Comparison between Reading Barcode and UHF RFID Wristband for Attending the Rehearsal Sessions and Graduation Ceremony*
การเปรียบเทียบผลการอ่านรหัสแท่งกับอาร์เอฟไอดีย่านความถี่สูงยิ่งในสายรัดข้อมือบัณฑิตสำหรับการซ้อมและรับพระราชทานปริญญาบัตร

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Abstract

In the recent years, the most valuable applications of passive ultra-high-frequency radio frequency identification (RFID UHF) tags are low cost and long recognition distance. The RFID UHF technology is very potential technology suitable for various areas of applications. This research is comparative study between reading 2D barcode on alumni's card and UHF RFID wristband for identifying the graduates. This application manages to identify and verify graduates for attending the rehearsal sessions and Maejo University's graduation ceremony in 2016. It aims to increase efficiency for identification and verification. The designed system has using barcode reader and two the distinctive range of RFID readers: (1) for short distance, the policy verify the wristband tags

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by using UHF RFID desktop reader reading one by one attached to the computer via USB port or the smart phone via USB On-The-Go (OTG) for typing alphabets like computer keyboard and (2) for long distance, the policy verify the wristband tag with UHF RFID fixed reader reading many persons at the same time attached to the computer via RS232 port with connection to Microsoft SQL server database directly. The results showed that the duration time to read the student ID of the three methods is very different. Furthermore using UHF RFID readers take 2x faster than barcode reader. In the future work we will develop graduates tracking system.

Keywords

Graduation Ceremony, Barcode Reader, UHF RFID Wristband, RFID Desktop Reader, RFID Fixed Reader

บทคัดย่อ

เนื่องจากแท็กอาร์เอฟไอดีและอุปกรณ์มีราคาต่ำลงทำให้การประยุกต์ใช้อาร์เอฟไอดีย่านความถี่สูงยิ่ง (RFID UHF) มีการใช้งานอย่างกว้างขวางเทคโนโลยีการอ่านแท็กมีระยะห่างไกลขึ้น งานวิจัยได้เปรียบเทียบผลการอ่านรหัสแท่งบนบัตรกับการใช้อาร์เอฟไอดีย่านความถี่สูงยิ่งในสายรัดข้อมือ เพื่อตรวจสอบและระบุตัวตนของบัณฑิตการที่เข้ารับพระราชทานปริญญาบัตร ระบบนี้ช่วยในการระบุตัวตนและตรวจสอบบัณฑิตสำหรับการเข้าร่วมการฝึกซ้อมและพิธีพระราชทานปริญญาบัตรของมหาวิทยาลัยแม่โจ้ซึ่งจัดขึ้นประจำ ปี พ.ศ. 2559 สำหรับระบบที่ออกแบบประกอบด้วยเครื่องอ่านรหัสแท่งบนบัตรสมาชิกของสมาคมศิษย์เก่าโดยบันทึกข้อมูลผ่านเว็บแอพพลิเคชั่น การใช้แท็กอาร์เอฟไอดีในสายรัดข้อมือกับเครื่องอ่านอาร์เอฟไอดีย่านความถี่สูงยิ่ง 2 รูปแบบคือ (1) อ่านระยะใกล้ใช้เครื่องอ่านเดสก์ทอปอ่านทีละคนโดยเชื่อมต่อกับคอมพิวเตอร์ผ่านทางพอร์ตยูเอสบีหรือสมาร์ทโฟนผ่านทางยูเอสบี On-The-Go (OTG) บันทึกข้อมูลผ่านเว็บแอพพลิเคชั่นด้วยการส่งรหัสประจำตัวนักศึกษาแทนการป้อนของแป้นพิมพ์(2)อ่านระยะไกลใช้เครื่องอ่านแบบจานอ่านได้หลายคนพร้อมกันในเวลาเดียวกันโดยเชื่อมต่อกับ เครื่องคอมพิวเตอร์ผ่านทางพอร์ต RS232 บันทึกข้อมูลเข้าสู่ฐานข้อมูล Microsoft SQL Server โดยตรงจากการใช้งานจริงด้วยการบันทึกเวลาเริ่มต้นและสิ้นสุดแต่ละวิธี ผลการเปรียบเทียบพบว่า ระยะเวลาในการอ่านรหัสประจำตัวนักศึกษาทั้ง 3 รูปแบบมีความแตกต่างกันอย่างมาก โดยเฉพาะการใช้เครื่องอ่านอาร์เอฟไอดีจะใช้เวลาอ่านเสร็จรวดเร็วกว่าประมาณ 2 เท่า ระบบนี้มีเป้าหมายเพิ่มประสิทธิภาพในการระบุตัวตนและยืนยันการรายงานตัว ตรวจนับจำนวนที่เข้ามาฝึกซ้อมแต่ละรอบจนถึงวันรับปริญญาจริง สำหรับการพัฒนาในอนาคตจะพัฒนาระบบการติดตามระบุพิกัดตำแหน่งของบัณฑิตด้วยอาร์เอฟไอดีต่อไป

คำสำคัญ

พิธีพระราชทานปริญญาบัตร เครื่องอ่านรหัสแท่ง อาร์เอฟไอดีย่านความถี่สูงยิ่งในสายรัดข้อมือ เครื่องอ่านอาร์เอฟไอดีแบบเดสก์ทอป เครื่องอ่านอาร์เอฟไอดีแบบจาน

Introduction

RFID, stands for radio frequency identification, is the use of radio waves and electromagnetic fields to automatically read information stored on tags which are attached to objects for identification (Radio frequency Identification - Wikipedia, 2016). Its technology involves a tag attached to an object which identifies and tracks the object via electromagnetic waves to transfer identification data at radio frequencies by automatic system that integrates between information technology and electrical engineering.

A RFID system can be made up of three components: readers, tags and application software. A typical passive ultra-high-frequency (UHF) RFID system consists of a reader system and microchip-controlled tag attached to the object to be identified. The identification data of an object is stored in the chip. If the tag is located inside the reader's interrogation region it gets enough energy from the reader's electromagnetic fields to activate the chip, which then modulates the identification data to the carrier signal and back scatters it to the reader (Finkenzeller, K., 2010 ; Kataja, , Ukkonen, Schaffrath, Sydanheimo&Kivikoski, 2006). It enables identification from a long distance unlike earlier barcodes technology. Thailand's National Telecommunications Commission established regulations for the use of UHF RFID area that became effective on 20 January 2006. Frequencies to be used are between 920-925 MHz. The technique to be used is frequency hopping spread spectrum (FHSS) with a maximum power output effective isotropic radiated power (EIRP) of 4 Watts. Licensing is required for outputs above 0.5 Watts (Radio Frequency Identification (RFID) in Thailand, 1977). RFID system enclosures reader device, tag, antenna, middle ware, and application software. The technology of UHF RFID has been various fields of applications e.g., vehicle management, car park management, material management, inventory control, manufacturing automation etc. RFID tags are the most valuable applications due to its inexpensive and long recognition distance. For example, the passive UHF RFID Tag was designed for automatic vehicle identification in Hong Kong using detachable windshield tag and thin-wire vehicle headlamp tag. The proposed detachable windshield tag design allows drivers to switch to an appropriate card, with particular unique tag ID, for identification, which is ideal for fleet management for example. On the other hand, for the proposed thin-wire vehicle headlamp tag, apart from minimizing blocking of light, the thin-wire

antenna is tried to realize an inconspicuous design. Moreover, measurements show that both designs can achieve read range of over 8m in the global RFID UHF band of 860-960 MHz (ISO-18000 6C). It is believe that such UHF vehicle tags designs are favorable to the electronic toll collection system in the near future (Mak, 2017).

The advantages of RFID are read RFID tags from a greater distance than barcodes; do not need to be positioned in a line of sight with the scanner, read at a faster rate than barcodes. RFID tags can be read at the same time, work within much greater distances, carry large data storage e.g., product maintenance, shipping histories, and expiry dates; which can all be programmed to the tag, once these are setup; it can be run with minimal human participation, and be more reusable and rugged as they are protected by a plastic cover. However, RFID is a great technology with various features still to process development and performance tuning. Therefore, it is difficult to manage RFID system to identify and verify the walking of graduates into the rows of ceremony place. Thus, this research proposes the new concept of applying the passive UHF RFID wristband tags for attending the rehearsal sessions and university's graduation ceremony.

Research Objectives

The following are the three main research objectives of this study;

1. To analyze and design RFID system to identify and verify the walking of graduates into the rows of ceremony place for attending the rehearsal sessions and Maejo University's graduation ceremony in 2016.

2. To develop management information system for attending the rehearsal sessions and Maejo University's graduation ceremony in 2016.

3. To compare between reading 2D barcode on alumni's card and UHF RFID wristband for identifying the graduates.

Research Methodology

To serve the main objectives of the study, mixed methodology was used to conduct and to analyze data in five phases as follows;

1. Phase 1: RFID study

In this phase, researchers prepared the primary information necessary for the RFID design corresponding to the issues and needs. Publications relevant to RFID were gathered and the information obtained from them was applied as primary best practices. The relevant information was obtained and categorized by the RFID technology.

The RFID is a technology that automatically read information stored on tags to be wireless transferred between the reader and the tag. It has three parts: reader, tags, and application software. Generally, a reader device, gather information from tags, has two types: desktop reader that reading one by one and fixed reader reading many tags at the same time. The internal reader can be made up of three components: (1) an antenna, (2) a interrogator or reader with a decoder to interpret the data to computer, and (3) a transponder or tag, device for receiving a radio signal and automatically transmitting a different signal. RFID how to work as shown in Fig. 1.

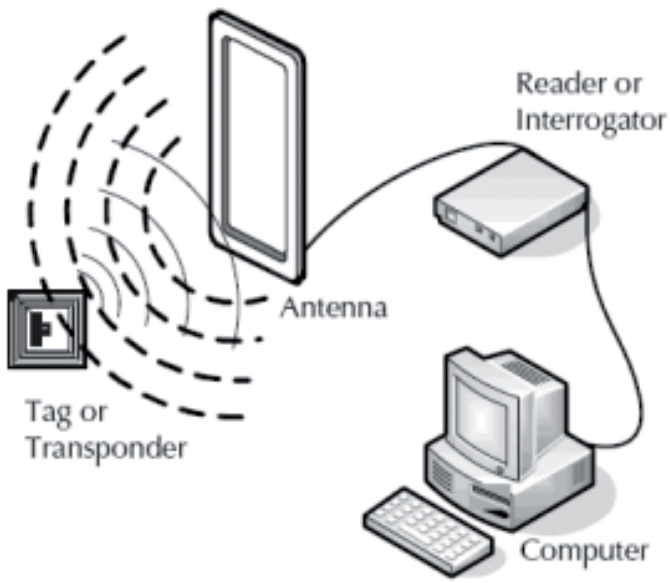

Fig. 1. RFID how to work

Sources: How does a RFID system work?, 2016

The passive tags and active tags are different technologies that passive RFID systems use tags with no internal power source and instead are powered from a RFID reader by the electromagnetic energy transmitted, whereas active RFID tags are battery powered, so they can give a very strong signal back, allowing readers to identify the tag easily even at large distances, commonly used as “beacons” to accurately track the real-time location of assets or in high-speed environments such as tolling. Passive tags provide a much shorter read range than active tags, but they are also much cheaper. Thus, they are used for many applications such as supply chain management, access control, livestock tracking, file tracking, race timing, health care, library, and more.

A RFID tags can be offered in different frequencies: microwave frequency 2.45 to 5.8 GHz band, ultra-high-frequency (UHF) 433 MHZ and 860 to 956 MHz bands, high-frequency (HF) 13.56 MHz, and low-frequency (LF) 125 to 134 KHz band (RFID Frequencies What you need to know about them, 2016). A passive UHF RFID tags work according to the principles of the electromagnetic coupling in the UHF ISM band. ISO 18000-6:2010 standards defines the air interface for RFID devices operating in the 860-960 MHz industrial, scientific, and medical (ISM) band used in item management. The 900-MHz ISM band is a very common frequency range for UHF RFID readers and tags, ISO18000-6B/6C standard technology can be read more than one meter (ISO/IEC 18000-6, 2010). The ISO18000-6B tags storage has only data area that can be written by user, start 8 to 233 bits, 1-4 words length. While, ISO 18000-6C protocol, well-known as electronic product code (EPC) or EPCClass 1 Gen 2 or for short EPC Gen 2. The ISO 18000-6C tags storage unit divided into four areas as shown in Fig. 2.

1. Password area, 32 bits visiting password and 32 bits killing password, can be readable and writable.

2. EPC area: the area to store EPC number, currently can store maximal 96 bits of EPC number. It can be readable and writable.

3.TID area: the area to store the tag identifier (TID) or ID number set by tag manufacturer; currently have 32 and 64 bits those two kinds of ID number. It can be only readable, but un-writable.

4. User area: vary from different manufacturers such as Impinj and NXP. Impinj's Gen 2 tags don't have user area. NXP's tags have 224 bits. It can be readable and writable.

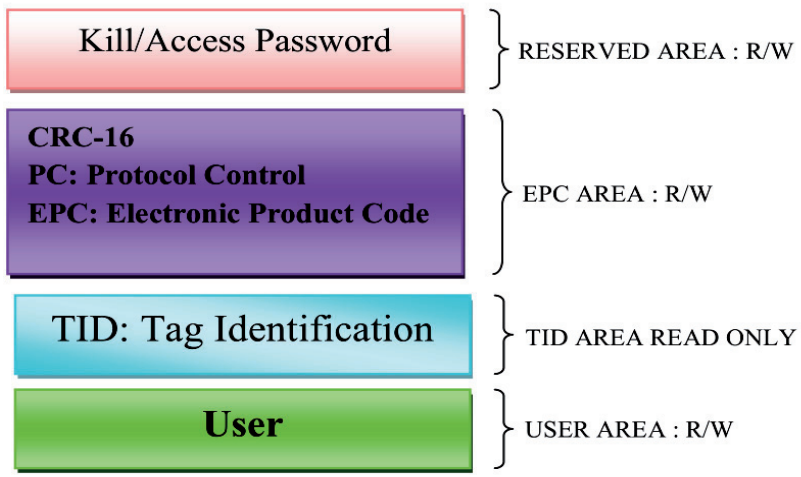

Fig. 2. The ISO 18000-6C tags storage unit

Deploying an RFID system necessitates multiple actors and many different components. Typically, installing a system requires basic hardware-including tag chips, tag antennas, readers, and reader antennas-as well as reader control and application software, and solution providers to put it all together. When all of these components come together, an infinite number of creative applications are possible (Creating an RFID Solution, 2016). In Thailand, UHF RFID readers and tags use ISO 18000-6 standard in the frequency range 920-925 MHz, 4W EIRR power, FHSS technique by readers about 3-5 meters. The UHF RFID wristband for this research is shown in Fig. 3. The UHF RFID desktop readers of this research have the internal antenna and USB connector operated at 920-925 MHz, as shown in Fig. 4. The UHF RFID fixed reader is exhibited in Fig. 5.

Fig. 3. The UHF RFID wristband tag.

Fig. 4. The UHF RFID desktop reader.

Fig. 5. The UHF RFID fixed reader.

2. Phase 2: Information Management System Development

In this phase, researchers submitted a newly developed two platforms; the web-based and windows-based system (Suriya, 2015);

2.1 The web-based graduation ceremony management system to use the UHF RFID desktop reader; USB port attracted the computer or the smart phone via USB On-The-Go (OTG). It is divided into sub-system. In this part, each system is elaborated to show how it works and its benefit.

2.1.2 Scan Code System: The graduates are scanned number ID from typing keyboard or barcode on alumni's card by barcode reader or wristband tags by UHF RFID desktop reader. The system manages to identify and verify graduates. The administrator will set up the rehearsal session's periods in the graduation ceremony.

2.1.2 Graduates List System: This system displays graduates list of each faculty: sequential number, number ID, name, major, degree, attendance status, and seat code. It shows seat map picture for graduate. The graduate details can be searched from putting number ID from typing keyboard or barcode on alumni's card by barcode reader or wristband tags by UHF RFID desktop reader.

2.1.3 Document Download System: The graduates can be download importance information about the graduation ceremony.

2.2 The windows-based system uses the UHF RFID fixed reader. The lower layer sub-system is configuration part on computer attracted to the UHF RFID fixed reader via RS232 port. The upper layer sub-system named application is directly connection to database management, as Microsoft SQL server. The system manages to identify and verify the graduates that display in the monitoring system. Many numbers ID of graduates are scanned into database at the same time, as shown in Fig. 6.

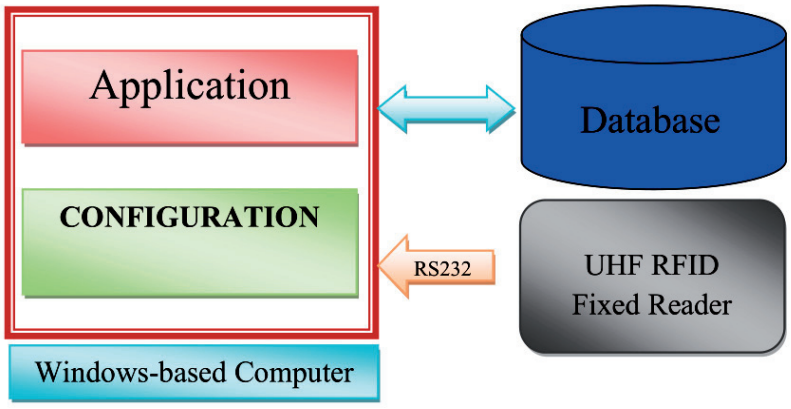

Fig. 6. System of UHF RFID fixed reader

3. Phase 3: Writing UHF RFID wristband tag

In this phase, researchers write UHF RFID wristband tag that the ISO 18000-6 standard is different between ISO 18000-6 type B and type C. The ISO 18000-6B tags storage has user's data area that can be written by user. However, ISO 18000-6C protocol uses EPC Class 1 Gen 2 that user must get ID number for customer's product from the standard organization as Table 1. Thus this research selected ISO 18000-6B to write UHF RFID wristband tag by UHF RFID desktop reader that can be readable and writable function.

Table 1.

ISO 18000-6B/6C Data area

Tag type	Data area	Data length (bit)
ISO18000-6C	EPC	96
	TID	64
	USER	512
ISO18000-6B	ID	-
	USER	220-223

The number ID of graduates is university student code that numeric 10 digits format. The writing tag has five steps:

3.1 Prepare graduates ID file that comma separated values named CSV Excel format and UHF RFID wristband tags as Fig. 7.

3.2 Take UHF USB desktop reader to write ISO 18000-6B tag that wristband tag by using the program of desktop reader. Tag ISO 18000-6B's user area can be written start 8 to 223 bits, data length 1-4 words. In Fig. 8 illustrates the read and write ISO 18000-6B/C tag program that run on windows platform. The user can choose to generate data to write or import data from standard file as Fig. 9. The user must define data length between 1 to 8 words to write number ID into wristband tag.

3.3 Click import data button and select student code file. Then the data is input to the list of data to write.

3.4 Click begin write tag button and touch tag on the face of desktop reader to write as Fig. 10.

3.5 Verify written wristband tags to read tags by UHF RFID desktop.

Fig. 7. UHF RFID wristband tag.

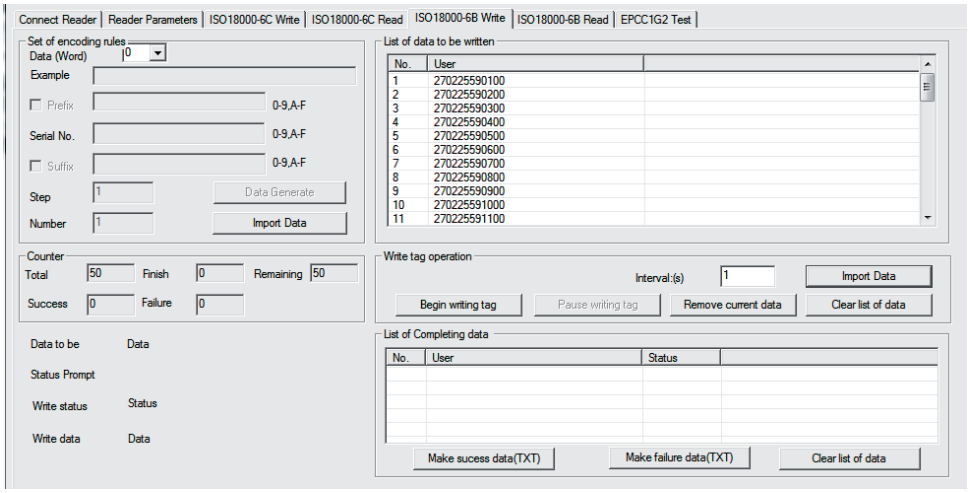

Fig. 8. To generate ID or import data into tag.

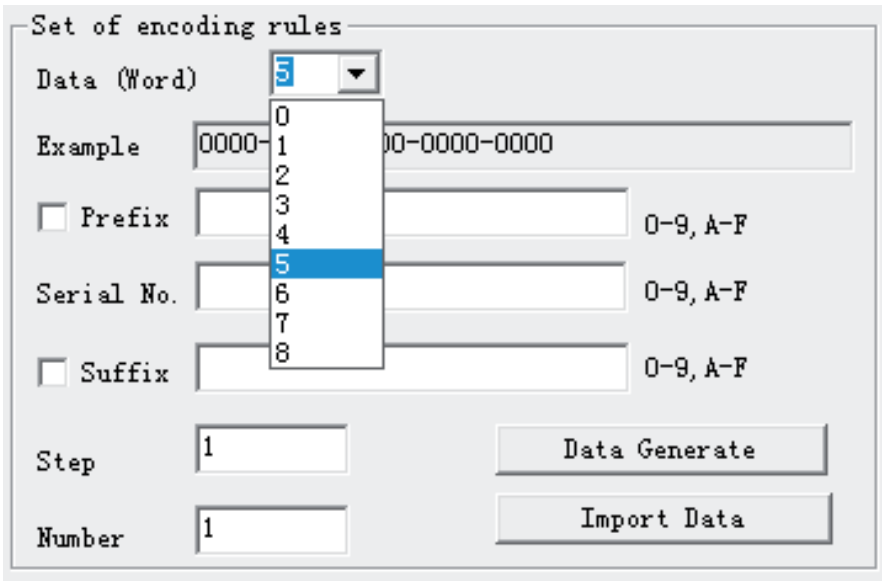

Fig. 9. To generate ID or import data into tag.

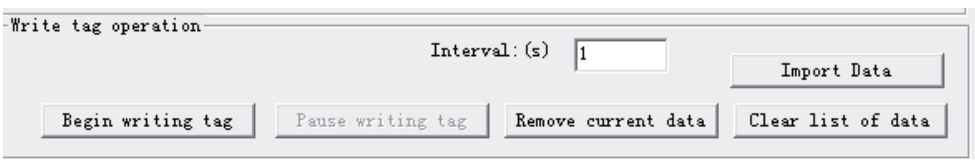

Fig. 10. Write tag operation.

Fig. 11. Write ID into wristband tag by UHF RFID desktop reader.

4. **Phase 4: UHF RFID wristband tag implementation**

In this phase, researchers implemented the graduation ceremony. In academic year 2016, the graduation ceremony was held in the Maejo University that managed five days; the three days for graduation registration and rehearsal sessions; the graduation ceremony in two days later. There were 3,762 graduates, 16 faculties, divided into two groups. First group, there are 1,886 graduates, 6 faculties e.g., school of graduate, faculty of business administration, Chumphon campus in southern of Thailand, faculty of science, faculty of animal science and technology, and Phrae campus in northern of Thailand. Second group, there were 1,876 graduates, 10 faculties e.g., faculty of agricultural production, faculty of liberal arts, school of administrative studies, faculty of economics, faculty of information and communication, school of tourism development, faculty of engineering and agro-industry, faculty of fisheries technology and aquatic resources, faculty of architecture and environmental design, and school of renewable energy as shown in Table 2.

Table 2.

Graduates by faculty in the graduation ceremony

No.	Faculty/School/Campus	Amount
1	School of Graduate	138
2	Faculty of Business Administration	726
3	Chumphon campus	102
4	Faculty of Science	289
5	Faculty of Animal Science and Technology	164
6	Phrae campus	467
7	Faculty of Agricultural Production	572
8	Faculty of Liberal Arts	41
9	School of Administrative Studies	257
10	Faculty of Economics	337
11	Faculty of Information and Communication	34
12	School of Tourism Development	182
13	Faculty of Engineering and Agro-Industry	207
14	Faculty of Fisheries Technology and Aquatic Resources	79
15	Faculty of Architecture and Environmental Design	81
16	School of Renewable Energy	86
	Total	3,762

The first day, the graduates went to registration's place to get UHF RFID wristband tags, alumni's card with ID barcode, and more. They were scanned wristband tag by UHF RFID desktop reader for their identification. The second day, the graduation rehearsals was scanned by barcode reader from their alumni's card. Then the graduation rehearsals and ceremony were held five times. They were identified and verified to scan UHF RFID wristband tag to search graduate's information, attendance time check, and seat management in ceremony’s place as shown in Table 3.

Table 3.

Identify and verify graduates schedule by group

Day	Period	List	Group 1	Group 2
1	Morning	Registration, Get wristband tag and more	X	X
	Afternoon	Rehearsal Session I: scan barcode from card	X	X
2	All day	Rehearsal Session II; RFID	X	X
3	Morning	Rehearsal Session III; Scan RFID for group 1	X	
	Afternoon	Rehearsal Session IV; Scan RFID for group. 2		X
4	Afternoon	Graduation Ceremony; Scan RFIDforgroup.1	X	
5	Afternoon	Graduation Ceremony; Scan RFID for group.2		X

5. Phase 5: System deployment and evaluation

In this phase, researchers evaluated the graduation ceremony management system that was deployed for the graduates attended rehearsal sessions and graduation ceremony to identify and verify that date-time verified data was recorded in the database, and changed attendance status. The graduation rehearsals were scanned wristband tag using the UHF RFID fixed and desktop reader as shown in Fig. 12.

Fig. 12. Scanning wristband tag using UHF RFID fixed and desktop reader

Results and Discussion

To perform efficiency of the UHF RFID wristband system to identify and verify 3,762 graduates, 16 faculties. The group 1, there were 1,888 graduates, 6 faculties as shown in Table 4. The group 2, there were 1,876 graduates, 10 faculties as shown in Table 5.

Table 4.

Barcode and RFID reader in Group 1 (N=1,888).

Kind of reader	Start scan	Stop scan	Duration (min.)	Speed (persons/min)
Barcode	7:00am	7:47am	47	40.13
RFID day 1	13:00pm	13:24pm	24	78.58
RFID day 2	6:04am	6:23am	19	99.26
RFID day 3	10:00am	10:23am	23	82.00
RFID Avg.			**22**	**85.73**

Table 5.

Barcode and RFID Reader in Group 2 (N=1,876).

Kind of reader	Start scan	Stop scan	Duration (min.)	Speed (persons/min)
Barcode	10:00am	10:56am	56	33.50
RFID day 1	13:00pm	13:37pm	37	50.70
RFID day 2	11:20am	12:41pm	21	89.33
RFID day 3	10:07am	10:42am	35	53.60
RFID Avg.			**31**	**60.52**

The results of graduation ceremony management system were applied to identify and verify attendances by duration time and speed measurement. The two groups' difference was speed of RFID faster than barcode reader.

Conclusion and future work

The comparison between usable barcode 2D, UHF RFID fixed and desktop reader with passive UHF RFID wristband tags written ISO 18000-6B standard has been designed, developed, invented, and implemented for attending the rehearsal sessions and university's graduation ceremony. The result of implementation was speed of UHF RFID faster than barcode reader. This RFID system can support many aspects: economic time, graduates' satisfaction to RFID technology, and innovation. This system solution was effectiveness and appropriation in the graduation rehearsal sessions and ceremony (Sitti, 2016). However, this system is more than enough for our application. In the future work we will compare between the speed of fixed and desktop reader, and develop graduates tracking system.

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