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Radio Frequency Identification (RFID) Based Car Parking System

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***Abstract*— Radio Frequency Identification (RFID) technology is widely used in various applications such as attendance system, tracking system, monitoring system or parking system. Currently, the existing parking system used manual entrance through security guard to access the premise. Therefore, the company need to hire security guard to monitor the premise. In addition, the security guards need to monitor all movement of vehicle or person that enter or leave the premise. As a result, unauthorized vehicle or person can easily access the building. To address this problem, we proposed a parking system using RFID technology that can monitor vehicle's movement that enter or leave the specific area or place by scanning the RFID tag. The potential benefit is it can improve security for both security guards and users. Besides that, this parking system can facilitate access control for users and improve traffic flow during peaks period. There are five modules in the proposed parking systems which are user registration, vehicle registration, RFID tag, staff and report generation.**

***Keywords*— Radio Frequency Identification (RFID), RFID tags, parking system.**

I. INTRODUCTION

Various technologies have been introduced with the aim of facilitating the user in daily life. This may indirectly improve the productivity and efficiency in solving several matters. Radio Frequency Identification (RFID) is a wireless communication technology that able to uniquely identify tagged objects or people. RFID systems have been widely used in many application, such as inventory control, product tracking through manufacturing and assembly, parking lot access and control, container or pallet tracking, Identification (ID) badges and access control, equipment or personnel tracking in hospitals and others [1][2][4][12].

RFID use the electromagnetic fields to transfer data, for the purposes of automatically identifying and tracking tags attached to objects. RFID technology is applied in the Intelligent Transportation Systems (ITS) to monitor the traffic flow and control system for parking. The case study for this project was conducted at Fujitsu, Parit Raja. Fujitsu did not provide any parking system for their staff. Therefore, staffs have to park their vehicle at their own risk. Besides, this will not ensure that only the authorized person can access the premise. Thus, the security guard plays an important role to make sure only authorized person can access the premise. They need to monitor vehicles or persons movement entering or leaving the premise. As a result, we proposed the parking system using RFID technology to overcome these problems.

Our major contributions are summarized as follows:

1. to design a parking system for Fujitsu based on Radio Frequency Identification (RFID) technology.
2. to develop a parking system that can monitor vehicle that enter or leaving the premise.
3. to evaluate the proposed parking system in terms of system functionality and usability testing.

The rest of the paper is organized as follows: Section II describes the related work on parking system using RFID. Section III presents the parking system methodology that is Object-Oriented Software Development (OOSD). Section IV discussed the development and implementation of parking system for Fujitsu, Parit Raja. Finally, Section V concludes the overall production results for the RFID based car parking system

II. RELATED WORKS

This section gives review about RFID history, standard, architecture, technical specification and related work on car parking system.

A. RFID History

RFID technology is an emerging trend in many industries worldwide over these decades. Table 1 shows the history of RFID technology over decades [3].

TABLE I
THE DECADES OF RFID [3]

Decade	Event
1940–1950	Radar refined and used major World War II development effort. RFID invented in 1948
1950–1960	Early explorations of RFID technology, laboratory experiments
1960–1970	Development of the theory of RFID. Start of applications field trials
1970–1980	Explosion of RFID development. Tests of RFID accelerate. Very early adopter implementations of RFID
1980–1990	Commercial applications of RFID enter mainstream
1990–2000	Emergence of standards. RFID widely deployed RFID becomes a part of everyday life
2000–now	RFID explosion continues

B. RFID Standards

Table 2 shows RFID Standardization in International Standard Organization (ISO) based on group, general title and ISO standard [5]. As RFID evolves, standards are showing an interest between cost and security. There are various tag types are commercially available, including passive, semi passive, active, semi active, Lower Frequency (LF), High Frequency (HF), Ultra High Frequency (UHF), microwave, onboard sensors, ruggedized housings and implantable.

TABLE
RFID'S ISO [5]

Group	General Title	ISO Standard
Sub Group 1	Data Protocol: Application Interface Data Protocol: Data Encoding Rules and Logical Memory Functions	ISO/IEC 15961 ISO/IEC 15962
Sub Group 2	Unique Identification for RF Tag	IOS/IEC 15963
Sub Group 3	Part1: Reference Architecture and Definition of Parameters Part2: Parameters for Air Interface Communications below 135kHz Part3: Parameters for Air Interface Communications at 13.56MHz Part4: Parameters for Air Interface Communications at 2.45GHz Part6: Parameters for Air Interface Communications at 860 - 960 MHz Part7: Parameters for Air Interface Communications at 433MHz	ISO/IEC 18000-1 ISO/IEC 18000-2 ISO/IEC 18000-3 ISO/IEC 18000-4 ISO/IEC 18000-6 ISO/IEC 18000-7
Application Requirement Profile (ISO/IEC TR 18000)	Implementation Guidelines – Part1: RFID- Enabled Labels Implementation Guidelines – Part2: Recyclability of RF Tags Implementation Guidelines – Part3: RFID Reader/Antenna Installation	ISO/IEC 24729-1 ISO/IEC 24729-2 ISO/IEC 24729-3

C. RFID System Infrastructure

RFID system infrastructure consists of three typical components, which are RFID tags, RFID readers, and a database that stores RFID data transferring between reader and tags as shown in Figure 1 [7]

1) RFID Tags

RFID tags contain two major parts which are integrated circuit and antenna. The integrated circuit is a microprocessor chip whereas the antenna is responsible for defining the reading range of the tag RFID tag is activated to be read and written by the emission of radio signals from antenna.

- *Active RFID Tags:* Active RFID tags have its own power source and transmitter that enable the tag to broadcast its signal. Active tags are capable to read longer ranges (100 meters or more) and have greater memory capacities (128kb). To achieve a huge read range and larger memory, it generates a greater power supply. Active tags usually are powered by a long life battery.

Passive RFID Tags: Passive RFID tags did not have internal power source. Passive tags consist of microchip and antenna. Both microchip and antenna commonly referred as RFID inlay. Passive tags need to wait for interrogating signal from RFID reader. Thus, the antenna draws energy from the electromagnetic waves. Once the microchip powered, it transmit a signal.

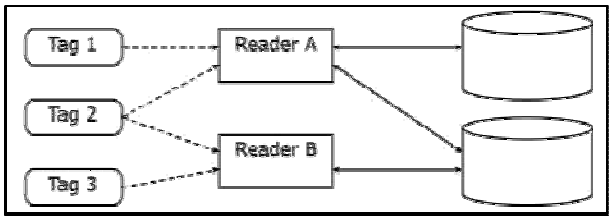

Fig 1. Components of RFID system [7]

Table 3 shows the comparison between active RFID and passive RFID tags based on its power, required signal strength, communication range, range data storage, cost and applications [8].

TABLE 3
COMPARISON OF RFID TAGS [8]

Description	Active RFID	Passive RFID
Power	Have own power source	No internal power source
Required Signal Strength	Low	High
Communication Range	Long range (100m+)	Short range (3m)
Range Data Storage	Large read/write data (128kb)	Small read/write data (128b)
Cost Applications	Expensive Auto Manufacturing, asset tracking	Inexpensive Electronic tolls, item Level tracking

2) RFID Reader

The RFID reader is an electronic device which includes two basic parts: an antenna and a transceiver. The antenna is designed to allow the open communication between the tags, whilst the transceiver is responsible for acquiring the RFID data. Moreover, the RFID reader has a function of reading data from RFID tag and writing data to the RFID tag.

3) RFID Database

RFID databases associate tag-identifying data with arbitrary records. These records may contain product information, tracking logs, sales data, or expiration dates. Independent databases may be built throughout a supply chain by unrelated users, or may be integrated in a centralized or federated database system.

D. RFID Frequency Bands

RFID tags fall into three regions in respect to frequency: Lower Frequency (LF), High Frequency (HF) and Ultra High Frequency (UHF). Table 4 shows the comparison between the RFID frequencies [9].

TABLE 4
RFID FREQUENCIES [9]

Description	LF	HF	UHF
Frequency Range	125 kHz – 134.2 kHz	13.56 MHz	860 MHz - 960 MHz
Operating Range	Less than 0.5m	1m	3-6m
Applications	Animal Tags, Vehicles immobilisers	Item Tracking, Access Control	Box and Pallet Tracking, Logistics
Benefits	Inexpensive, good penetration (non-metal)	Medium read range, medium speed	Long range, high speed
Disadvantages	Short read range, slow speed	Expensive system	Need line of sight to read

Initially, we consider selecting passive RFID tag for our proposed system because it is cheaper and affordable. Therefore, the communication range is 3 meter and the range of data storage is 128b. The RFID based car parking system use HF that has higher transmission rates and ranges than LF. This parking system has similar frequency to Smart tags which work at 13.56MHz.

We conducted an evaluation on the existing and proposed system. The findings from the study will be used to improve the proposed system. There are two existing systems that have been considered which are Park-A-Lot [11] and Intelligent Parking System [6]. The comparison between the existing system and the proposed system is shown in Table 5

TABLE 5
COMPARISON BETWEEN EXISTING SYSTEM WITH PROPOSED SYSTEM

Details	Park-A-Lot[11]	Intelligent Parking System[6]	RFID Based Parking System
User friendly	Yes	Yes	Yes
Output display	Yes	Yes	Yes
Database record	Yes	No	Yes
Control functionality	No	No	Yes
Security	No	No	Yes
Technology use	Arduino	Ultrasonic sensor	RFID
Detection object	Vehicle	Vehicle	RFID tag on vehicle
Premise access	Everybody	Everybody	Authorized person only
Programming language	PHP	Java	Visual Basic

Our proposed RFID based parking system differs than other system in such a way that, we used RFID technology as a detection tools as compared to others. So, only authorized person have access to the promise. Moreover, we developed the proposed system using Visual Basic programming.

III. SYSTEM METHODOLOGY

The methodology used in this study is Object-Oriented Software Development (OOSD). Figure 2 shows seven phases of OOSD model. The seven phases are requirement specification phase, system analysis phase, system design phase, implementation phase, testing phase, deployment phase, maintenance phase [10].

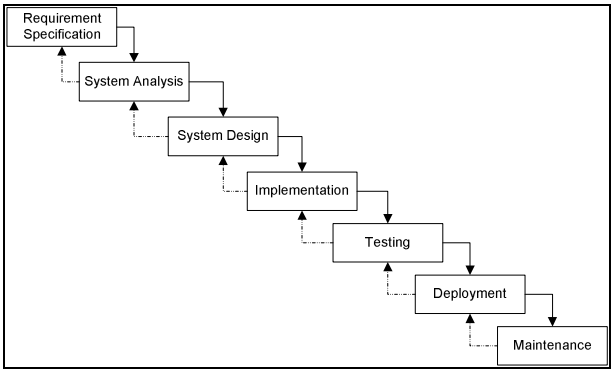

Fig 2. Object Oriented Software Development process [10]

Figure 3 shows the activity diagram for RFID based car parking system. First, admin need to login by using valid username and password before accessing the car parking system. The system will make sure either the input is valid or not. If not, the admin need to register again with the valid input. Then, admin can register new staff information, register staff's vehicle, scan tag ID, view staff's detail and view vehicle's information in the system. Moreover, the admin can view tag details, update staff and vehicle's detail and generate report.

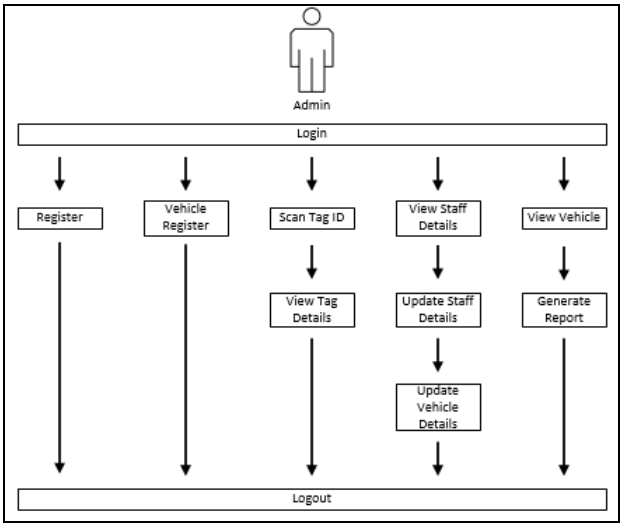

Fig 3. Activity Diagram RFID based car parking system

IV. Performance Analysis

This section focuses on the implementation of the actual system. There are two main parts which are system design and implementation and testing.

A. *System Design*

The system interface is designed to suit the needs and requirements of the users which are users friendly and not too complex. This system is developed using Visual Basic and OOSD methodology.

1) *Login interface*

Figure 4 shows the admin login interface for the RFID based car parking system. The admin needs to login using valid username and password before accessing the system.

Fig 4. Login Interface

2) *RFID based Parking System Main Page*

Figure 5 shows the main page of RFID based car parking system for Fujitsu. This page shows all admin modules such as registration module, vehicle registration module, RFID tag module, staff module and report module.

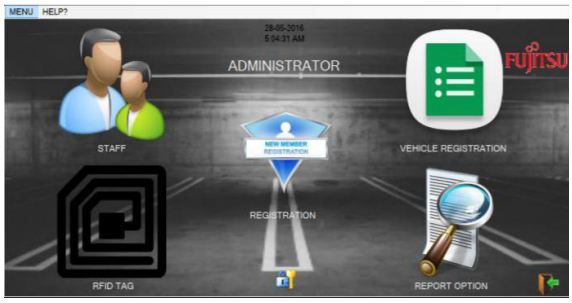

Fig 5. Admin main page

3) *Registration Module*

Figure 6 shows the registration form for new user. User need to register before accessing the RFID car parking system. So, user have to fill up personal details in the registration form such as full name, identification number, staff ID, email address, address, phone number, username, password, security question and security answer.

4) *Vehicle Registration Module*

In order to access the premise, all vehicles should be registered into the system. Figure 7 shows the vehicle registration form that user need to fill up such as name, identification number, type of user, type of vehicle, plat number, model, vehicle colour and tag ID.

5) *RFID Tag Interface*

Figure 8 shows the RFID tag interface that consists of Scan Tag ID and Show Tag Details. The Scan tag ID module allow admin to scan users' RFID tag that show the RFID's tag owner name, Tag ID, time in, time out and date as shown in Figure 9.

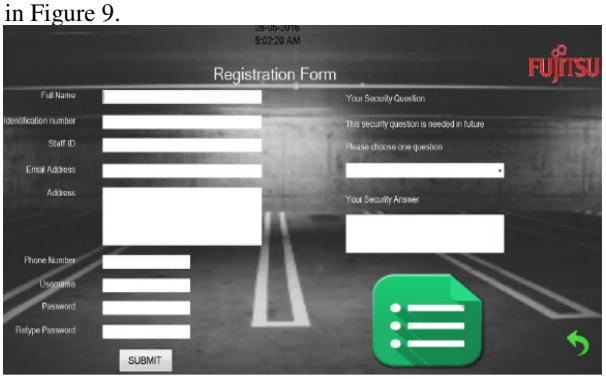

Fig 6. Registration form

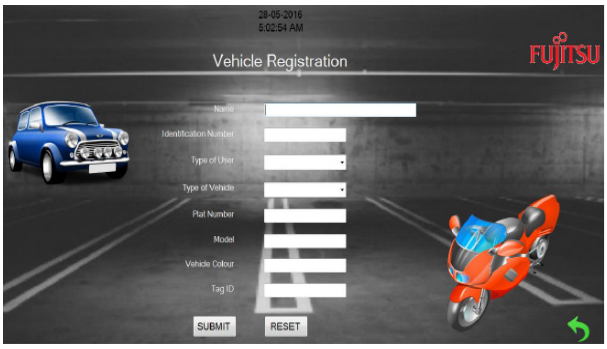

Fig 7. Vehicle Registration form

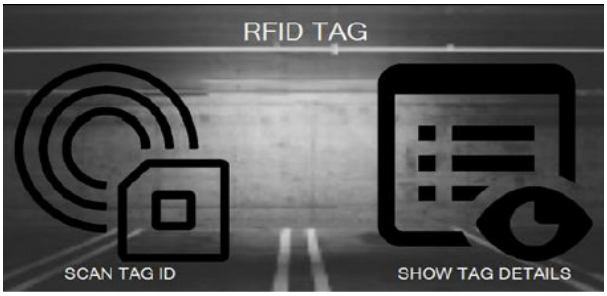

Fig 8. Scan RFID tag interface

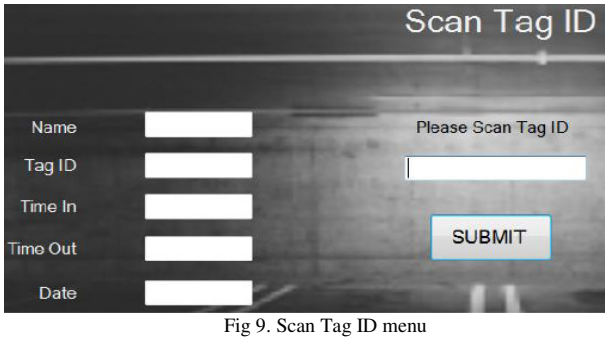

Fig 9. Scan Tag ID menu

B. *Implementation and Testing*

The implementation of the actual system is based on the analysis and design that has been carried out. Then, we conduct the physical system and usability testing to

guarantee that the RFID car parking system that has been developed meets its requirements and users' needs. The questionnaire is prepared and delivered to target user to test the proposed system. This is done to collect user's feedback, comments, bugs, and suggestions. The questionnaire is done on 5 respondents. Figure 10 summarized the physical system testing result which majority of the respondent agrees that the system is easy to understand, strongly agree that each button function as expected and agree that the system can easily view the content.

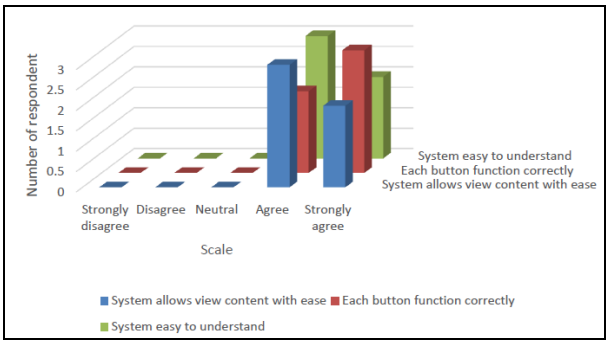

Fig 10. Physical System Testing

Figure 11 shows the usability testing result where 3 respondents agree that the system works well. Besides, 4 respondents strongly agree that the RFID based car parking system is a user friendly system. Furthermore, 3 respondents agree that the system achieved its objectives.

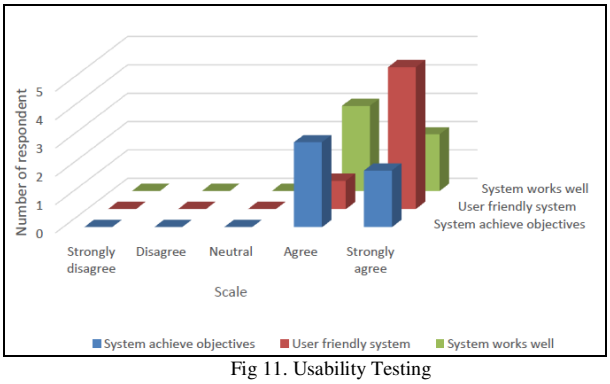

Fig 11. Usability Testing

V. Conclusion

As a conclusion, the RFID car parking system has successful been developed for Fujitsu and achieved the project objectives. The system is built up using Object-Oriented Software Development (OOSD) model with five modules which are user registration, vehicle registration, RFID tag, staff and report generation. We expect that this system will inspire the designers and developers to develop the parking systems with additional features and security elements.

The advantages of this system are:

i. Provide platform for Fujitsu to have a systematic parking system.
ii. This system only allow authorized person to enter the factory area.
iii. Improve traffic flow during peak period.
iv. Facilitate the security guard to guarding Fujitsu entrance.
v. Allow admin to monitor staff and workers record by referring to the database.

Although the advantages of this system mentioned, there are also some weaknesses in the RFID Car Parking System such as:

i. System cannot update username information.
ii. System can only monitor the while the vehicle entering the premise.
iii. Any change of data must key in by the admin.
iv. Staff or workers cannot update their details by themselves.

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