#
   a. 3.1 GANTT
      CHART ............................................................................................................#
   b. 3.2 Timeline ....................................................................................................#
   c. 3.3 Individual Team
      Contributions ..................................................................................................#
Section 1: Introduction & Background

1.1 Introduction

The customer aims to create new standards in luggage tracking systems. The current system depends entirely on barcodes and automatic 360 degree barcode readers built on conveyor belts in airports. The issue with this approach is centered around the low readability rate of the barcode tags. The goal of the project is to replace the current barcode system with a RFID scanning process. In order to create a solution to the customer's issue we will need to design a
process with the following: programmable RFID tags to hold the information the barcodes originally held, mountable RFID scanners to log and route luggage and a mobile app that links with the airport databases to provide real time tracking and updates for passengers.

1.2 Background

Satish Udpa, executive vice president for Administrative Services at Michigan State University, and receiving customer of the finished product, introduced the concept of RFID tracking to the design team after losing his own luggage during one of his travels. The current system depends entirely on barcodes and automatic 360 barcode readers mounted on conveyor belts in airports. The issue with this approach is the readability rate of the barcode tags. Wrinkled tags are hard to read and dirty barcode readers cannot read tags efficiently, which leads to missing luggage bags. After establishing some basic specifications the team began to do research on the utilization of RFID systems and found that the technology has also been used in several airports around the world in an effort to reduce the number of mishandled bags. However, the technology has not been adopted globally due to the high cost of RFID tags over past years and the lack of understanding of the new technology (IATA). In addition, many researchers believe that the system has to be adopted at all airports at once for it to be effective since no integration with current scanning/routing systems has been available (IATA).”

There are many different types of RFID tags, operating on different frequency ranges. The higher the frequency, the faster the tag can be read, the more data can be stored and transferred and the longer distance the label can be interrogated from (reading distance). The three main types of RFID tags are:
- Passive LF(Low Frequency) operates from 30 KHz to 300 KHz
- Passive HF(High Frequency) operate at 13.56 MHz
- Passive UHF (Ultra High Frequency) operates at 860 to 960 MHz

The International Telecommunications Union (ITU) is responsible for regulating the global use of the electromagnetic spectrum. Different countries have different regulations and per IATA
(International Air Transport Association), operating at the range of 850MHz to 960MHz band may be used anywhere in the world. This limits our options to use the UHF tags which is convenient since they are easier to manufacture and therefore cheaper.

SECTION 2: Design Solution

2.1 Fast Diagram
The overall goal of the project, to successfully track luggage, can be seen in the FAST diagram below. While this is only a brief overview of the project, it does help break down the major aspects of the project. When looking from the left to right, the diagram breaks down into three subcategories which are: the airport integration, mobile app and RFID integrated tag.
2.2 Design Parameters
The table below was used to determine which team member’s conceptual design we would use to design our prototype.

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Description</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Integration</td>
<td>Due to the low cost of RFID tags, they can be used with the existing regular barcode tag. The data on the RFID will be the same as the data that can be read from barcode tag. This will allow us to use existing handling systems without having to create a separate baggage handling system. This smooth transition will convince more airports and airlines to adapt our technology.</td>
<td>30</td>
</tr>
<tr>
<td>Accessibility</td>
<td>The ease of use for the customer when considering the mobile app. The app should aid in the process of tracking the customer's luggage without creating any further hassles in the departure and return process.</td>
<td>30</td>
</tr>
</tbody>
</table>
Cost Due to the budget constraints the overall cost of hardware/software and labor must be taken into account. 30

Time How long it will take for the hardware/software to be delivered. Also, and estimated time for completion of the proposed solution. 10

<table>
<thead>
<tr>
<th>Concept Designer</th>
<th>Design Summary</th>
<th>Integration</th>
<th>Accessibility</th>
<th>Cost</th>
<th>Time</th>
<th>Total</th>
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<tr>
<td>Brian Prange</td>
<td>Low Frequency Readers</td>
<td>3</td>
<td>1</td>
<td>5</td>
<td>4</td>
<td>13</td>
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<tr>
<td></td>
<td>-Cheap</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>-Must be fairly close to scan</td>
<td></td>
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<td></td>
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<tr>
<td></td>
<td>-lower frequency can penetrates thicker</td>
<td></td>
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<tr>
<td></td>
<td>steel frame luggage</td>
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<tr>
<td></td>
<td>Passive RFID</td>
<td></td>
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<tr>
<td></td>
<td>-Can be picked up by LF readers</td>
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<tr>
<td></td>
<td>-Cheap</td>
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</tr>
<tr>
<td>Emmanuel Wadieh</td>
<td>Passive RFID</td>
<td>4</td>
<td>5</td>
<td>4</td>
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<td>17</td>
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<td></td>
<td>UHF Reader</td>
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<td></td>
<td>-Small, mountable</td>
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<td></td>
<td>-Radial scanning</td>
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<td></td>
<td>-can scan multiple tags at once</td>
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<td></td>
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<tr>
<td></td>
<td>Mobile updating</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>-Instead of passenger scanning they</td>
<td></td>
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<tr>
<td></td>
<td>will receive updates on their luggage</td>
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<tr>
<td></td>
<td>from the airport database</td>
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<td>Ziye Xing</td>
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<td>4</td>
<td>2</td>
<td>2</td>
<td>11</td>
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<tr>
<td></td>
<td>-More costly</td>
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<td></td>
<td>-Larger radius and reliable than passive</td>
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<tr>
<td></td>
<td>tags</td>
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</tbody>
</table>

Table 1: Design Parameters

2.3 Conceptual Design Matrix

Each team member was asked for an individual conceptual design to solve the customer's issues. Table 1 below shows a brief description of each member’s proposed solution and a breakdown of how it was scored. In the end Marwans design was chosen as the team's best proposed solution.
Mounted radial RFID scanners
- Similar to 360 barcode scanners
- Not affected by dust and small debris

Henry Nguyen
Twin pillar checkpoint towers
- Similar to those in retail stores
- Picks up on radio frequencies for RFID tags as they are passed through

Cellphone scanning app
- Utilize the wireless capabilities of the iPhone and iOS app developer to allow customers to scan for their bags with their phones

Marwan Baraya
Permanent RFID
- Embedded in lining of luggage

Reading Arch
- Reader would be built in arch shape
- Anything passing through the arch is scanned

Table 2: Conceptual Design Matrix

*Scale is from 1-5, with 5 being very good and 1 being very poor

** Values are the average of ratings given by other teammates

2.4 Final Proposed Solution: Software

Another important part in this design is the mobile phone application which allows user querying the baggage information in real-time. This will accomplish the goal to let the passenger have intuitive knowledge about where the baggage has recently been. The application will be developed on the iOS platform only, since the potential target clients mainly focus on the high level Apple users. The development of the application will be conducted on the latest Xcode 7.0 environment, and the software will be written in Swift language standard. The application will be created based on the standard Model-View-Controller (MVC) architecture for the user interface design and integrate object orientation concept to implement the internal execution code. The simplified conceptual object diagram can be viewed as in Figure #.
The basic design idea for the software is that the phone application will prompt the user for the information about a baggage to create a baggage object which includes identify where the baggage come and to go and the passenger’s flight number etc. The software will save this baggage object in an item list, and allow user to check the object from the history items. The baggage object will send a query to database object and get the response of the latest information about the queried item. The database object is an abstract intermediate to contact the actual SQL database host on a remote server which connect to the scanning system mentioned in the hardware section. The query responded from the SQL database will then be presented to the users at the client. Some extra features could be added depends on the development progress and demands, such as the actively pushing notification to user’s client which requires Apple license and supplementary software design.

The design of phone application will be tested by the user’s satisfaction and accepting degree to the App. Whether the App is user friendly and intuitive for user to get along with, in what degree the user like the interface of the software, and also most important whether the result retrieved from the database is accurate/reliable or not. All those questions are needed to assess and rated. If this design is successful, after a baggage passing through a scanner and reader, the passenger who owns the baggage should be able to use this App to track the real-time location of it. And furthermore, when the baggage goes passed another checkpoint, the user should immediately see
the updated information of the baggage on the phone. If all the requirements stated above are achieved, then it marks the design of the cell phone application is successful.

2.5 Final Proposed Solution: Hardware

The proposed design solution consists of the following parts:
- UHF RFID tags.
- UHF RFID scanner and antenna
- Computer software to store customer’s data

Each RFID tag has a unique ID that will be assigned to the itinerary of an individual traveler. The data associated with each traveler must be logged into a database.

This solution has been selected among others because it upgrades the currently used systems and could take advantage of the currently used databases in luggage tracking. This solution also makes it possible to use both RFID tags and regular barcode tags together until this new technology becomes the new standard.

The RFID scanners will be mounted on the conveyor belts during the luggage routing process. These scanners must be able to scan individual tags and pull data from the database to make routing decision. Routing decision making is not part of this solution since the current routing algorithms work efficiently to route luggage. This solution mainly focuses on replacing the barcode used in luggage tracking with an RFID tag and provide the existing routing systems the same data it would obtain from the barcode to be used in database queries and/or routing decision making.

These scanners will be also used similarly in multiple tag scanning. For demonstration purposes, we will use the same scanner to do both tasks, but our solution suggests using hand held scanners to make multiple scans for verification. Such a quick scan will compare multiple entries to an inventory list to detect any discrepancies that indicate missing luggage.

The Computer database function is to make sure RFID tags are being programmed with the right information and they can be read and provide a valid input for database queries. It will also be used to link the luggage information with a mobile device application that will make tracking luggage from smart phones possible.

The type of RFID tag that will be implemented in our solution is UHF (Ultra High Frequency). These tags could be read from 5 meters using the right type of scanner antenna. They can also be read simultaneously and due to the high operating frequency, these tags can be read fast and store more data. They are also cheaper than their lower frequency peers. UHF tags can be used in all airports without violating any of the frequency allocation regulations.

The reader is attached to an 8dB antenna that will allow scanning from 5 meters. The longer scanning range facilitate multiple tag scanning in room as previously discussed.

The overall design concept can be seen in the figure below:
2.6 Risk Analysis

The initial risk the team faced was lack of adequate experience with RFID technology, database and IOS development. This was however minimized due to sufficient information found online in the form of articles and other useful research done by a previous senior design group at Michigan State University in these areas.

Time also served as a risk factor in terms of if the team would be able to complete this design project in a timely manner. The initial idea the team had was to build the RFID reader from scratch. However, after talking to the team facilitator, the team came to a conclusion that it would not be a feasible concept to build the RFID reader due to lack of experience, and also due to the fact that given the time frame it would be close to impossible if not impossible to finish the project within the given time frame. The plausible solution would be to purchase both the RFID tags and reader.

Another risk the team faced was going over the budget. The budget allocated for this project was $500, taking into consideration that the team would have to purchase both an RFID tag and reader brought up concerns of whether the budget for this project would be enough.
The risk of reading the RFID tags due to where it would be placed is also another issue. The range of these readers must be enough to read these RFID tags no matter where they would be placed on or in the luggage. Also, the issue of whether the RFID tags could fall off when attached to the luggage is also another risk. This degree of risk is high since without these tags it would be impossible to read information regarding a specific luggage. The RFID tags would be placed inside the luggage or attached firmly on the strap of the luggage to avoid such instances.

Finally, trying to infuse the RFID technology into the real world system. The team realized that most of the airports in the United States and around the world have not been brought up to date with this technology. The issue was whether or not and how this transition from the old technology, which is the use of paper tag and barcodes to RFID technology, would be a feasible real world solution for the prevention of luggage loss in the airline industry. The team also learnt that this RFID technology has already been implemented in an airport in Las Vegas, which makes the project applicable in real world situations regarding airline companies.

SECTION 3: MANAGEMENT

3.1 GANTT Chart

![GANTT Chart]

Figure 3: GANTT Chart

3.2 Timeline
Figure 4: Timeline

3.3 Individual Team Contributions

<table>
<thead>
<tr>
<th>Personnel Management</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Team Member</strong></td>
</tr>
<tr>
<td>Brian Prange</td>
</tr>
<tr>
<td>Marwan Baraya</td>
</tr>
<tr>
<td>Henry Nguyen</td>
</tr>
<tr>
<td>Emmanuel Wadieh</td>
</tr>
<tr>
<td>Ziye Xing</td>
</tr>
</tbody>
</table>

Table 3: Personnel Management

3.3.1 - Brian Prange
As the Project Manager for Design Team 1, I have been tasked with ensuring that the team meets all deliverables set forth by the ECE 480 instructors. These deliverables include written documents, oral presentations, technical demonstrations, and the Design Day presentation. Additionally, I have been in charge of outreach for the team, maintaining active communication with our Sponsor, Facilitator, and Department in an effort to keep a steady flow of reporting and feedback.
My technical role on the team has been and will continue to be overseeing the integration of the two aspects of the project - the RFID scanner and the iOS Application. It is vital to the success of the project that these two components interact seamlessly with each other to meet the requirements of the sponsor. In the event that the two sub-teams work independently of each other at times throughout the semester, I will maintain a dialogue between the two to make sure each is aware of the progress of the other.

3.3.2 - Ziye Xing
I will be in charge with the mobile phone application development task. The task will start as soon as the design phase begins. The design process of the software includes user interface design, program coding, and software testing. I need also make the software compatible with the SQL database from the data collection stage. As the webmaster of the design team, I will also be in charge with developing the web page of our team’s design project, demonstrating the accomplishment of our team design on a well developing the web page.

3.3.3 - Henry Nguyen
As document prep. for our team I am in charge of compiling, editing and finalizing all written reports and documents for the team. As for the technical role, I will be working with Marwan on the RFID scanner. Due to time constraints our team decided to order a scanner instead of building one. So instead of building a whole new scanner I will be working with Marwan into researching how to boost the signal range for the scanner. So far we have found that increasing the power at the ultra high frequency can produce a larger range, but it is more easily attenuated. Another technical aspect of the scanner is to integrate it with both the RFID tags and the database system. One of the biggest concerns with the scanner that Marwan and I will be addressing is it’s ability to not just pick up the RFID tags but also the scanner's ability to extract all of the embedded information and store it in the correct manner.

3.3.4 - Emmanuel Wadieh
As the lab coordinator for design team 1, I would be in charge of all purchases needed to complete the design project. I would also be in charge of making sure that the equipment either purchased or borrowed from the ECE lab store are made available for the team and also kept in good condition.

My technical contributions to the team would consist of working with Ziye in IOS development to develop the mobile application for the team. This would involve creating a mobile application that would help track the luggage as well as a database to store the information such as the itinerary of the end user. The mobile application should be able to generate the passenger’s information such as name and flight details.
3.3.5 - Marwan Baraya

As the presentation preparer, I am responsible for presenting our design to our customer and our peers. The presentations should be descriptive and easy to follow. I try to implement new presentation ideas that attract our audience. Such new tools as “Prezi” are more appealing and gets audience attention much better than traditional powerpoint presentations. “Prezi” is also team based, which means that my team and I can work together simultaneously to create and edit presentations.

My technical role in the team started from day one. I was responsible for the research that has been done on the current technology and the RFID technology to see which one is the best fit for our specifications. I have also contacted the supplier of our scanner in China and inquired about the technical specifications of their product before discussing with my team and decide to purchase. I was able to get an 8.5% discount which will also help our tight budget.

This research led my team to make a decision on what technology we should use. UHF RFID was our choice. My next step is to test the kit and integrate it using the provided SDK libraries with Henry. My main role is to make sure that the scanner is working properly and provide data to our software team. Also, I will be working with my team to test and demonstrate our solution to make sure it solves the design problem.

Section 4: Costs
4.1 Budget Breakdown
<table>
<thead>
<tr>
<th>Product</th>
<th>Quantity</th>
<th>Cost</th>
<th>Total Per Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>RFID Kit</td>
<td>1</td>
<td>$250.00</td>
<td>$250.00</td>
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<tr>
<td>Apple Developer Account</td>
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<td>$99.00</td>
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<tr>
<td>RFID Tags</td>
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<tr>
<td>3-D Printed Case</td>
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<tr>
<td>Luggage</td>
<td>1</td>
<td>$80.00</td>
<td>80.00</td>
</tr>
</tbody>
</table>

Total cost: $459.00

Table 4: Budget Breakdown

References