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RFID for Cargo and Passenger Automation and Control in Airline Industry

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Abstract— Air industry still relies on manual methods for controlling cargos. The manual procedure results in sustaining great deal of waste of time and human errors. There are many solutions for more efficient controls and barcode-based RFID (Radio Frequency Identification) is one among many. This article deals with control using RFID technology, where each passenger and items is marked by a RFID tag. The tag bears unique traits of the passenger for identification. Different types of RFID readers will be used from issuance of flight cart until boarding. Tags are identified by the key inside RFID Tag. Before implementation, the system was studied through simulation and as the results showed, RFID tags were read with 99% accuracy and better performance was achieved. The minimum delay time for passenger and cargo in the simulation was acceptable.

Index Terms—RFID Tag, RFID Reader, Baggage, Passenger, Downlink, Uplink.

I. INTRODUCTION

Recent years are featured with reports of important and interesting results in utilization of RFID technology in supply chain management [1][2]. This article it focused on applying RFID for passenger and cargo control in airline industry [3]. A feasible system in the industry is introduced with economic advantages and minimum technological requirements relative to other systems. The output of the system was tested to find out that RFID is of great positive effect on control system. Supply chain management and urban traffic control is not the only field of application for RFID [4], as it is now clear that the technology is effective on airline industries as well[5]. The results showed high accuracy (99%) of the completely automatic system (barcode technology barely reaches accuracy of 95% and in some case hits 60 or 70% accuracy during transfer in some airports [6]) [7]. International Air Transportation Association (IATA) is currently working on accepting RFID in the airline industry (e.g. baggage tag, baggage track, boarding pass, and employee pass) [8]. Acceptance of RFID technology in airline industry holds great promises for reducing errors and damages. In 2010, 2944 million baggage were mishandled, that is 12.07 baggage for each 1000 passengers and 2.94billion dollars of lose [9]. This figure for 2011 is 25.8 million or 8.99 mishandle of baggage for each 1000 passengers. [10]Results in [11] regarding utilization of well-disciplined methods with RFID technology for mapping baggage and contents of cabinets of airplanes with real time connection between the airplane and airport and land-based operation are impressive. RFID tags in [12] with mapping capability were used for distribution and transportation of the baggage to achieve more customer satisfaction and performance. RFID technology reduced average waste of time for checking passenger and a bag (2min) up to few seconds [13]. The technology was also applied for predicting short-term demands and optimization of transportation fleet for real time function. Passengers' habits for transportation were applied for predicting origin and destination matrixes and statistic [14]. An RFID based technique was utilized for identifying passenger; so that each passenger holds a RFID tag in their pocket or handbag for identification purposes [15][16]. Passengers' identification rate in two different gates and ID cards (two-band card 86% and single-band card 91%) were measured as well. An airplane maintenance system was implemented based on RFID technology that was interacting with inventory and airplane schedule system through an integral design. The system was used for insuring the performance and safety of the passengers [17]. RFID chip on ticket is another use of the technology, so that passenger may enjoy more facilities and decency in passing gates. In addition, the technology provides the possibility to track the passengers and control of passenger flow. [18]

In our case study simulation, Passive and RFID Reader/Writer (UHF passive MR6011) were used. The system was developed based on RFID and for controlling and directing baggage, passengers. Each passenger is provided with an RFID Tag on the ticket or handbag to keep it throughout the trip. In this way, passengers can be tracked whether in airplane or flight terminal. Databank key was passport number + flight number (a unique number). The baggage and passengers were assigned to each other in the query, passport number, and flight number recorded in RFID. Moreover, several formulas such as downlink and uplink signal coverage cover, and relation between quality of signal and performance of the system were under consideration in the study.

II. SYSTEM

The RFID system for passenger and baggage control in airplane is comprised of 5 main elements:

- Passenger
- Airplane
- Baggage
- Suitcase
- Airport

Baggage is a cargo, which is handed over to the cargo department, and suitcase, on the other hand, is carried out by the passenger onboard.

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To have an intelligent system, these four elements are interacting, so that when the passenger enters the airport (fig. 1), each baggage, and suitcase and flight card are tagged with an RFID tag. The RFID information distinguishes the passenger and their cargo. The optimum code find in the study is:

(Time + flight code + flight number + P/B/S + seat number + passport number + date)

Where, P/B/S refers to passenger, baggage, and suitcase respectively, and seat number and number are assigned to the passenger and cargo respectively. The system uses GEN 2 tag with three memory sources, and memory bank user is the only memory for writing the data (32 characters-hexadecimal). It is noticeable that every data is coded before being written in the RFID tag and decoded before analyzing. This ensures that passenger, baggage, and suitcases are assigned with RFID tags with unique key. Use of combined key avoids any probable interruption between the keys. Each passenger receives a flight card tagged with RFID tag as suitcase and baggage are assigned with an RFID tag before being delivered to cargo department. Passenger with their suitcase (if any) both with RFID tags pass through the first FRID reader (each passenger and baggage pass through 3 RFID readers before boarding and there are portable readers which are not mentioned here). Passengers are counted at this stage before passing X-Ray Gate (suitcase and security check are omitted). Single trip flight is default setting of the system. The second RFID Reader is positioned after X-Ray gate, where number of passenger and suitcases passed the gate are counted. The passengers who failed to pass the security gate are determined at this point. The next stage is passing flight gate and boarding. The third Reader is installed at the airplane door to check whether all passenger entered the flight terminal are on board or not. The next stage begins when no problem is found in the previous one. At the next stage, the passengers are on board and baggage are loaded beforehand and identified by the third RFID reader). Passengers and baggage are counted as presence of the passenger and their baggage is of great importance. The airplane is prepared for flight when everyone and their baggage are on board safe of sound.

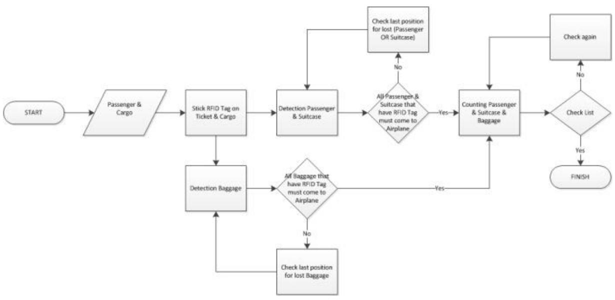

Fig. 1 System Overview for one way flight.

Up to this point, the passenger is tracked up to boarding point. When the baggage are delivered to cargo department, they are tagged with an RFID tag before entering unit load device (ULD). First reader is installed on baggage checking point (four RFID readers in four different directions [19]. This ensures 99% accuracy procedure. Afterward, the baggage passes through X-Ray Gate before meeting the next RFID reader. At this point, baggage is recorded and ready to enter ULD section, where they classified based on time distance and sorted in groups. A noticeable point regarding the system is that the baggage are laid out based on FILO method, while RFID enables laying out the baggage from end to top. In this way, passengers are laid out in FIFO model, though not organized quite based on time distance. This is because the baggage packages are arranged based on time distance and 100% time-based arrangement requires more work forces. Finally, the third RFID reader reads the baggage when they are transported from ULD unit toward the airplane for loading. Up to this point, passenger and baggage are managed automatically and intelligently. At the end of the trip (fig. 2), passengers are directed toward exit gate and baggage are unloaded simultaneously. Each passenger finds their baggage and an RFID reader checks the tags on the cargo and flight card. Any inconsistency is reported to security department otherwise the passenger will pass the gate and the procedure will end.

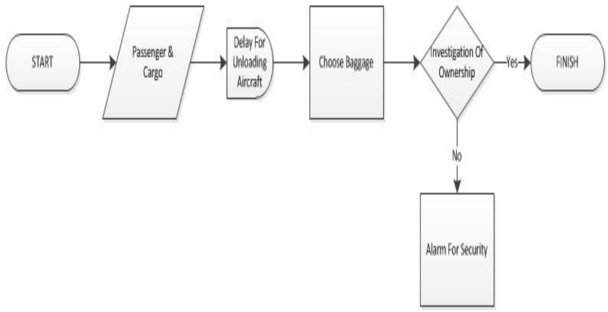

Fig. 2 System Overview for End of trip.

The surveys showed that downlink and uplink are the most important elements in receiving the information from RFID Tags. They play a pivotal role in communication between RFID tag and RFID Reader. The first step is to determine signal coverage of RFID Reader (uplink) at the spots where the readers are installed. Having the signal coverage is essential to improve performance of the reading. Moreover, RFID Tag reading is obtained from the following formula:

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$$r = \frac{\lambda}{4\pi}\sqrt{\frac{P_t G_t G_\tau \tau}{P_{th}}} \qquad (1)$$

Where, λ is wave length, P_t is signal transfer power by RFID Reader, G_t is antenna gain, G_τ is receive gain, P_{th} is minimum power threshold for enabling chips of the tags, and τ is power transfer coefficient of the antennal and chip impedance. This shows that majority of passive RFID systems have uplink limitations.

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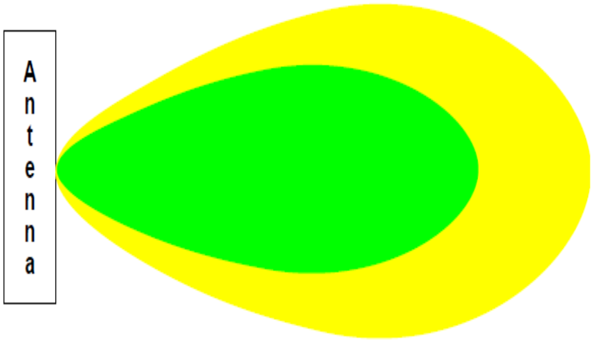

Fig. 3 Typical interrogation zone generated by antenna used in RFID systems .Interrogation zone is marked with green and extended interrogation zone with yellow.

Quality of signal is another important factor for spotting tags in the airplane. Received scattered signals from RFID Tags depend on the function of 3 main parameters.

- Return signal strength indicator (RSSI)
- Signal phase angle rotation
- Doppler shift

RSSI (dBm) refers to strength of return signal angle rotation from RFID. RSSI shows power of Downlink from RFID Tag to RFID Reader. Power of the received signal is:

$$P_\tau = P_t \tau G_\tau^2 G_t^2 \left(\frac{\lambda}{4\pi r}\right)^4 \quad (2)$$

Where P_τ is received signal power , and r is the distance between RFID Reader and Tag's antenna. That is, the shorter the distance from RFID Reader, the smaller the RSSI and, consequently, the higher the rate of read Tags.

Signal phase angle rotation is natural result of accurate measurement by the reader. Although, the reader cannot indicate the phase difference angle of received backscattered signals from the tag, it reports phase angle difference between received and emitted signal and balances the rotation to improve signal clarity.

The relation between wavelength and RF wave signal carrier is:

$$\lambda = \frac{c}{f} \quad (3)$$

Where, c is light speed, f is frequency unit, and λ is wavelength. Signal phase angle rotation is obtained from backscattered signals

$$\theta = 2\pi\left(\frac{2R}{\lambda} + \theta_T + \theta_R + \theta_{TAG}\right) \quad (4)$$

Where R is the distance between the reader and the tag, λ is wavelength, θ_T phase angle rotation caused by reader's transmit circuits, θ_{TAG} is phase angle rotation caused by the tag's reflection characteristics, and θ_R is the phase angle rotation caused by the reader's receive circuits.

Phase angle difference is a consecutive function with sequence of 2π and, therefore, phase angle difference is repeated with an integer and half of wavelength multiple.

$$R_n = \frac{n\lambda}{2}, n = 1,2, \ldots \quad (5)$$

Doppler transfer happens when the reader and the tag have relative movement [20]. When the tag moves toward the reader, received wavelength is shortened and vice versa.

Received phase angle rotation is obtained from received packs:

$$\Delta\theta = 2\pi(2 f_m \Delta T) \quad (6)$$

Where, f is Doppler frequency, and ΔT is transfer time of data packs. Doppler frequency received from the reader is obtained as follows:

$$f_m = \frac{\Delta\theta}{4\pi\Delta T} \quad (7)$$

III. RESULTS

The model was simulated in two different paths (passengers and cargo paths) in Awesim software. Three RFID readerswere used in each path, with an additional unit (ULD) in baggage transfer section. Uniform functions were used in the simulation for 200 passengers and 200 baggage in 200 time units (fig. 1). The results showed 99% tag reading accuracy by the readers (fig. 3), in addition system performance for 200 passengers or baggage is better performance than that of barcode based systems. Average waiting time in lines for boarding is illustrated in figure 4.

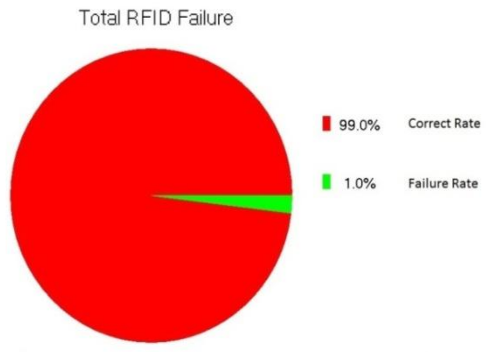

Fig. 3 Total RFID failure

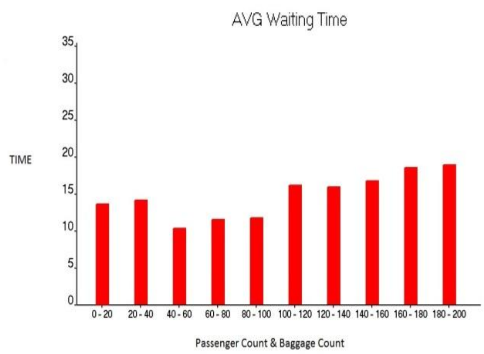

Fig. 4 Average Waiting time

IV. CONCLUSION

A simulation of the recommended system (RFID based) was surveyed. The results of simulation showed that 99% of the tags are readable and the remaining 1% have the chance to repeat the process (only adds 1 time unit to the procedure). Therefore, all tags are identifiable with acceptable performance. The system showed higher performance than conventional systems (barcode-based) and easily extendible. The system extension only needs adding one RFID Reader to the system.

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The simulated model tested exponential, Poisson, etc. functions and finally uniform model generated the best results. Moreover, higher performance is achievable by more power and coverage of downlink and uplink and higher quality frequency.

In general, in comparison with conventional system, RFID technology can be used with minimum expenditure and workforce demand to implement an intelligent and highly reliable system.

REFERENCES

1. P.D. Devries, in: *The state of RFID for effective baggage tracking in the airline industry*, International Journal of Mobile Communications, vol. 6, iss. 2, pp. 151-164, 2008.
2. T.S. Rangarajan, A. Vijaykumar and S.S. Suraj, in: *Stop getting strangled by your supply chain, Forrester Research*, 2004.
3. H.C.W. Lau, W.T. Tsui, C.K.M. Ho and A. Ning, in: *Development of a profit-based air cargo loading information system*, IEEE Transactions on Industrial Informatics, vol. 2, no. 4, pp. 303-312,2006.
4. Sasan Mohammadi, Abolfazl Rajabi and Mostafa Tavassoli, in: *Controlling of Traffic lights Using RFID Technology and Neural Network* .Advanced Materials Research Vols. 433-440 (2012) pp 740-745© (2012) Trans Tech Publications, Switzerland doi:10.4028/www.scientific.net/AMR.433-440.740
5. Chi-Kong Chan, Harry K. H. Chow, Alex K. S. Ng, Henry C. B. Chan and Vincent T. Y. Ng, in: *An RFID Case Study for Air Cargo Supply Chain Management* , Proceedings of the International Multi Conference of Engineers and Computer Scientists 2012 Vol I, IMECS 2012 , March 14 – 16, 2012 .
6. Dong Li, Yuhao Wang , Linli Hu , Jing Li , Xuezhao Guo , Jiance Lin and Jie Liu , in: *Client/Server Framework-Based Passenger Line Ticket System Using 2-D Barcode on Mobile Phone* ,IEEE E-Business and E-Government (ICEE), 2010 .
7. AeroAssist company : *RFID in Aviation:airport luggage control* , An AeroAssist white paper , 2008.
8. Ting Zhang, Yuanxin Ouyang and Yang He, in: *Traceable Air Baggage Handling System Based on RFID Tags in the Airport* , Journal of Theoretical and Applied Electronic Commerce Research ISSN 0718–1876 Electronic Version VOL 3 ,2008 .
9. SITA Company: *Baggage Report 2011* , Specialists in air transport communications and IT solutions , 2011.
10. SITA Company: *Baggage Report 2012* , Specialists in air transport communications and IT solutions , 2012.
11. Jacinto, C. , Romano, M. , Montes, A. , Sousa, P. and Nunes, M.S., in:*RFID tuning methodology applied on airport baggage tracking* , Emerging Technologies & Factory Automation, 2009 .
12. Yuanxin Ouyang , Yao Hou , Ling Pang , Dongwei Wang and Zhang Xiong , in: *An Intelligent RFID Reader and its Application in Airport Baggage Handling System* , Wireless Communications, Networking and Mobile Computing, 2008.
13. Aman khan : *United Airlines Tests RFID to Speed Baggage and Passenger Check-In* , The world's RFID Authority , 2009.
14. Oberli, C. Torres-Torriti, M. and Landau, D. , in: *Performance Evaluation of UHF RFID Technologies for Real-Time Passenger Recognition in Intelligent Public Transportation Systems* , Intelligent Transportation Systems, IEEE Transactions on, 2010.
15. Oberli, C. Landau, D. , in: *Performance evaluation of UHF RFID technologies for real-time passenger tracking in intelligent public transportation systems* , Wireless Communication Systems. 2008. ISWCS '08. IEEE International Symposium on , 2008.
16. McCoy, T. Bullock, R.J. and Brennan, P.V. , in: *RFID for airport security and efficiency* , Signal Processing Solutions for Homeland Security, 2005. The IEE Seminar on (Ref. No. 2005/11108), 2005.
17. Chang, Y.S. Oh, C.H. , Whang, Y.S. , Lee, J.J. , Kwon, J.A. , Kang, M.S. , Park, J.S. and Ung, Y.P. , in: *Development of RFID Enabled Aircraft Maintenance System* , Industrial Informatics, 2006 IEEE International Conference on , 2006.
18. Hasan, M.F.M. Tangim, G. , Islam, M.K. , Khandokar, M.R.H. and Alam, A.U. , in: *RFID-based ticketing for public transport system: Perspective megacity Dhaka* , Computer Science and Information Technology (ICCSIT), 2010 3rd IEEE International Conference,2010.
19. Simon, L. ,Saengudomlert, P. and Ketprom, U. , in: *Speed Adjustment Algorithm for an RFID Reader and Conveyor Belt System Performing Dynamic Framed Slotted Aloha* ,RFID IEEE International Conference on , 2008.
20. Jiexiao, Y., Kai, H. L. and Peng, L. A, in: *Mobile RFID Localization Algorithm Based on Instantaneous Frequency Estimation*. IEEE, 2011

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