RFID in Airports – Baggage and Passenger Tracking

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Abstract

The objective of this paper is to explore and analyze the use of RFID technology in airports today. It starts by looking at how RFID technology can increase the efficiency of baggage tracking over the conventional barcode technology. The technologies will be compared and the implementation described. It then moves on to how RFID technology can be utilized in tracking passengers in airports increasing the efficiency of airports. It will also discuss the details behind the technology and the controversies it raises. Finally, the paper finishes with how an integration of these two RFID applications can increase the efficiency of airports today.

Introduction

If anyone has been to an airport, it is really an amazing place to be at. Strangers working together from all over the world, towards a common goal of getting a group of people and their belongings from one part of the world to another daily. Of course, this is would be an understatement describing an airport, otherwise daily riots are inevitable.

Fortunately in reality, an airport is organized into many different units from the people you see checking boarding passes to make sure everyone gets in the right gate, to the computers in the back that no one ever sees, to make sure everything gets on the right plane. All these different units have to work together to complete every procedure every single day, to ensure that everything gets to the right place at the right time.

In a perfect world, one far from the one everyone is on, this system works. Everyone and everything does what they are supposed to do correctly, and everything is fine. However, to bring reality closer, people working at airports can and will make mistakes, computers systems working behind the scene can and will also make errors. In the end, we get a bustling, chaotic airport that guarantees delay, misplaced baggage, and people going to places where they are not supposed to go.

Delays are not only a hassle for other passengers, but also for the airline and the airport itself. For example, "a missing passenger at London City Airport delayed a flight to Frankfurt by 90 minutes" because of the airline has to find and remove that person's luggage. Not only that, "delays are costing the industry £100 million a year,"[1] about US$200 million a year.

Lost baggage is a common problem in our airports today. "Out of 2 billion plus pieces of luggage handled per year just over 1% are mishandled." That is more than 20 million pieces of luggage per year. Not only that, "Each baggage mishandling costs on average US$90."[2] That adds up to about US$1.8 billion a year.

Knowing where someone is at any given time is a good thing, especially at an airport where there is people roaming around everywhere all the time. To list a few benefits: finding a lost child, finding lost passengers that can potentially delay a flight, and to prevent terrorist from entering a secured area.

Even though we cannot decrease the amount of human error, other than having better trained personnel, we can definitely decrease the amount of computer error by utilizing newer technologies that can function more efficiently than outdated ones. This will not only save airports and airline companies time and money, but will also increases their image to the general public, a priceless asset. Not only that, to most people, this spells a memorable vacation, a painless business trip, or just a successful traveling experience.

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[1] Millward, David. "Airports to track passengers with radio ID tags." Telegraph. (4 Nov. 2007). 31 May 2008 <http://www.telegraph.co.uk/news/uknews/1548100/Airports-to-track-passengers-with-radio-ID-tags.html>.

[2] "Fact sheet: Radio Frequency Identification (RFID) for aviation." IATA. June 2008. 31 May 2008 <http://www.iata.org/pressroom/facts_figures/fact_sheets/rfid.htm>

Improving the efficiency of a major airport is not an easy job. It is a difficult process that should not be performed to get a small amount of improvement. With that said, the implementation of RFID technologies in airports will definitely show signs of significant improvements in efficiency. RFID tags and readers can be used to track baggage and people in airports. RFID technologies does not need a line of sight between the tag and reader, and will definitely decrease the number of lost baggage and delays, and will definitely deter terrorists from attacking an airport.

This paper will focus mainly on two cases of baggage tracking, one in McCarran International, Las Vegas, and the other for Delta air. It will also focus on two cases of passenger tracking, one in Debrecen Airport, Hungary, and another in Geneva International.

Baggage Tracking

Most airports today only provide airlines with a space to do their business. This includes a gate for planes to park at, and a counter for check-in, the airlines themselves have to take care of the baggage themselves. Tracking baggage efficiently is a major component of the airline business today. If travelers keep losing their baggage with one airline, they will avoid traveling with them again. There are exceptions, such as the McCarran International, Las Vegas, that also provides baggage handling service for all the airlines.

The conventional method of baggage handling is through a barcode tag attached to each piece of baggage usually on the handle at the check-in counter. In an overly simplified version, each baggage is then sent through a series of conveyor belts, through x-ray machines, then to more series of conveyor belts to a unit load device (ULD) in order to be transported to a plane, all automatically guided by computers connected to barcode scanners reading each tagged baggage. In reality, many factors will lead to a computer not being able to read the barcode. The baggage will then have to be diverted to a manual barcode reader, operated by humans, opening up the chance of the baggage being lost or misplaced.

For an average barcode system, the read rates are around 80-90%. This number may seem high, but for a large airport like McCarran International, travelers check in about 70,000 bags a day.[3] This spells out 7,000 to 14,000 bags to be manually handled per day. That is a lot of bags to be processed, and for an average airline such as Delta air, this leads to about 800,000 misplaced bags per year, which is around 0.7% of the total number of bags.[4]

The reasons for these relatively poor read rates are mainly due to technology. Barcodes need a direct line of sight between the tags and the readers and can be easily damaged, readers can only read one barcode per pass and have relatively poor accuracy, and the system needs high maintenance. Fortunately, RFID technology can easily address these issues. RFID does not need a direct line of sight and are more durable than barcodes, readers have the ability to read multiple tags and have a relatively high accuracy, and the system has a lower maintenance than barcode systems. See Figure 1 [5].

Not only that, but RFID is a relatively mature technology, especially in the airports, already been tested in many countries worldwide, see Figure 2[6], and the technology has been standardized by the International Air Transport Association (IATA). According to the RFID Journal,

> "International Air Transport Association (IATA) Joint Passenger Services Conference held in Geneva this week, IATA member airlines unanimously approved the IATA Recommended Practice (RP) 1740C document, which endorses the use of ultra-high frequency tags and readers (interrogators) compliant with the ISO 18000-6C protocol as a

[3] RFID Takes Off at U.S. Airports. 9 Nov 2006. American Society for Quality. 31 May 2008 <http://www.asq.org/qualitynews/qnt/execute/displaySetup?newsID=764>
[4] Delta Plans U.S.-Wide RFID System. 2 Jul 2004. RFID Journal. 31 May 2008 <http://www.rfidjournal.com/article/view/1013>
[5] RFID Business Case for Baggage Tagging. 30 Jun 2007. International Air Transport Aasociation (IATA).
[6] RFID Business Case for Baggage Tagging. 30 Jun 2007. International Air Transport Aasociation (IATA).

global air interface standard for RFID baggage tags. ISO 18000-6C is a candidate standard being considered for adoption by the International Standards Organization, and the protocol is expected to incorporate EPCglobal's Gen 2 air interface standard."[7]

Capability & Cost	Bar Code	RFID
↗ **Flexibility** Line of sight Reading	↗ Required	↗ Not required
↗ **Ability** Number of simultaneous scan	↗ One	↗ Multiple and distinguish bags from other items
↗ **Accuracy**	↗ Read rate highly variable	↗ Fully automated & accurate ↗ Read rate > 99%
↗ **Durability**	↗ Can be easily damage	↗ More durable, withstands handling
↗ **Data support**	↗ No write capability	↗ Possible to update data
↗ **Maintenance**	↗ High Maintenance	↗ Low Maintenance
↗ **Cost**	↗ Cheap tag ↗ Expensive readers	↗ Expensive tags ↗ Cheap readers

Figure 1. Capability and cost between barcode and RFID systems

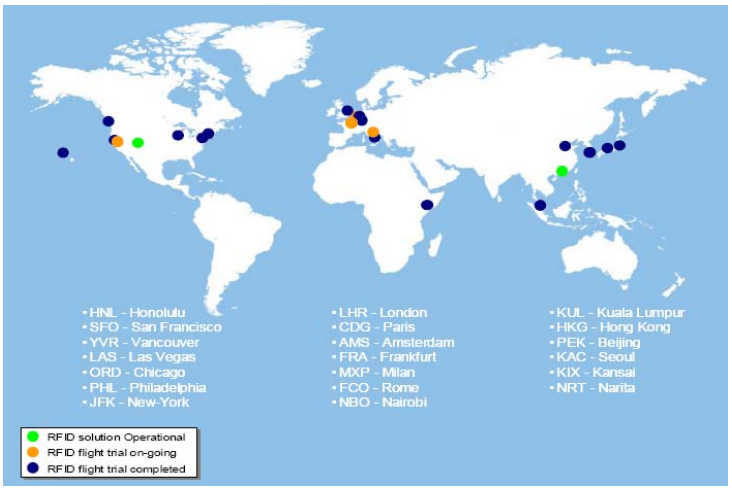

Figure 2. Worldwide distribution of RFID trials

EPC Codes

According to IATA discussed at an EPC Global conference in US in 2005, the EPC code contains the following:

- 10 digit IATA Bag Number
  - 1 digit prefix to indicate general classification of tag
  - 3 digit airline ticket number (e.g. 999 for China Air)
  - 6 digit serial number
- 96 bit EPCglobal Serialized Bag Tag Number (proposal – not ratified!)

[7] IATA Approves UHF for Bag Tags. 18 Nov 2005. RFID Journal. 31 May 2008 <http://www.rfidjournal.com/article/articleview/1994>

- Namespace: SBTN
- 8 bit header (00111111) identifies a IATA Baggage Tag
- 12 bit company prefix uses the IATA Airline Ticketing number
- 4 bit item reference identifies the General Classification of the tag
- 40 bit serial number translates the 6 digit serial number of the IATA tag (in the final standard we propose to pre-pend 16 bits to include the date the tag was issued to make the serial number unique – this feature is not used during the TSA pilot)
- 24 bits are reserved for future use

Also see Figure 3[8].

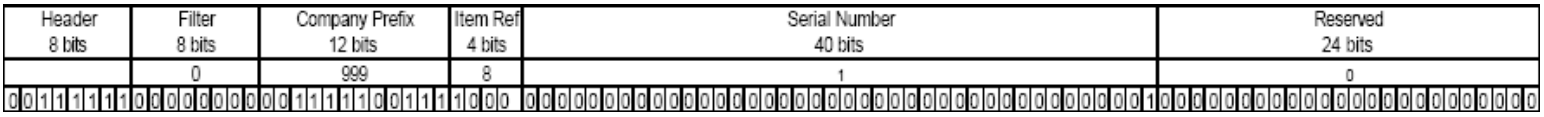

Figure 3. Data allocation for a 96bit EPC standard

Technology

The technology behind an RFID baggage tracking system utilizes Ultra High Frequency (UHF) tags and readers. For McCarran International, they are using passive 900Mhz tags from Matrics Inc. (now acquired by Symbol Technologies), and during the trial, Delta Air used passive 915Mhz tags from both Alien Technology Corp., and Matrics Inc. Both are using the ISO 18000-6C protocol incorporated with EPC Gen2 standards.

RFID printer and encoder will be placed at the check-in counter. Similar to the conventional way of bags check-in, customers will check-in their bags and the attendant will print a label and wraps it around the bag handle. The only exception is that the label will not only have the customers' information printed, but a unique ID number (UID) will also be encoded onto the RFID chip. See Figure 4[9].

Since each bag is identified by a 10 digit IATA Bag Number, a database is needed. Information on the database will include the passenger's name, flight number(s), and all cities on their ticketed itinerary.

RFID readers are placed inside the baggage handling stations at each security check point. This way, the computer can associate the X-ray of each bag with the respective passenger's information. Also, RFID readers are placed before splits in the conveyor belt. This way, each baggage can be sorted to the correct place. See Figure 5[10]. If readers do fail to read bags, manual handling of baggage can be performed with a mobile RFID reader. See Figure 6[11].

[8] Hogan, Bernie and Linster Marc. "Using EPCglobal Network to track baggage around the world." PowerPoint. EPCGlobal US Conference. 15 Sep. 2005.
[9] Kirk, Louis. "Applications of RFID in Aviation." PowerPoint. Symbol RFID Ecosystem Summit. 10 May 2006.
[10] Departure Control System. 2 Feb 2008. Flight Data Management Inc. 31 May 2008 <http://www.fdminc.net/dcs.html>
[11] Kirk, Louis. "Applications of RFID in Aviation." PowerPoint. Symbol RFID Ecosystem Summit. 10 May 2006.

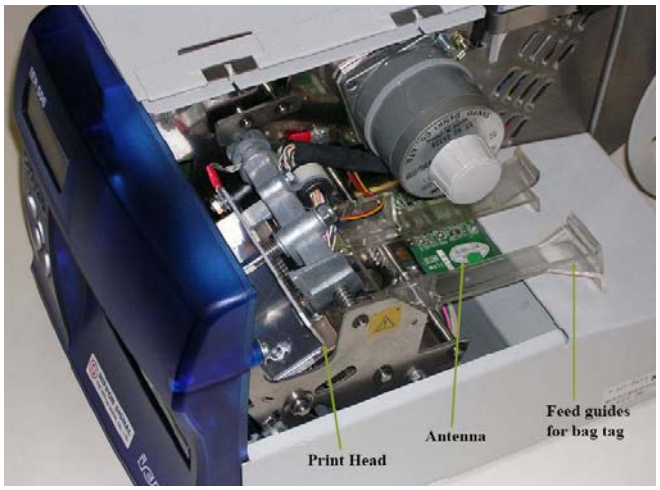

Figure 4. RFID printer and encoder

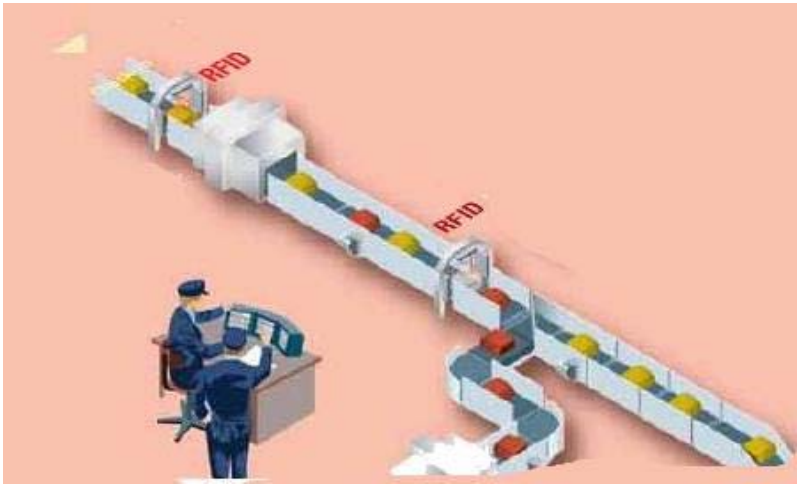

Figure 5. RFID readers in baggage handling stations


Figure 6. Mobile RFID reader from Symbol

Middleware

The middleware in an airport environment is important to make an RFID system work. Some functions include setting up the network, connecting readers, and encoders, so they can work together efficiently. For the readers, it needs to be able to send and receive signals to communicate with the passive tags. For the encoder, it needs to be able to write data on the tag in the correct order.

Another function of the middleware is a rules engine. A rules engine commands a computer to do specific job if something happens. Two of the most important rule for baggage tracking are: (1) At security checkpoints, if a bag fails the checkpoint, a rule engine is needed to alert employees what to do with it; (2) at each split, a rule engine is needed to tell the controller in the baggage sortation system where the bags needs to go; and (3), at each check point, a weighing device may be placed at each reader checkpoint, and each bag weighed. The weight of each bag can be compared with the first reading—at the check-in counter—to make sure nothing was taken out or added in. If the weight is changed, alert security of possible theft or added explosives.

A third function of the middleware is to connect to other applications. For example, it needs to let information in and out of a database, since the information on an RFID tag are just numbers and verification with a database is necessary in order to have the customer's information. Also, it needs to connect with the airline's software so that the customer's baggage tags can be printed correctly.

Security

Since there is virtually nothing intelligible on the tag, and everything is on the database, the tag does not need to be secure. However, since all the important information are on the database itself, the database has to be secure.

Cost

McCarran International, Las Vegas has a unique baggage sortation system. The airport provides all the airlines with baggage sorting. This increases efficiency in that all the airlines share the system same instead of everyone getting their own.

At McCarran International, Las Vegas, they have spent $100 million on equipments and infrastructures alone. They also bought 100 million passive tags over a five-year period for $25 million (25 cents per tag), totaling $125 million for 5 years. About $94 million of that amount is sponsored for by the Transportation Security Administration (TSA), so the airport pays only $31 million for the RFID baggage tracking system. [12]

[12] Las Vegas airport to implement RFID baggage-tag system. 6 Nov. 2003. Computer World. 31 May 2008 <http://www.computerworld.com/mobiletopics/mobile/technology/story/0,10801,86909,00.html>

"McCarran was handling 70,000 bags a day. If an optical system achieves 90% accuracy, that still means employees must deal with 7000 bags per day by hand. McCarran's RFID system is about 99% accurate. At that rate, employees would have to handle about 700 bags a day."[13]

On average, over 1% are mishandled or around 250,000 bags a year, and each baggage mishandling costs on average US$90, this totals to around US$23 million a year. RFID can deliver a prediction of 12% reduction in the number of lost or delayed bags, that is a saving of at least US$3 million a year on hard benefits alone.

According to International Air Transport Association (IATA), soft benefits contribute 3 times the financial return of hard benefits, that is an additional savings of $9 million. Some soft benefits include improved sales due to better management information, increase in general efficiency, so less workers needed, improved employee morale by automating boring tasks, so workers are more efficient, and more satisfied customers due to faster response and improved accuracy, so more future paying customers. All in all, that spells out a $12 million in savings, so the airport will breakeven in less than 3 years.

For Delta Air, they had about 800,000 misplaced bags per year, or a 0.7% of all their bags handled. Returning bags to their owners was costing the company close to $100 million a year. RFID baggage-tracking system is expected to cost between $15 million and $25 million to deploy. After calculating soft and hard benefits, predicted pay off is within a few years after deployment.

[13] RFID Takes Off at U.S. Airports. 9 Nov. 2006. American Society for Quality. 31 May 2008 <http://www.asq.org/qualitynews/qnt/execute/displaySetup?newsID=764>

Passenger Tracking

An airport today is a busy place to be at. It is not only big, but there can are thousands of people at any given day. It is easy for anyone, a child, and adult, or even terrorists to get lost in the crowd. Today, there is nothing in regards to passenger tracking other than video surveillance and security patrol. This method may be adequate for a small airport, but with a bigger airport, there are a lot of limitations. With thousands of cameras and even more people, it is almost impossible to find anyone anywhere inside an airport.

There are many reasons why an airport or airline needs to know where someone is at. The main reason is to prevent delays due to a missing passenger. This annoyance does not only affect the other passengers, but also to the airlines themselves. A plane cannot legally take off with a customer's luggage without the customer on the plane. A delayed 747 can cost around USD$1000 per minute (costs ramp up due to knock on effects), and it normally takes around 30-45min to unload the Universal Load Devices (ULD), locate the baggage and remove it and reload the ULDs. [14] See Figure 7.[15] Another reason is a missing child. If a child is lost in an airport today, it will probably take a while before he or she can be located. For a worse case scenario, if a child is kidnapped in an airport, the kidnapper probably have all the time in the world to escape. Thirdly, airport security today has many loopholes. If someone, either a confused traveler or worse a terrorist, somehow entered an unauthorized area, it is nearly impossible to find out where they are. Lastly, the main reason why there are long queues in airports is because supervisors might not know which area has the most congestion and not know whether or not a new line should be opened up.

Figure 7. Unit load devices (ULD)

With RFID technology, theses problems can all be solved at the same time. RFID technology can tell where each passenger is at an airport as long as they carry an RFID tag.

[14] Lea, Kelvin. E-mail interview. 22 May 2008.
[15] Wong, Marcus. "Unit load devices (ULD)." Photo. Wikipedia.org. 20 Feb. 2008. 31 May 2008.

Technology

Technology for RFID passenger tracking is different from baggage tracking. Most systems, including the two in the next few pages are proprietary. This means that most systems does not have a common standard, they are all different according to the company. The two case studies of passenger tracking are at Debrecen airport in Hungary, dubbed OPTAG, and lead by Professor Paul Brennan at the University College London. They've tested with an active 5.8 GHz RFID UHF tag, and a unique ID number is the only data on the tag. This number is to identify the passenger when compared with a database, which may contain the passenger's name, age, gender and flight number. See Figure 8.[16]

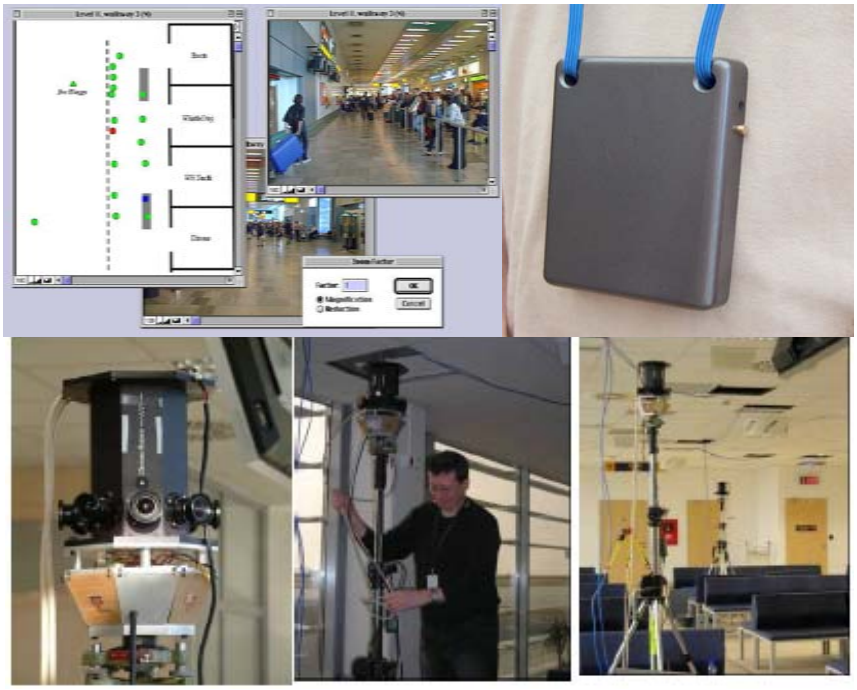

Figure 8. OPTAG RFID system

The other study is at the Geneva International, managed by Paxflow. They are using the Personal Passenger Assistant (PPA), and active 2.4 Ghz RFID Microwave tag with an LCD to communicate with the customer. Paxflow wants to be able to put "passenger's complete flight information, passport details, baggage tag numbers, and, where mandated by security agencies, biometric data"[17] See Figure 9[18].

For added security, since a RFID system is only effective if people carries the tag, a special feature on the tag should be able to sense if it is dropped, incase someone drops a tag.

RFID printer and encoder can be utilized again at the counter, and as the attendant prints and encode the RFID baggage tag with data, it can also do the same for a passenger's RFID tag.

[16] Brooks, Colin. OpTag Final Activity Report. Mar. 2007.
[17] "Paxflow Active Logistics Solution for Airports." Paxflow. 21 Jun. 2005.
[18] Irving, Todd. "Wireless Technology in Passenger Management." Powerpoint. Airport Service Quality & Facilitation Conference. 1 Apr. 2008.

Figure 9. Paxflow RFID system

RFID readers can either be placed at choke points such as security check points, splits and at boarding gates, or they can be placed in a matrix all over the airport with cameras on top of the readers for an even better passenger tracking system. For the OPTAG project, each reader has a read range of around 10 m radius. They have installed a digital panoramic camera system on top of each directional antenna so they can actually follow each person with video in a network sensor matrix. For the Paxflow, each reader has a read range of around 30 m radius, and are placed similarly to the OPTAG readers. See Figure 10.[19]

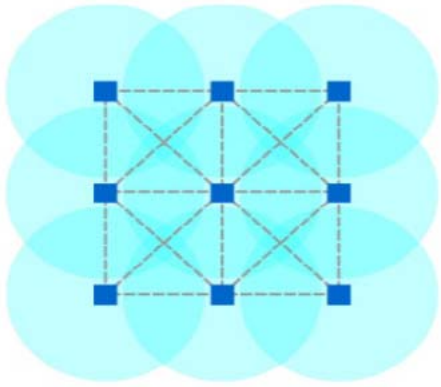

Figure 10. Network sensor matrix

Middleware

Middleware is also important to the application of passenger tracking. If readers are setup in a matrix, it needs to connect all the readers and encoders together, similar to baggage tracking. It will also need to be responsible for a rules engine.

[19] Irving, Todd. "Wireless Technology in Passenger Management." Powerpoint. Airport Service Quality & Facilitation Conference. 1 Apr. 2008.

Some rules for passenger tracking are: (1) Alert security if a reader picks up a tag in an unauthorized area; (2) alert the right airline if someone is not likely to make it to their flight; (3) alert security if a tag senses it has been dropped; (4) alert the right airline to start unloading passenger's bags if a reader senses the passenger leaving the airport; and (5) alert security if a tag suddenly drops out of radar, suggesting that either the tag is shielded by metal or damaged for malicious reasons.

In addition, the middleware needs to enable the ability to connect with other applications such as a database if necessary, or other airline applications.

Security

Security is an important issue especially in an airport environment, but depending on the data encoded in the tags, it can determine where security is needed. For the OPTAG system, only a UID is encoded in the tag. Since a UID is incomprehensible by a human being, the tag does not need to be secure. However, the database needs to be protected from hackers and the likes.

For the Paxflow system, since they want to put complete passenger information on the tag itself, the tags need to be secure. In an interview with a Paxflow employee, Lea, the "PPA encryption is strong utilizing European encryption technology and on the wireless side a brute force attack was calculated at a 100 years using a good sized super computer - since the device is issued and collected within the airport this makes it impractical to break the encryption."[20]

Cost

The cost for an RFID passenger tracking system in an airport is hard to estimate. According to Lea, Paxflow is provided as a service on a per use charge or a capital project. The system will be implemented over a 5+ year contract with 24/7 availability and 99.999% uptime, and will be different for each case. A typical large airport will cost millions of dollars to implement, operate and support.

However, the cost can be easily balanced by a decrease in the number of delayed flight. Again, the costs of a delayed 747 per minute can be around USD$1000 (costs ramp up due to knock on effects), PPA can alert airline employees to find the passenger before they are late, or it can alert airline employees to unload passenger's bags if they are too late to make the departure time.

In addition, targeted retail promotions on tag can help lower cost 200% increase of personal sales ratio for business travelers. According to Bryan Motteram an employee at mantic point, company similar to Paxflow, "particularly in Europe and Asia where retail income is such a major part of airport profitability. If you know when the passenger has gone through security and you know when their flight is scheduled to depart, you can determine if they have plenty of time to spare … if so, studies have shown that people who are airside with time to spare are quite impulsive in their shopping habits … and allowing airport retailers to target these passengers with timely promotional offers is hugely attractive to the retailer."[21]

[20] Lea, Kelvin. E-mail interview. 22 May 2008.
[21] Motteram, Bryan. E-mail Interview. 3 Jun. 2008.

Similar to baggage tracking, soft benefits are unpredictable, and play a big part in additional benefits.

Controversy

For passenger tracking, most people see it as an invasion of privacy, especially in the United States where privacy is a big issue. Most people do not want others to know where they are and when. Also, if tags do contain personal information, even with security features such as encryption, there is still a chance, although small, of a hacker breaking through security and into everyone's information.

Integration of Baggage and Passenger Tracking

In the previous sections, case studies show that baggage tracking alone does have its benefits, and similarly for passenger tracking too. However, each system alone lacks the benefits of the other, thus the integration of baggage and passenger tracking should be implemented for a full customer service. Not only does the integration provide both benefits, but also benefits that are derived from the integration.

To list a few benefits, integration can provide real time tracking of both baggage and passenger to ensure everything and everyone gets on the plane. Another benefit is that readers at airport exits can verify a match between baggage tag and passenger tag before the passenger leaves the airport. The reader can also kill tags after a match is confirmed.

Conclusion

This paper analyzed the application of RFID in airports in two areas, baggage tracking, passenger tracking, and the integration of both. RFID baggage tracking proves to be far more effective than the conventional barcode method. According to case studies, an RFID baggage system can help reduce the number of missing or misplaced baggage, help increases efficiency of baggage handling. These two improvements will simply help airlines and airports save money, and provide travelers with a hassle free experience.

RFID passenger tracking similarly also proves to be far more effective than the conventional method of video surveillance. It reduces delays due to a missing passenger, and can track anyone in an airport. These two enhancements can give parents a peace of mind by helping find missing children easier in an airport, detect anyone entering an unauthorized area deterring terrorists, and save airlines money.

The integration of baggage and passenger tracking proves to be far more effective than either system alone. It not only has both advantages of baggage and passenger tracking, but can match passenger with their bags when they get on the plane, and get out of the airport. This extra added enhancement can further decrease the loss missing or misplaced baggage, help airlines and airports save even more money and passengers an even more positive trip.

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