Radio Frequency Identification Tags for Airline Baggage Tracking

Group Number Nine (9)
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I pledge my Honor that I have abided by the Stevens Honor System.

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Abstract

Radio Frequency Identification Technology has begun to surge over the past few years. RFID technology allows companies to improve real-time visibility of their inventory, track works in progress, and monitor shipping and receiving operations. As the demand of RFID increases, so does the demand for innovative ideas and implementations of the technology to make everyday tasks more efficient and to save companies money.

With the given potential in RFID, the group has chosen to focus its senior design project on a baggage tracking system for use in the airline industry. Successful deployment of RFID technology has the potential to save airline companies millions of dollars in resources and man-hours currently used to recover missing packages and compensate affected customers. The system the group shall create will track the baggage in a real-time network and notify the appropriate employees in the event that baggage has been routed incorrectly.

The projects main aims are to design and develop a real-time network, server, and management software that will use RFID technology to track all of the baggage present in an airline as well as have an early warning system to detect luggage that may have been misplaced.

Project Proposal Plan

Introduction

Radio Frequency Identification (RFID) is an automatic identification method that utilizes small devices known as RFID tags or transponders to store and remotely retrieve data. These RFID tags possess an internal antenna allowing them to receive and respond to radio-frequency queries sent out by a RFID transceiver. The fundamentals behind this technology are not new and can be traced as far back as the 1920's where it was developed at MIT for use in providing a method for robots to communicate with one another. It was later used extensively in World War II by the British to track planes and other vehicles[1]. Despite its age, RFID is a proven tracking technology that has continued to improve over the years. With recent advancements, mainly in automated circuit assembly, costs to produce these systems have declined to the point where industries should look to incorporate RFID systems for use with new applications.

One of the industries that should consider RFID tracking technology is the airline industry. Currently, airlines typically use bar code scanners to track luggage and have so far only had mediocre success with it. There is no doubt that a stigma is attached to the airline industry for consistently losing their patrons luggage. In 2004, Delta Airlines estimated that each year they misplace approximately 800,000 pieces of luggage. They further estimated that they spend close to $100 million a year finding these lost bags and returning them to their owners[2]. This cost is significant enough for airlines to seek out ways to improve their accuracy in tracking luggage in order to improve customer satisfaction as well as greatly reduce unnecessary costs. The answer to this particular plight of the airline industry is RFID technology. Unlike conventional bar code systems that require line of sight for their scanners to work, RFID systems only require the tag to pass within range of the RF transceiver resulting in an increase in accuracy and speed. Delta Airlines has recognized this opportunity to reduce costs and began testing RFID equipment in Florida's Jacksonville Airport.

The goal of our design team is to develop an RFID solution for airlines to track their customers' luggage. We would like the solution to be general enough so that it can be applied generically in any airline's environment. The solution should be simple and easily maintained as well as cost effective. The basic hardware components of our prototype will include multiple RFID readers, RFID tags and multiple servers. In addition to hardware, three pieces of software will be needed. First, a database will be required to store baggage information. Second, a program will be needed on the RF scanner side to assess the bags current position and send that information to the database on the server. Finally, a program will be required on the server to determine if the scanned luggage is in fact in its proper location, and if not, alert employees of the error.

The basic process of a bag being checked at an airport utilizing our system is as follows. A tag containing information about the bag's owner and destination will be affixed to a piece of luggage. The information about the bag's owner will also be placed in a database running on a network-enabled server. When the bag passes by the reader a computer program will update the database with the bag's current position. Then another program will check this updated information to see if it matches the data stored in the database. If the information matches, it is known that the bag is in the correct place. However, if the information is not a match, the program will alert personnel that a bag is heading in the wrong direction.

Design Requirements

The final RFID tracking system will be a combination of both hardware and software. First, strong consideration needs to be taken in the requirements of hardware products. The essential pieces to any RFID system include RFID transponders or tags and RFID readers. To make the system complete, information needs to be sent when the reader scans a tag to determine if the scanned piece of luggage is in the correct place. This calls for two networked servers to be introduced to the system. The first is a node computer that is needed on the RFID reader end of the system to send information to the second, which is actually acting as a dedicated server to the RFID tracking system. To complete the tracking system, several pieces of software will be required. A program on the node will be required to interpret the response from the reader and send this information through the network to the dedicated server. On this dedicated server, a database will be required that stores information about the piece of luggage, including the owner and destination.

Most importantly, the purpose of our system is to minimize the number of lost bags for an airline. The key to minimizing this number lies in the realization that a bag has been misplaced and the notification of personnel to remedy the problem. To accomplish this, a final piece of software will be required to match the destination information in the database with the current position information received from the reader attached to the node. If this software determines that the information does not match, and that the bag has been misplaced, it will initiate an alert so airline employees can retrieve the bag and move it to its proper location.

Design Approaches

In a project as complex as this one, there are many different design approaches to be considered. From varied types of hardware to using pre-built or custom software, many different choices must be made.

The first fundamental choice to be made is the type of RFID reader to use. Ranges, power levels, and tag formats can vary greatly from reader to reader. Passive RFID tags generally have a range from 2 millimeters to 6 meters. An RFID reader should be selected which optimizes read distance for larger bins of luggage. In addition, tuned and directional antennas for the readers can be used to increase both range and selectivity when reading tags. The use of multiple antennas may be able to limit some of the effects of tags being in one another's "shadow", which prevents stacked tags from being seen by a reader.

Another concern is selection of the RFID tags themselves. The tags need to be small, portable, and as low cost as possible. Passive tags seem to be the ideal solution to the current needs of the airline industry. Passive tags can cost as little as $0.20 per tag in large quantities. Active tags have the benefits of increased range and detection ability, however with these advantages comes significant added cost. In addition, active tags are substantially larger then their passive counterparts, requiring the use of a power source. Passive tags can be printed as flatly as a common piece of paper, making integration into existing baggage systems easy. Some tags are programmable, allowing airlines to add rudimentary data on the tags themselves ensuring easier tracking when a master database becomes unreliable or unavailable.

Next, server interfaces must be considered. The simplest method would be to use a general-purpose computer to interface the master server and RFID readers. This allows for versatility in configuration, environment, and user accessibility. In addition, existing information technology (IT) infrastructure can be used to handle the new hardware and communication needs of the baggage system. With these advantages comes an increased cost associated with extraneous hardware that will rarely be used. Using dedicated hardware RFID readers with only minimal data processing capability can lower such costs. This solution will generally require larger support costs to train new users and for maintenance above and beyond what is required for normal IT support. In addition, the decreased hardware power may hamper user interface options.

The type of server interface must be considered for this application. Use of HTTP allows clients and servers to communicate with a minimum of complications and allows for easy traffic shaping by network administrators. Many different existing software works over HTTP requests allowing for faster prototyping and easier administration on deployed networks. By using standard HTML and web browsers user interfaces can be made to be extremely versatile and updateable on the fly. This comes at a cost of increased traffic and processing power however. Use of a dedicated network protocol could help to reduce the amount of network processing that is required for inter-device communication. This could make increase costs if a dedicated network format is required at the user site. Administration could also become a problem, as the RFID network grows large.

Server software is also a large concern for the project. When using standard HTTP based requests, a simple web server such as Apache or IIS could be used to handle information requests. Using a back end language such as PHP, Perl, or a .NET based language would allow us a large degree of freedom in handling our RFID baggage tracking system. Using standard dynamic web pages in a mix of languages allows for a rich user interface mandating a minimum of training for users of the system. The interface could also be easily updated as changing conditions warrant. Alternatively, if a lower level network protocol is used, custom software will have to be written to support it. This allows for a higher degree of customization compared to HTTP requests but at a greatly increased development cost. Processing of requests could also be done faster allowing for less powerful server hardware.

Regardless of server processing method some form of back end database would be required. Writing custom database software would be inefficient and wouldn't be as efficient as current software options. MySQL is a GPL based database that could be easily deployed for minimum cost. It could be customized as needed for our particular application not only in schema but also in code. Oracle databases are powerful systems that could allow for a fast and large database back end. This software can be expensive and has recently come under fire for improper security measures. Many other forms of database software exist, each with their different strengths and weaknesses.

There are many options for approaches that this design project can take. It is through proper analysis of the varied aspects of each option and careful review of customer needs that the group plans to make this project a success.

Financial Budget

The financial summary estimates the cost of researching and implementing an RFID system at a major United States Airport. All costs are approximate.

For the purpose of the group's design goals and severely limited availability of funds, these estimates are unrealistic. The design project for each group in the CpE/EE department is constrained by the same financial restrictions.

Production Analysis:	**Cost**	**Quantity**	**Total**
Labor:			
Project Staff 600 Hours @ $30/hr	$18,000.00	5	$90,000.00
24/7 Operations Support Staff @ $20/hr	$175,200.00	1	$175,200.00
Materials and parts:			
TI Low Frequency RFID Eval Kit	$595.00	100	$59,500.00
RFID Tags	$0.20	1,000,000	$200,000.00
HP DL380 Server	$6,000.00	2	$12,000.00
Generic Node Computer	$1,000.00	100	$100,000.00
Software:			
Windows Server 2003	$999.00	1	$999.00
Windows 2003 Client License 20-pack	$799.00	5	$3,995.00
		Total Cost:	$641,694.00

Project Analysis:	**Cost**	**Quantity**	**Total**
Labor:			
Project Staff 600 Hours @ $30/hr	$18,000.00	5	$90,000.00
Materials and parts:			
TI Low Frequency RFID Eval Kit	$595.00	1	$595.00
		Total Cost:	$90,595.00

Project Schedule

The project schedule in Gantt chart form is included in the appendices. A summary of all tasks, their respective start and end dates, as well as the assigned group member or members are included below in summary.

Preliminary Project Phase	3 days?	9/1/05	9/5/05	Group 9
Group Formation	3 days?	9/1/05	9/5/05	Full Team
Identify project	3 days?	9/1/05	9/5/05	Full Team
Advisor Selection	3 days?	9/1/05	9/5/05	Full Team
Weekly Project Report	66 days	9/5/05	12/5/05	Brian Compter
Weekly Team Effectivness Survey	66 days	9/5/05	12/5/05	Group 9
Develop Design Proposal	26 days?	9/13/05	10/18/05	Group 9
Title Page and Table of Contents	24 days?	9/13/05	10/15/05	Brian Compter
Abstract	24 days?	9/13/05	10/15/05	Chris Lubin
Project Proposal Plan	24 days?	9/13/05	10/15/05	Full Team
Conclusion	1 day	10/17/05	10/17/05	Justin Ong
Final Review and Editing	1 day	10/18/05	10/18/05	Full Team
Research and Exploratory Development	36 days?	10/18/05	12/6/05	Full Team
Advanced Development	65 days?	12/7/05	3/7/06	Full Team
Develop Final Design Report - Semester 1	36 days?	10/18/05	12/6/05	Full Team
Prepare Oral Presentation and Slides	6 days?	11/29/05	12/6/05	Full Team
Prototype and Initial Product Development	49 days?	1/17/06	3/24/06	Group 9
Server Configuration	35 days?	1/17/06	3/6/06	Chris Lubin and Jeff Smith
Network Configuration	35 days?	1/17/06	3/6/06	Justin Ong

Backend Software Development	35 days?	1/17/06	3/6/06	Brian Compter and Reid Borsuk
Frontend Software Development	35 days?	1/17/06	3/6/06	Brian Compter and Reid Borsuk
Final Testing	14 days	3/7/06	3/24/06	Full Team
Spring Iterim Report	36 days?	1/17/06	3/7/06	Full Team
Develop Final Design Report - Semester 2	41 days?	3/8/06	5/3/06	Full Team
Prepare Senior Design Day Presentation	6 days?	4/26/06	5/3/06	Full Team

The tasks included in the project schedule include product research and development as well as project reports and other deliverables. All project deliverables and reports are a group effort and where applicable, tasks were assigned to individual members.

In the fall semester, there are three major deliverables; the project proposal, the fall semester final design report, and the oral and slide presentation. There are three major deliverables in the spring semester; the interim project report, the spring semester final design report, and the prototype and poster demonstration.

Major portions of the schedule include research, development, and prototyping. These sections are intentionally vague to allow for the maximum amount of flexibility in the development of the project.

Prototyping responsibilities and individual task that may be added later are assigned according to expertise. Brian Compter and Reid Borsuk are to head the development of software and related items of programming. Both are competent programmers with a wide range of programming knowledge and experience. Justin Ong, Chris Lubin, and Jeff Smith all have experience in network and server maintenance and administration. They will split the tasks relating to network and server setup.

Conclusion

RFID technology has been proven successful in asset management and several other applications. These applications can range from warehouse inventory to livestock tracking and in our case, airline luggage tracking. The group's RFID solution has the potential to minimize the rate of lost baggage. A lower rate of lost luggage would result in a reduction of insurance claims, baggage delivery cost, and customer reimbursements. In the end, this leads to saving money and resources.

Our project expects to provide an alternative cost efficient solution to an industry that is just beginning to mature and develop. With our own software package and infrastructure design we plan to provide the best option available to this new concept of RFID airline luggage tracking. Once the infrastructure is installed there will be minimal labor costs as well. The labor required to correct lost luggage will be reduced as well as customer service representatives who investigate lost claims will be reduced as well.

The implementation requires a significant investment in research and design. Over time, airlines can save millions in claims, save on labor for lost claims representatives and increased sales due to customer satisfaction. With an advertised lower rate of lost luggage and use of new technology for tracking, we expect passengers to select the airlines that use RFID over previous barcode technology. This will produce increased revenues for the airlines as well since more passengers will choose their airline.

References

[1] G Dargan, B Johnson, M Panchalingam, C Stratis, "The Use of Radio Frequency Identification as a Replacement for Traditional Barcoding." 5 March 2004, <http://www.andrew.cmu.edu/user/cjs/index.html> (18 October 2005).

[2] Johnathan Collins, "Delta Plans US-Wide RFID System" 2 July 2004, <http://www.rfidjournal.com/article/articleview/1013/1/1/>, (18 October 2005).

Additional References

Robert J. Sweeney II, RFID for Dummies (Hoboken: Wiley Publishing, 2005).

Diane Crawford, "RFID", Communications of the ASM, September 2005.

Additional Web Resources

<http://www.dot.gov>, Department of Transportation

<http://www.bts.gov>, Bureau of Transportation Statistics

<http://www.faa.gov>, Federal Aviation Administration

<http://www.ti.com>, Texas Instruments

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