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Abstract: The implementation of RFID had aroused discussion in every area. Experts believe that the emergence of RFID will cause another business revolution. Many industries had deployed RFID, like aviation industry, in which RFID is used in maintenance materials and baggage management. This paper discusses the implementation of RFID in MRO process and the building of a ubiquitous computing environment. We believe that our proposal has three merits to MRO (1) anti-counterfeit parts (2) MRO liability (3) efficient and effective inspection. The architecture can address the competition pressure that aviation industry faces and consequently enhance competition advantages.

Keywords: Personalized, Mobile, and Ubiquitous E-service.

I. Introduction

Ubiquitous computing, or Ubicomp, first proposed by Weiser, is the method of enhancing computer use by making many computers available throughout the physical environment, but making them effectively invisible to the user [5]. Ubicomp enables users to access demanded services and information under various environment, and eliminate the media break that connect the virtual world (including ERP, IS, Internet, etc.), and the physical world (objects, person, assets). The applications of Ubicomp in business environment help improve business processing efficiency and eliminate human intervention during information processing. Among technologies that had been used to implement Ubicomp, RFID is the most practical and feasible one. RFID is not a new technology; in fact, it was invented during World War Ⅱ [8]. Nowadays, it attracts attention from various industries and academics. RFID system comprises three primary components: tag, reader, and back end database [6][8][12]. RFID tag consists of antenna and electronic circuit [6][7][8][12]. The antenna transmits data or receives data from readers. The antenna also allows tag to couple to an electromagnetic (EM) field to obtain power [6][8][12]. The electronic circuit is divided into two parts: memory and logical gate. There are two kinds of memory, ROM and RAM, and their capacities range from hundreds to 1K bits [9].

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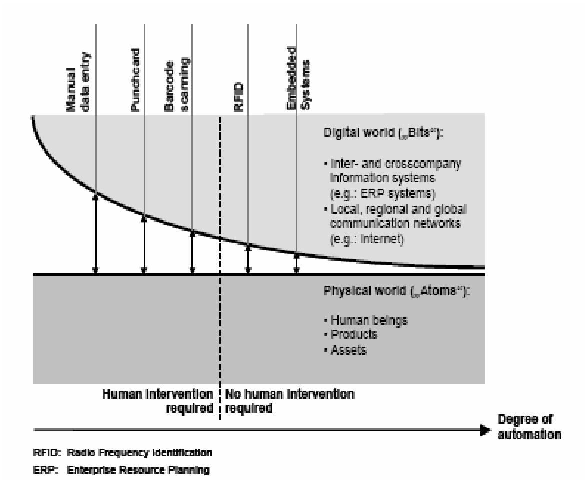

Figure 1 Media Break Between the Physical and Digital World [4]

There are about a few thousand of logical gates [12] to perform the basic computation in tag. Tag is categorized as passive or active and as low frequency or high frequency, depending on the power source and data transmission radio frequency [6][7][8][12]. Furthermore, RFID tag has many characteristics, for example, the unique identification, the basic computation, and its traceability. RFID is considered the successor of barcode. There are some applications of RFID system, for example automatic road toll collection, anti-theft systems, goods tracing and identification. The participants of aviation industry also notice this new application. Currently, the competition among aviation companies is intense due to the entering of new competitors and the stagnation of market growth. To conform to regulations, huge budget is spent on maintenance procedures. In aviation industry, aircrafts have to perform maintenance regularly. Such a process is called MRO (Maintenance, Repair, Overhaul) [1]. For safety reasons and public interests, the law enforcements, like FAA, have set up conscientious demands or regulations to make sure that the airline companies carry out MRO as requested.

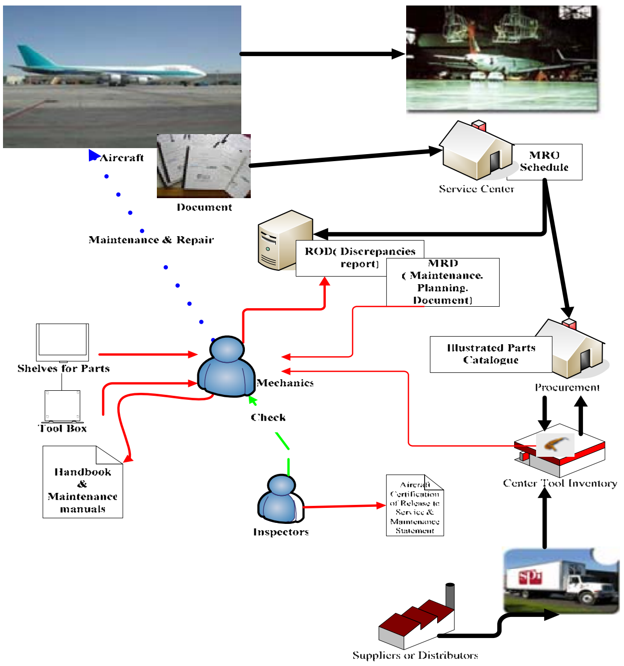

Figure 2 MRO Processes [1]

MRO is required every 650 flying hours, and it costs approximately 12% of total operation cost of an aircraft [1]. The opportunity cost of an idle aircraft is about US $ 23,000 per hour [1]. Therefore, the airline companies are searching for solution to decrease costs and increase the MRO efficiency and effectiveness. In [1][4], the authors propose architectures that build the Ubicomp environment to improve tool management and tool inventory management during MRO process by using RFID. The authors believe that this architecture will upgrade the MRO efficiency and maintenance accuracy. Not only academy, the aviation companies also perform RFID field test, like baggage tracking [11]. Boeing and Airbus had cooperated with FedEx to attach RFID tags in some aircraft parts, like onboard maintenance power. In 90-day test, all the RFID tags perform well. Boeing and FedEx expect that the RFID tags will be attached to all parts of aircraft in the future [2][3]. Delta Airline, working with Boeing, put RFID tags in components of engine. They look forward to the deployment of RFID throughout MRO process to provide better services [2][3]. Boeing and Airbus team up to set up requirements of implementing RFID and establish standards [10].

II. Motivation

We had reviewed many studies about using RFID to improve MRO. These studies all focus on issues of upgrade the level of MRO efficiency, but do not emphasize on the accuracy of MRO process [1][4]. In [1][4], the architecture aims to improve tool management and tool inventory by attaching RFID tags in tools. However, the proposed architecture cannot detect the possibilities that mechanics may skip standard maintenance procedures or miss some parts. We believe that the accurate MRO is more important than efficiency. Besides, [1] and [4] do not address the fake parts problem, which costs the aviation industry US $100 million each year. In our proposed architecture, we use the standard MRO procedure to sequence all replacing or repairing parts. By this means, it can hopefully ensure that mechanics follow the standard procedure to do their job and do not bypass any important step. We also introduce an approach to solve the problem of fake part, and it can be implemented in tags with limited computing power. Finally, to improve inspection process, we propose an electronic and credible certificated process. It provides the legitimate audit trails.

III. Architecture

III. 1 Tag

The tag stores two types of data:

(1) Unique Identifier (Tag_ID): This attribute follows EPCglobal standard and stores 96-bit electric product code.

(2) Manufacturer's Authentication ($MAC_{manufacturer}$(R)): The Manufacturer first generates a unique random number R for each tag. Before the product is shipped to the customers, the manufactures will encrypt R by using MAC with secret key of manufacturer and then store it inside the tag. The secret key is only possessed by the manufacturer.

Tag_ID	$MAC_{manufacturer}$ (R)
EPC	*********

Figure 3 Data Format for RFID Tag

Tag_ID	R	CustomerID	Key
Tag_ID^1	A1111111	Northwest	123456
Tag_ID^2	B2222222	Northwest	123456
Tag_ID^3	C3333333	Northwest	123456

Figure 4 Database of Manufacturer

The Manufacturer stores each tag's EPC, R, customerID, and key in database.

III. 2 Before MRO

After the aviation companies received the parts they purchased, they will perform the following actions:

(1) Authenticate Purchased Parts: As illustrated in Figure 5, the companies start to authenticate these parts after the purchased parts arrived. MRO server is responsible for recording tag unique identifier (Tag_ID), which is generated by product manufacturers. The reader collects the Tag_ID and $MAC_{manufacturer}$ (R) and then sends to MRO server. The MRO server will wrap up these collected data along with CustomerID and send to the manufacturer. After the manufacturer received these transmitted data, it uses the key (manufacturer) to examine the received $MAC_{manufacturer}$ (R).

It also checks CustomerID to make sure that the aviation company does not receive the wrong parts. Finally the manufactures send all information, including the production date and expiration date, back to the aviation company if the whole authentication result is O.K.

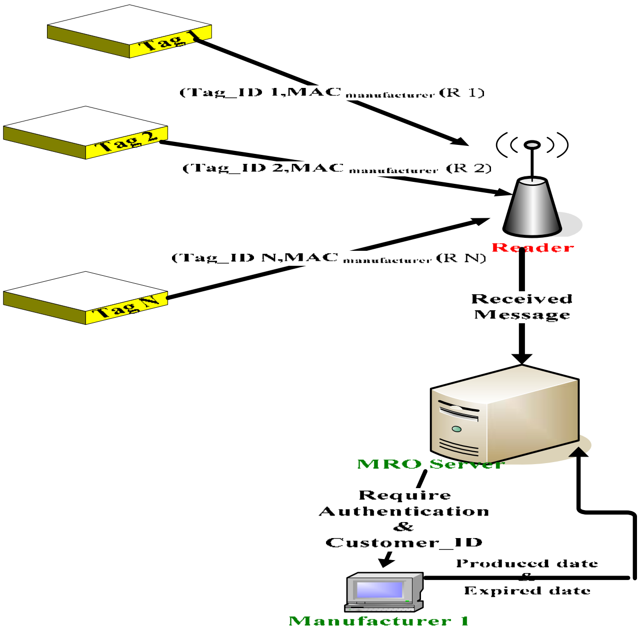

Figure 5 Procedure of Parts Authentication

(2) Prepare the MRO procedure: After completing the authentication process, MRO server records all corresponding information, including the production date and expiration date. The MRO server also arranges the MRO schedule, sets up standard maintenance procedure, and provides on-line technical supports to mechanics. As for MRO scheduling, the MRO server will choose the appropriate parts for some standard MRO procedure based on information of the production and expiration date. After the schedule is arranged, the sequence of usage is also set up according to the standard MRO procedure. For example, if the part of Tag_ID[1] needs to be replaced first and parts of Tag_ID[2] and Tag_ID[3] should be installed simultaneously later according to standard maintenance procedure. Then the MRO server will monitor if the parts are used based on this sequence by using RFID reader.

III. 3 During MRO Process

As Figure 6 illustrates, the mechanics carry the mobile device, like smart phone, PDA, or notebook during MRO process. The mobile device can communicate with MRO server wirelessly by using 802.11. It is also equipped with a RFID reader to read tag information. Before the mechanics start working, the mobile device downloads the MRO schedule. Besides, the mobile device also downloads the assembly instruction from MRO server. When the mechanics begin performing MRO process, he or she scans the parts based on the sequence of usage. Meanwhile, the mobile device will compare the scanning sequence of tags with predefined assembly order, which is stored in device. If the comparison result is not correct, the mobile device informs the mechanics that some parts are missed or the assembly sequence is wrong. This action will make sure: (1) all parts are used according to the planned schedule and designed sequence. (2) no part is missed.

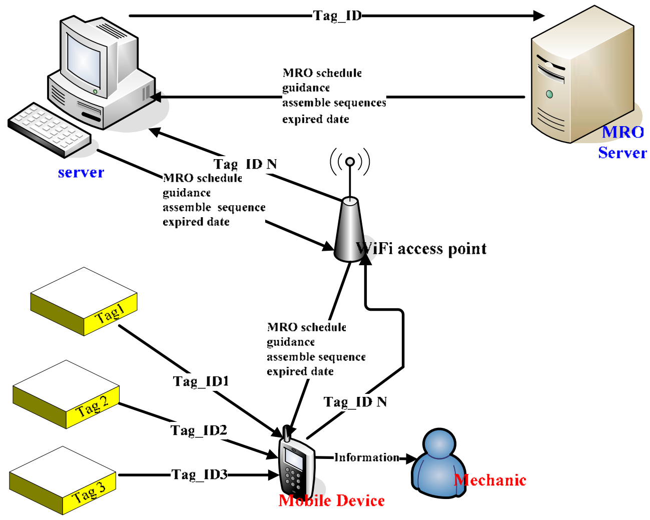

Figure 6 Process of Using Mobile Device to Run MRO

III. 4 Inspection

After the MRO is finished, the aircraft must be inspected before taking off. An inspector will do so by reading tags and checking MRO schedule and sequence with mobile device. If everything is O.K., the inspector uses mobile device to generate the e-document of "Aircraft Certification of Release to Service & Maintenance Statement", and e-signs this statement. Then this electronic document will be sent to the database of authority along with the corresponding digital signature.

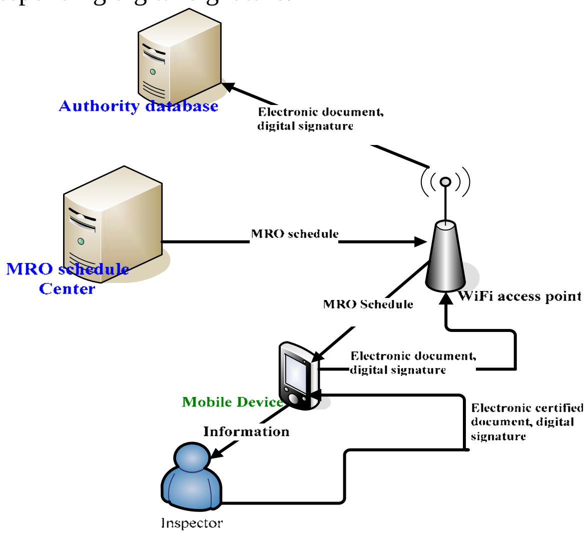

Figure 7 Process of Storing e-Document and Issuing Digital Signature

IV. Conclusions and Future Works

We believe that this architecture has the following benefits:

(1) Prevent Fake Parts: In this architecture, a tag will store MAC data for self-authentication and the secret key is only kept by manufacturer. This enhances the ability of fake-resistance.

(2) Decline Man-made Error: The maintenance schedule and sequence is stored in MRO server. When the mechanic performs MRO process, it is easy for him/her to check whether he/she uses the assigned parts and follows the predefined assembly sequence. It can decrease or eliminate human errors that may occur during MRO.

(3) Fast and Credible Inspection: The inspector issues electronic document of "Aircraft Certification of Release to Service & Maintenance Statement" with digital signature after completing the inspection. It provides an effective and efficient certification approach.

In conclusion, this architecture not only can be deployed into MRO process of aviation industry, but also is extended to other areas such as vehicle industry or delicate apparatus assembly line, in which the procedure accuracy is a critical concern.

References

[1] Matthias Lampe, Martin Strassner, and Elgar Fleisch," A Ubiquitous Computing Environment for Aircraft Maintenance", ACM Symposium on Applied Computing, Nicosia, Cyprus, March 14-17, 2004, 1586–1592.

[2] Aviation Today, "RFID: The Future of MRO Supply Chain Management",http://www.aviationtoday.com/cgi/am/showmag.cgi?pub=am&mon=0904&file=rfidthe.htm, September 1, 2004.

[3] Robert W. Moorman, "Airbus and Boeing are driving adoption of RFID in the Aviation Supply Chain", Air Transport World, June 2005, 52-55.

[4] Matthias Lampe and Martin Strassner, "The Potential of RFID for Moveable Asset Management", Workshop on Ubiquitous Commerce at Ubicomp, Seattle, October 2003.

[5] Elagr Fleisch, "Business Perspective on Ubiquitous Computing", M-Lab Working Paper No.4 Version1.0, November 30, 2001, 83-87.

[6] "Radio Frequency Identification (RFID) White Paper", November 16, 2001, Accenture.

[7] "Radio Frequency Identification (RFID) Strategy Paper, January 1, 2004, Comter

[8] Shepard, "RFID, Radio Frequency Identification", 42-74.

[9] "How much memory can a tag have?" http://www.zebra.com

[10]"Aviation Industry Forums", RFID Journal, http://www.rfidjournal.com /article/articleview/1428/1/1/

[11]"Federal Aviation Administration", http://history.nasa.gov/presrep99 /pages/faa.html

[12] Damith C. Ranasingle, Daniel W. Engels, and Peter H. Cole, " Low-Cost RFID Systems: Confronting Security and Privacy", September 2004, Auto-ID Labs Research Workshop.