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Fusion of Radio Frequency Identification (RFID) and Fingerprint in Boarding School Monitoring System (BoSs)

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1. Introduction

This chapter discussed the implementation of RFID integrated with biometric sensor to improved Boarding School's (BS) management of student's and facilities. BS may offer a variety of extracurricular activities where conducive learning environment with good facilities such as computer room, gymnasium and entertainment room contribute to good way of mind relaxing and boost up brains development. Currently, most BS managements are having difficulties to monitor their students using the old-fashioned paper-based system; where the procedures are inefficient in monitoring the student's whereabouts. The application of RFID Metric Card system as a Boarding School Monitoring System is to improve the school management procedure, automatically monitor the interest group movements and increase their safety. By using RFID technology, it is easier and faster to detect students handling at that time and reduce assets losses. In this system the fingerprint recognition is also adopted to enable the process of identifying of BS student more reliable and secure for facilities management. Through enhancing security in BS access and facilities control, it help the school management to provide visibility of assets and effective users tracking.

This research work offers an important implication for monitoring the BS assets and eases the workload of the school management and save time for various student activities. In order to analyze and design the system, this application use student's metric card embedded with RFID tag for tracking their whereabouts and fingerprint registered to the access the facilities room. When the metric card passes through the RFID reader, it will trigger the system to read the data from the RFID tag to the database where the access data can be viewed online by BS management for monitoring purposes. For the facilities room access, RFID will be detected when someone with an RFID tag passes through the RFID reader and verify by matching fingerprint image. Upon verification with database is success, the system will enable the room to be access. Thus, the management people may know the students location and also view log record of room entry via internet. This will ease the management in monitoring the availability of boarding school, easy access to BS facilities and reduce unattended assets loses.

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2. Related work

Recent advances in Information and Communication Technology leads to rapid growth of technology especially in monitoring system to improve any glitch and errors. Single-based authentication system seems unable to monitor and authenticate effectively due to easy to hack and break out. Since that, the introduction of Radio Frequency Identification (RFID) has taken place as an alternative to the previous authentication systems such as biometrics and bar code system as well as smart card technologies. However, the integration of those technologies is expected to provide an effective monitoring system and a very high secured system that can perform and monitoring to mitigate the ratio of unauthorized person access. Nowadays, the trend of RFID is clear that the technology is playing an essential role especially in various field such as in engineering, medical, business, construction (Corporation, 2005; EraBuilder, 2006), library (Shahid, 2005), farming management (Bakery, et al., 2007) and etc. Several methods and technologies have been used to develop monitoring systems.

i. Biometric Procedure
ii. Barcode
iii. Smart Card
iv. RFID

2.1 Biometric procedure

Biometric technology is one of the popular method that have been used to recognize a person identity based on the biological and behavioural characteristic, which reliably distinguishes one person from another, used to recognize the identity, or verify the claimed identity of an enrolee and enrolled into a template and store in a system database (Boatwright & Luo, 2007; Gil, et al., 2003). There are many type of biometrics recognition technology that exist today and the fingerprint is one of the widely used biometrics satisfying uniqueness and permanency (Boatwright & Luo, 2007; Gil, et al., 2003; Ratha, et al., 2007; Reillo, 2003), hand geometry, voice, retina, iris (Boatwright & Luo, 2007; Reillo, 2003) and face recognition (Boatwright & Luo, 2007; Ratha, et al., 2007).

Figure 1 illustrates biometric characteristic can be classified into two which is physiological and behaviour. Physiological are related with recognition of face, finger print, hand, iris and DNA meanwhile behaviour are recognition of sound, keystroke and signature (Simao, et al., 2008).

Wu stated that, the use of biometric depending on the application context, biometrics systems operate in either positive recognition or negative recognition. Generally, positive recognition must be performed in verification mode and negative recognition must be performed in identification mode. For these Biometrics-based network authentication systems, they have five subsystems: data collection, signal process, matcher, storage and transmission (Wu, 2008). Gil et al. developed an Access Control System that utilizing high level security fingerprint to verify user to gain access to property or service. It indicates data that use fingerprint can improve the security from token based security method (Gil, et al., 2003). The application of attendance system using biometric system has been demonstrated by Simao, Fonseca and Santos (Simao, et al., 2008) with integration with wireless communications. However, the weaknesses of the system has been discovered by Zhang et al. (Zhang, et al., 2003) by introducing palmprint which developed an attendance system to record the employee attendance including elderly people which may not provide clear

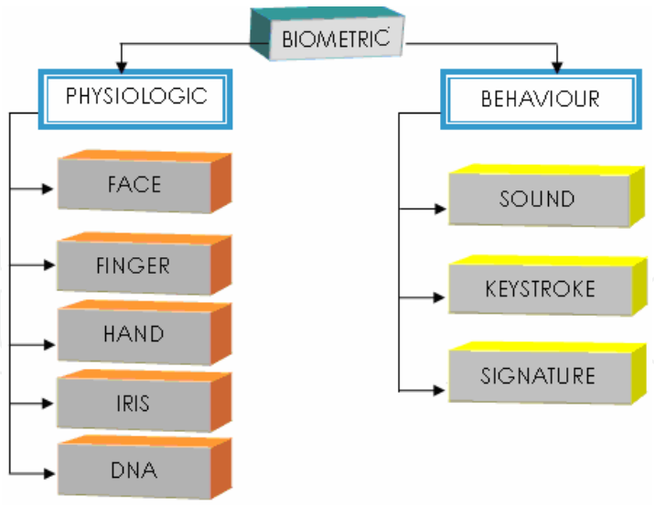


Fig. 1. Biometric Characteristic Classifications.

fingerprint due to problematic skins. An online system captures palmprint images using a palmprint capture sensor that is directly connected to a computer for real-time processing. An offline palmprint identification system usually processes previously captured palmprint images, which are often obtained from inked palmprints that were digitized by a digital scanner. Meanwhile, a similar project has been implemented by Kadry and Smaili (Kadry & Smaili, 2007) which applied wireless iris recognition attendance management system. This system is mainly used for employee identification. The biometric system is suitable for highly secured systems. The security of the system can be further enhanced by applying the multiple authentication system such as integrate with other techniques and technology.

2.2 Barcode

Barcode technology is a method of identification which is used to retrieve in a shape of symbol generally in bar, vertical, space, square and dots which have different width with each one (Gao, et al., 2007; Shepard, 2005). A reader or scanners are needed to identify the data that are represented by each barcode by using light beam and scan directly to barcode. During scanning process, a scanner measured the intensity of reflected light at black and white region. A black region will absorb the light meanwhile white region will reflected it. There are several types of code bar scanner:

i. Pen Reader
ii. Laser Reader
iii. Charge Coupled Device (CCD) Reader
iv. Camera Reader

According to Gao, Prakash and Jagatesan (Gao, et al., 2007), the barcodes stored data in the form of parallel lines in different widths, and they are known as 1D barcodes, and could only encode numbers. The method of arranging the bars and spaces of barcodes are called symbology which is barcode symbology refers to the protocol that defines a standard for arranging the bars and spaces that comprise a particular type of barcode, such as UPC-A and EAN. It defines the technical details of a particular barcode type, including the width of bars, character set, method of encoding, checksum specifications and others Hebert et al. (Hebert, et al., 2004) designed a DNA barcode to identifying birds. Short DNA sequences

from a standardized region of the genome provide a DNA barcode for identifying species. Compiling a public library of DNA barcodes linked to named specimens could provide a new master key for identifying species, one whose power will rise with increased taxon coverage and with faster and cheaper sequencing. Beside that, barcode technology also has been used with mobile phone (Kato & Tan, 2005)to carry more data that its ID counterpart. Previously, barcode has been used in attendance system which indicated by Susan, Mitchell, and Dudley (Susan, et al., 2002) which used handheld barcode readers and the scanner to keep track of students' attendance at LEAD event. Because of several disadvantage of barcode such as read range, data capacity and others, barcode technology is not suitable to implement for this project. This is because to implement an attendance record system for huge amount of student at wide area using barcode will take a long time.

2.3 Smart card

Smart card is built with variety of chip with a simple memory consisting of byte of information that may have range from 1K up to 64K of microcontroller or multi-application memory (Carr, 2002). Smart card are used as individual identification, building access and network access which are part of a multi-tiered program that is in the final stages of rolling out. The data in smart card can be read when there is a physical contact with a reader. Smart card has been used in a wide range of application such as to store operation history, medical record or telemetry (Hendry, 1995) as well as student identification in most organization with a multipurpose of usage (Omar & Djuhari, 2004).

Based on Halawani and Mohandes (Halawani & Mohandes, 2003), smart card has been developed at campus environment as identity cards for students and employees to grant access to certain data, equipment and departments according to their status. Meanwhile, a similar project has been implemented by Mustafa and Kyng (Mustafa & Kyng, 2007) which utilized MyKad Touch N Go features for student web-based attendance system. This system could be accessed by teachers, headmaster and parents via internet and intranet facilities. Because the smart card need physical contact to the reader before the data in the smart card can be transfer, the implemented attendance record system for huge amount at wide area using smart card will take a long time.

2.4 Radio Frequency Identification (RFID)

Nowadays, the RFID technology has been widely used in medical surgeries, animal identification, baggage handling, library services and real time location tracking (Sam, 2007). According to Yoon, Chung and Lee (Won-Ju, et al., 2008), RFID is an automatic identification method, whereby identification data are stored in electronic devices, called RFID tags (transponders), and these data are retrieved by RFID readers (interrogators) using radio frequencies. RFID systems can be classified into two categories according to the tags' power supply: active RFID systems or passive RFID systems. In active RFID systems, tags are equipped with their own batteries, whereas tags in passive RFID systems do not have an internal power supply. Therefore, compared with passive RFID tags, active RFID tags enable a greater communication range. Table 1 shown differentiation between active and passive RFID.

Sabri et. al. (Sabri., et al., 2007) used RFID as a method to record the web-based attendance application to overcome the problem in recording the student's attendance. The system only accepts five different levels of accesses which are the Administrator, Lecturer, Student,

	Active RFID	Passive RFID
Tag Power Source	Internal to tag	Energy transferred from the reader via RF
Tag Battery	Yes	No
Availability of Tag Power	Continuous	Only within field of reader
Required Signal Strength from Reader to Tag	Low	High (must power the tag)
Available Signal Strength from Tag to Reader	High	Low
Communication Range	Long range (100m or more)	Short (3m or less)
Multi-Tag Collection	• Collects 1000s of tags over a 7 acre region from a single reader • Collects 20 tags moving at 100 mph	• Collects hundreds of tags within 3 meters from a single reader • Collects 20 tags moving at 3 mph[2] or slower
Sensor Capability	Ability to continuously monitor and record sensor input; date/time stamp for sensor events.	Ability to read and transfer sensor values only when tag is powered by reader; no date/time stamp.
Data Storage	Large read/write data storage (128KB) with sophisticated data search and access capabilities available.	Small read/write data storage (e.g. 128 bytes)

Table 1. Comparisons between active RFID and passive RFID

University Administration and the Guest. Each user has its own limited access according to the user level. For example, the Administrator has all the security clearance. Meanwhile other users have limited access to the system. The disadvantage of this system is it unable to indentify the student who is late attending the class. Furthermore, Chen and Chang (Chen & Chang, 2008) also applied the RFID technology in developing the project. The project is developed using active RFID and wireless GSM message to construct an active student attendance system that sends the message to parents cellular phone informing whether their children has safely arrive in classroom in the morning. Meanwhile, the system is also used to relieve the traffic congestion around kindergartens especially while parents are driving to pick up their children after class at rush hours or on rainy days.

On the other hand, Qaiser and Khan (A. Qaiser & S. A. Khan, 2006) used RFID technology for the automation of time and attendance using RFID Systems. Students and faculty members are provided with RFID tags. When these tags pass through the reader generated interrogation field, they transmit information back to the reader, thereby identifying them. The RFID System makes it possible to monitor the movement of tagged users and record their real time data and pass it to processing system to maintain a system Log. A similar

project has been implemented by Herdawatie, Siti and Helmy (Kadir, et al., 2008) which is used to monitored boarding school students using RFID. The data will be sent online to the school management for monitoring purposes. However, Joseph and Yusuf have developed a similar student attendance system using RFID in which the information of student attendance will be sent to parents by using Short Message Service (SMS) (Joseph & Nakhoda, 2008).

Other than that, RFID technology also has been used to monitor a transportation system which is used to monitor the container tracking from Yokohama Port to Kobe Port using active RFID Systems. The results show that active RFID system has the capability to acquire a movement history and sensor data easily with low power consumption without GPS (Mizuno & Shimizu, 2007). According to Ogata et. al. (Ogata, et al., 2008), the paper proposed basic support for ubiquitous learning (BSUL) environments as an extension of e-learning systems. For the attendance-taking module, every student has a RFID tag. When the student enters the classroom, the system reads the RFID tag and sends a message to a web service based on the simple object access protocol (SOAP), asking to update the system database. There have four different statuses for the students: attendance, absence, delay, and a fourth one called remote attendance, which means that the student is viewing the class through the streaming video source. The criteria for deciding whether a student is late or not, can be configured by the teacher in charge of each course. The teacher can view the records of each student's attendance during the course using the environment website, but the students can only view their own records.

2.5 Fusion of RFID with other technologies

Multiple authentication system has been a trend due to the improvement of the security of either restricted area or to monitor the place which consider as private and confidential. The previous work presented on a transportation and logistics company which utilized RFID and cellular positioning automated tracking and tracing of general cargo in order to solve shipments which have all assumable sizes and shapes and, forwarders are very often organized in open logistics chains or networks (Hillbrand & Robert, 2007). The integration of RFID and Accelerometer Sensing were used to monitor an effective and obstructive activity recognition based on 10 housekeeping performed by 12 subjects. The results indicates that recognition accuracy can be significantly improved by fusing the two different types of sensors (Stikic, et al., 2008). However, there are fusion of RFID and wireless sensor network to build a wireless localization system in a children's theme park. The main purpose of the project is to localized system to track and locate children within a certain range near some landmarks in the park. The design experience in this project can be exported to other applications such as object tracking and surveillance (Chao Chen, 2006). The work presented by Won-Suk Jang, Mirosław J. Skibniewski (2008) utilizing RFID and GPS to produce a prototype framework for automated tracking and monitoring system for construction materials on Project Sites (Jang & Skibniewski, 2008).

3. BoSs architecture and design

Boarding School Monitoring System (BoSs) is an integrated monitoring system that enable the school management to fully centrallized the data of each registered student movement and permit access within the define area to improve the security, reliability and tacking efficiency of student's. It's combines the RFID technology to track the student movement

and fingerprint reader to enable the management to give authorized to selected student's to access facilities room thus enables the school management to monitor individual location and also view the evidence of room entry via internet. An overall view of BoSs is shown in Figure 2.

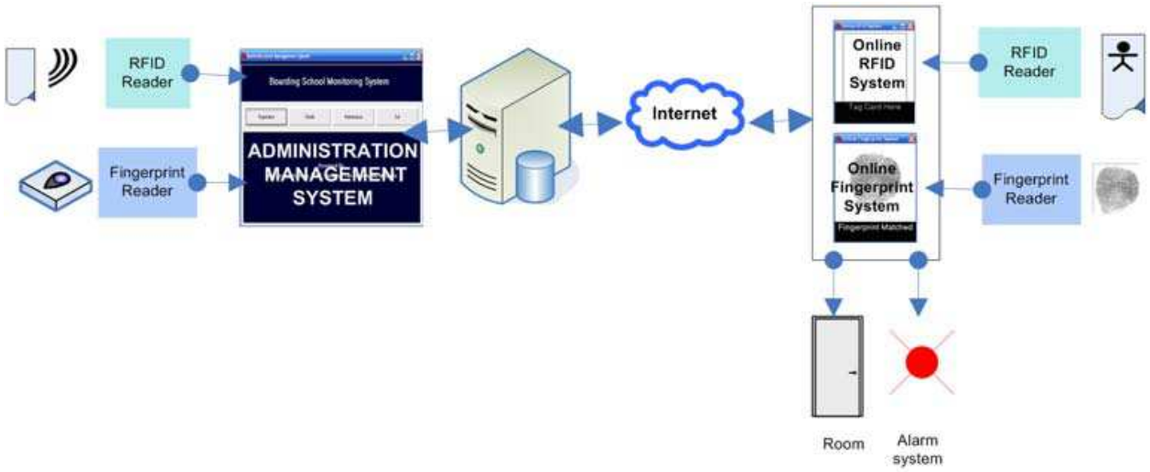


Fig. 2. BoSs Architecture

Generally RFID is an auto-id device technology that used to store and extraction data within range (up to few metres depends on the reader) by using radio waves The use of RFID system can reduce operating costs and simplify the data storage and retrieval (Nement et al., 2008). In a security perspective, biometric recognition was used, and more specific fingerprint was chosen to provide correct identity of the card holder due to its low cost for data authentication (Bazakos, et al., 2005).RFID technology is composed of three main components; a RFID tag, which contains the identification number, a RFID reader, which activates the tag to broadcast its identification number, and a RFID Middleware, which integrates the information from the reader to the backend database system. Nowadays, RFID is used in many areas and every where possible. However at present, the popularity of RFID technology opens several issues within the security umbrella. Although the combination RFID and fingerprint is not an answer to unauthorized access however it is the key to reduce forgery and counterfeiting of passive RFID tags (Smith & Coetzee, 2008) and solve the problems in the traditional system thus increase the efficiency of management process (Jiang, et al., 2005).

In BoSs, the RFID tags enable the school management to track the student around the boarding school area and access in and out of the facilities rooms. An individual without the RFID card or without the correct fingerprint image will disable the entry to the facilities room. The system will also trigger the security signal and this will notify the school management upon the unauthorized access using an online monitoring system. This system used the main component of passive RFID system and fingerprint sensor, database management system and networking i.e. wireless. When the RFID tag pass through the RFID reader in a range zone and match fingerprint image for the scan tag, the system will record the data from the RFID tag to the database system. Then the data will be sent online to the management for record and supervision of rooms' access. This could ease the management to observe access of selected area and facilities rooms.

4. Application scenarios

For easy monitoring the area were divided into four areas: zone one, zone two, zone three and zone four. RFID reader will be located in appropriate area in each zone to enable the student movement monitoring. In zone one, the centre point is the area that are consider as restricted area; it provide the facilities such as computer room, society room, television room and mini library for student activities. The RFID reader will be located at the in/out door of the building and fingerprint reader will be located at each facilities room to enable easy access of usage by the authorized individual. Thus, restricted the access for each room in order to enhance the security of the assets. The boarding school hostel, canteen, study room, pantry and residential advisors are located in zone two and zone four and last zone is located in sport centre area. To illustrate the BoSs concept a sample of layout of boarding school map were provided in Figure 3.

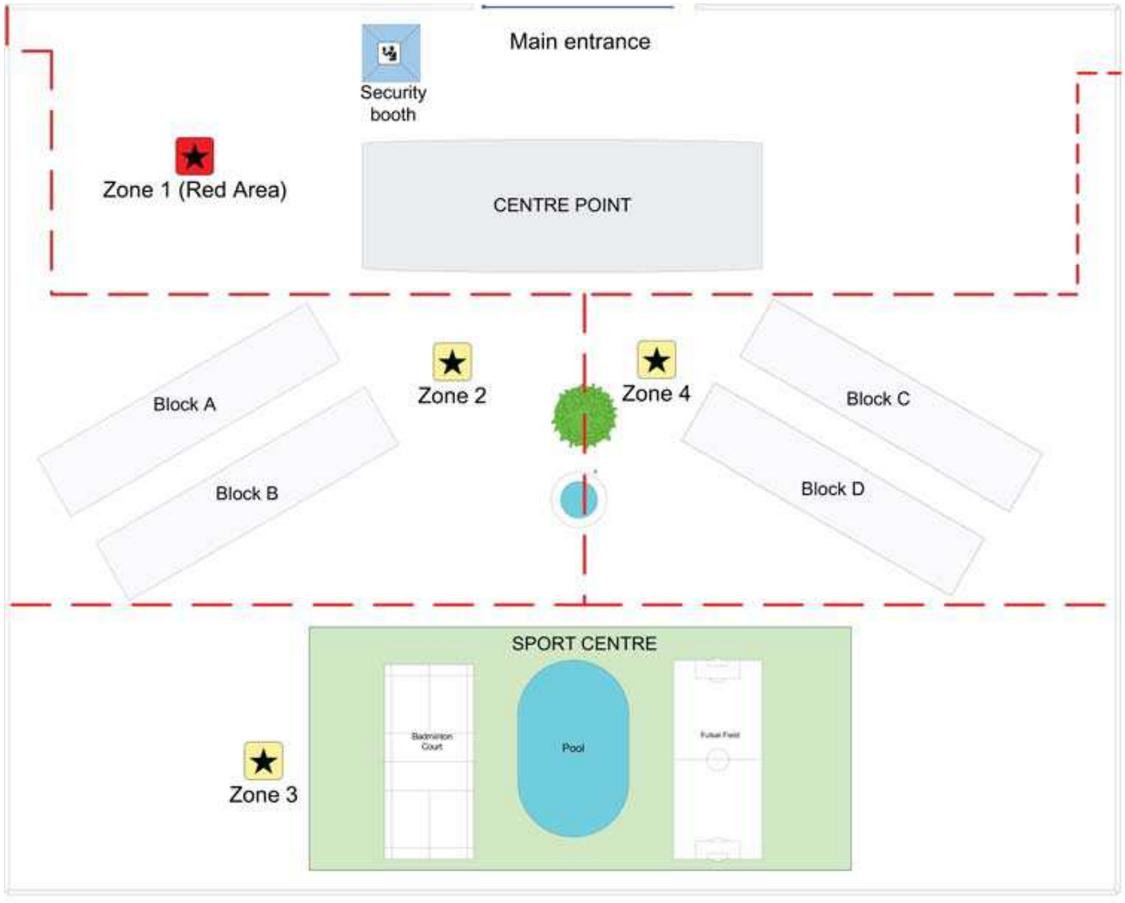


Fig. 3. Boarding School map layout

By implementing BoSs, the school administration people will be able to search within the database for the student data and able to scan the last location of the student whereabouts, if the student is found missing or a disaster happens. By defining the selected area the whereabouts of the students are easier to pinpoint whereas the student location and time were recorded by the BoSs system and provided appropriate emergency information for tracking and life saving.

5. System implementation

BoS system records students' presence at Zone 1 – Zone 4 area and privileges on accessing hostel facilities at Zone 1. In order to records student's presence at particular zone area, RFID technology is used. The overall system flow is shown in Figure 4.

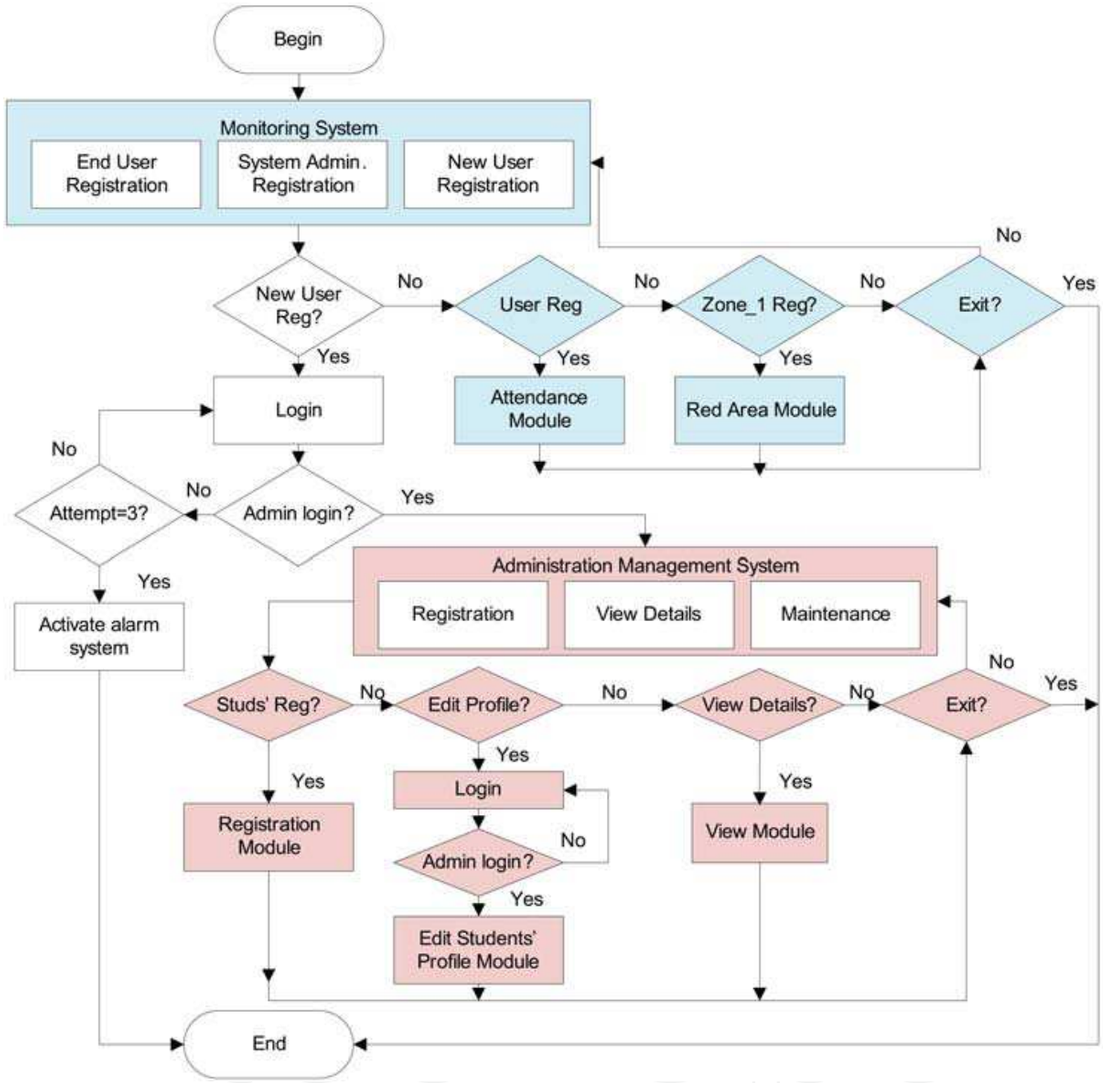


Fig. 4. Boarding school monitoring system flow

BoSs consists of two main subsystem; monitoring system and student management system. Monitoring system is used to keep track of student's movement around the school area. New users' registration or modification on users' profile should be done by system administrator through Student Management System. To be part of the BoSs's entities, new user must be registered by system administrator. In order to make sure an authorised personel login to the system, the correct password of system administrator should be entered. Any unsuccessful login will be stored into BoSs's database with a maximum of three times login attempt before activating an alarm system. This type of security mechanism is also applied to protect the data inside BoSs's database. A successful login

instantly activates the RFID reader to read a RFID tag. Once the reader reads a unique number of RFID tag, it will be stored into the database. Each tag that has been stored in the database is assigned to a student that indicates the tag and the user have been registered into BoSs. Therefore, if registered user is in RFID range, BoSs's automatically store the user's presence into the database. Other than holding information on student's profile, the tag also carrying information on student's permission level of accessing a certain restricted school area (mentioned afterwards as red area). Because of the characteristic of the tag; easy to change from one hand to another, an additional security mechanism is created to act as a second level of security system and to ensure an authorised person entered to the system. The second level of security system employed a biometric system using fingerprint. The detail on flow on registration module is shown in Figure 5.

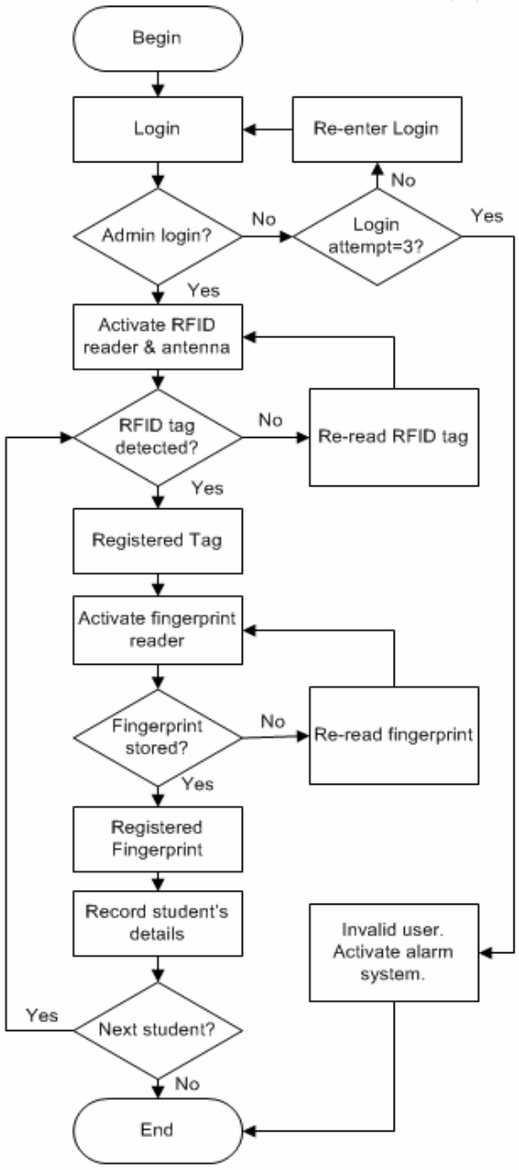


Fig. 5. System flow on registration module

To access Zone 1 (red area), user must be registered to the database to enable RFID and biometric reader to give entry permission; these two technologies were combined to produce two levels of security system. Besides that, the permission level of each user at Zone 1 is also determined where the fingerprint verification consists of two steps: enrollment and verification as shown in figure 6.

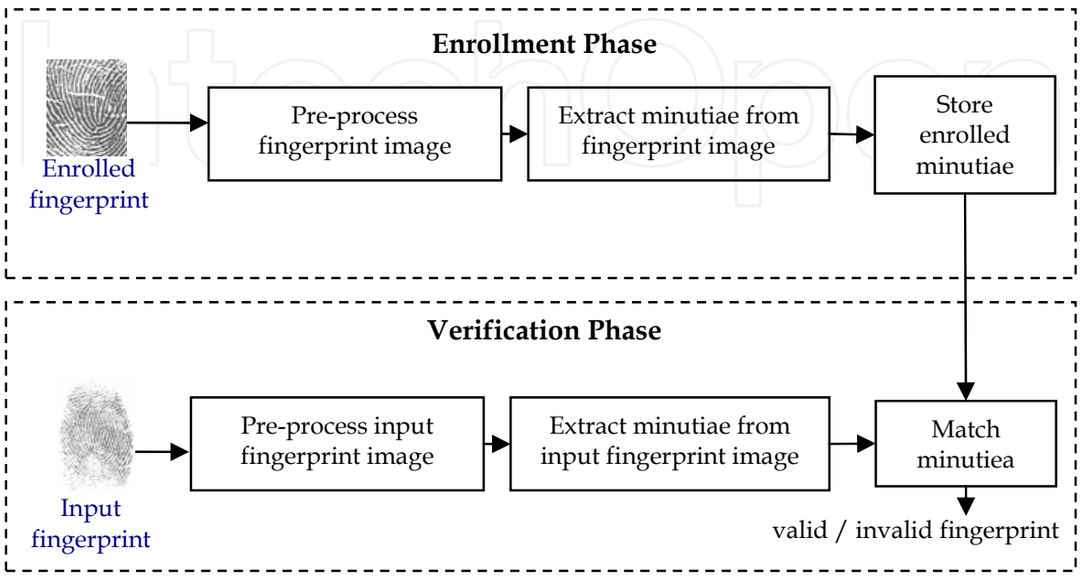


Fig. 6. User authentication system using fingerprint

The red area determines the type of permission level that user had before the system allowing any user to entered the area; for instance a computer room. The permission level for each user is determined by the system administrator during user's registration. In accessing the red area, the user must provide a valid RFID tag and a valid fingerprint. At this area, there are two types of readers; RFID reader and fingerprint reader, which will be in a stand-by mode. These two readers will indicate two security parameters are needed and should be correctly inserted to enter the red area.

The intended user must present his/her RFID tag within RFID range. BoSs also needs user's fingerprint by placing his/her registered finger onto fingerprint reader. The reader reads the tag and the fingerprint and sent signals to BoSs. The entered tag and the entered fingerprint are compared to the same parameters in the database to check parameter validity and accessing level. If these two security parameters matched, meaning that the user belong to the system and this will create a successful attempt. A successful attempt will makes a secured door opened and starts recording user's activities such as date, time in, time out, room no. etc. Any unsuccessful attempt from any of these two security parameters will allow the user to re-enter with a maximum three times attempt before BoSs's activates the alarm system and logged such attempted. The details of system flow and system interaction on red area are shown in Figure 7 respectively.

6. Boarding school monitoring system interfacing

The development of BoS system is divided into three access parts; users' access, system administrators' access and online access.

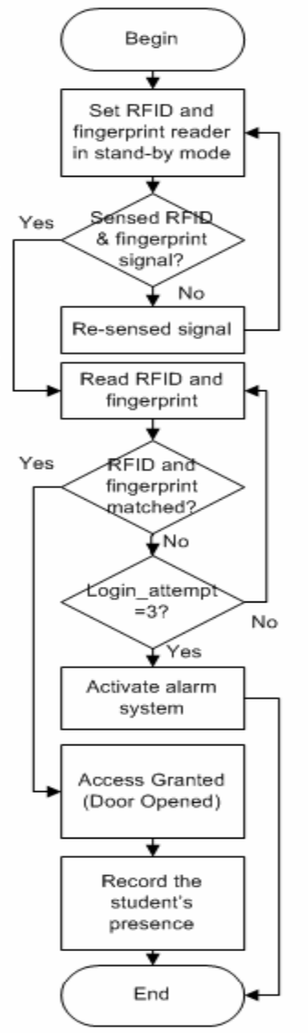


Fig. 7. System flow on red area module

6.1 Users' access

There are two interfacing technique: for user and system aministrator. For user interface, the system, its will give the user permission to prompt the access facilities from zone 1 until zone 4. There are two reasons for this interfacing (a) to record the user movement in all defined zone (b) to show and determine the user's permission level on accessing zone 1. The recording of user's presence in each zone is done using RFID technology. User need to scan their RFID tag into RFID reader as prompted by Online RFID System (refer Figure 8). If the tag was registered into BoS system, the system will displays the user's name and opened the gate. If not, the system will displays a message that indicates unsuccessful login. For such case, the system will allow the user to re-tag up to three times before activating the alarm system. The activation of alarm system will alert security staff to take an appropriate action.
Each successful login indicates that the user is allowed to enter the system. Therefore, the user is allowed to be at any zone area and their presence will be recorded into the BoS system. This can be accomplished by placing a pair of RFID device at each zone entrance.

(a) Main RFID GUI (b) Registered user (c) Unregistered user

Fig. 8. RFID Tag status

Even though user can access all zone area, extra identification system that uses biometric technology is needed each time the user wishes to enter a facility rooms in Zone 1. The identification system needs user to present their fingerprint (Figure 9) onto fingerprint reader.

(a) Main Fingerprint GUI (b) Registered user (c) Unregistered user

Fig. 9. Fingerprint status

BoS system will matches the fingerprint with the one stored in the database system. If the fingerprint does not match, the system will displays the message and allows the user to re-enter up to three times before activating the alarm system. If it matched, the door will be unlocked and the system begins to record the room uses.

6.2 System administrators' access

User interface for system administrator is needed to allow the administrator to maintain the BoS system. There are three modules; Registration, Details, and Maintenance. Before they proceed to each module, the system administrator needs to enter administrative password (Figure 10). Any successful login will allow the administrator to manipulate the data.

Otherwise, the administrator needs to re-enter the security password up to three times before activating an alarm system.

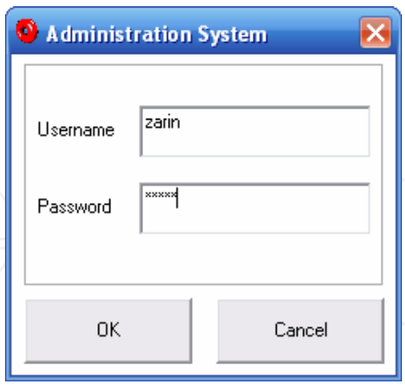


Fig. 10. System Security for Administrative Staff

The main GUI of maintaining the BoS system is shown in Figure 11. For the purpose of this chapter, we will focus on two modules that use RFID and biometric technology; Registration module and Details Module.

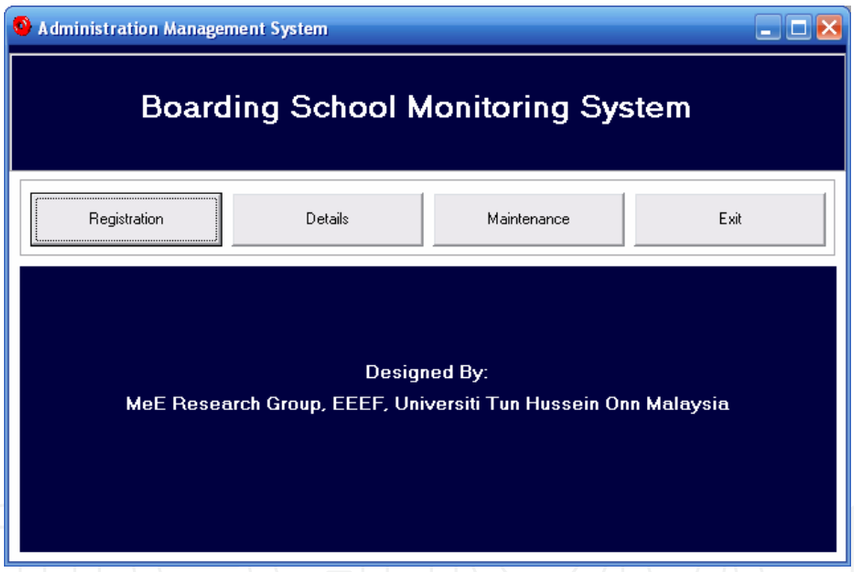


Fig. 11. Main GUI of BoS system

a. Registration Module

Registration module can be access by pressing on *Registration* button. This will allow the administration to add new user. The following are two purposes of registration module.

1. Register a new user to be part of BoS entities.
2. To access all facilities in Zone 1.

The user can be part of BoS entities by inserting user's information as shown in Figure 12. In order to enter hostel area, the user should have a RFID tag. The tag is registered into BoS system by clicking the *Register RFID Tag* button. By doing so, the RFID reader reads the tag ID and sends it to the system before displaying it to the user and save the information into the database.

Fig. 12. Registration Module

Each new or registered user could access all facilities in Zone 1 by clicking the *Register Access* button. For registered user, the *Search* button in Figure 12 is used to gain user's information before proceeding to zone 1 registration (Figure 13).

Fig. 13. Access Registration of Facility at Zone 1

Accessing Zone 1 acquire extra identification system. In this application, the identification used user's fingerprint. Therefore, each user needs to register one of their fingerprints into the system. The fingerprint is registered into BoS system by clicking the *Register Fingerprint* button. By doing so, the fingerprint reader reads the fingerprint and sends it to the system before displaying it to the user and save it into the database. The overall flow of registration process is shown in Figure 14.

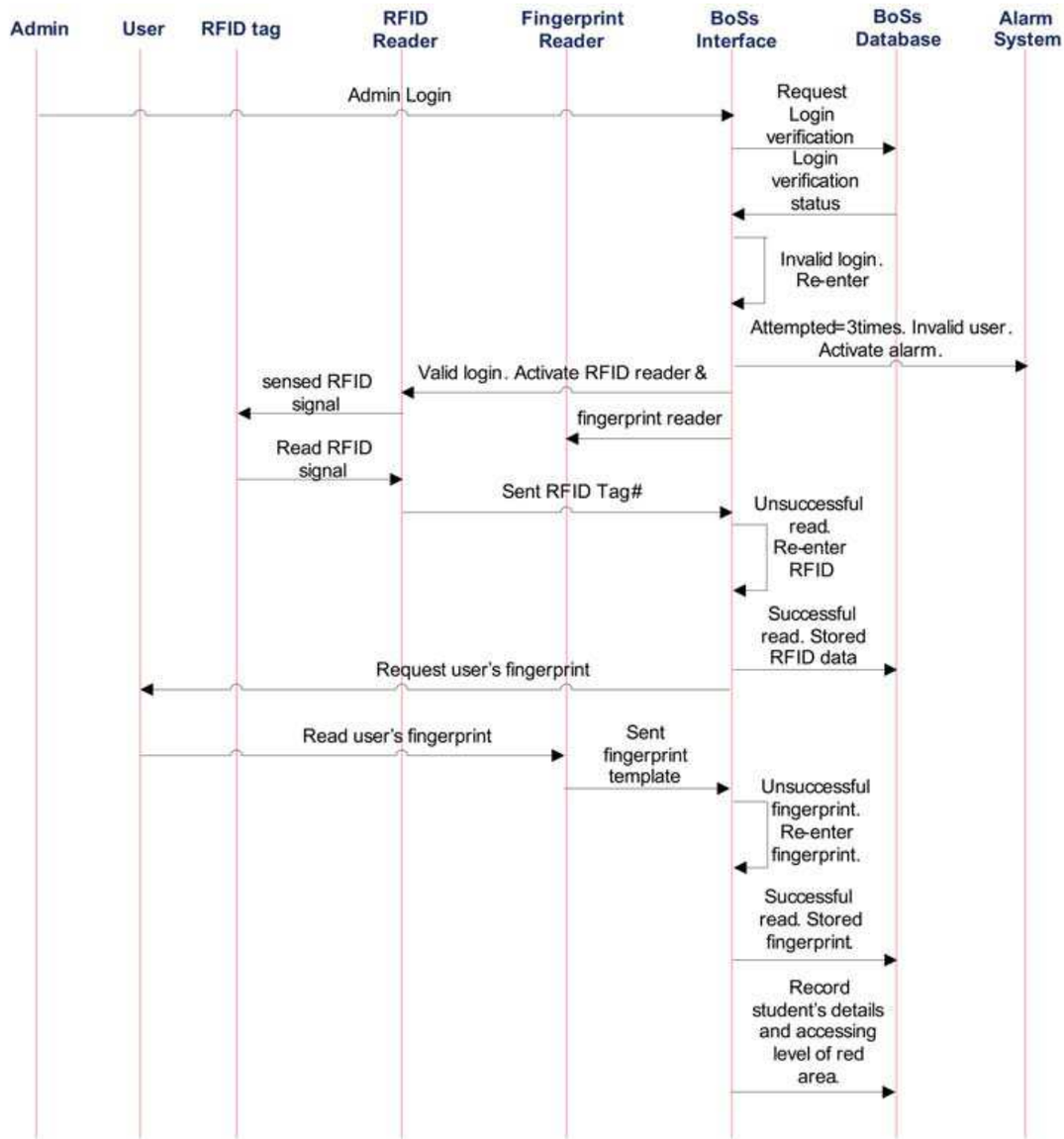


Fig. 14. Overall flow of Students' Registration and Access Registration on Facility Room at Zone 1

b. Details Module

System administrator can access Details module by pressing on *Details* button. This will allow the system administrator to view information on user's presence at hostel area (Figure 15). This detail will give information such as time entered and time out of the zone, date entered and out of the zone and etc.

c. View access information at all zone

The number of records of user presence at particular zone is depending on the number of user presence at the zone and it may have significant number of records. Therefore, in order for the system administration to views any particular record, the filtering is provided. The filtering process can be done by entering the zone code and the date before clicking on the *Search* button as illustrated in Fig. 16.

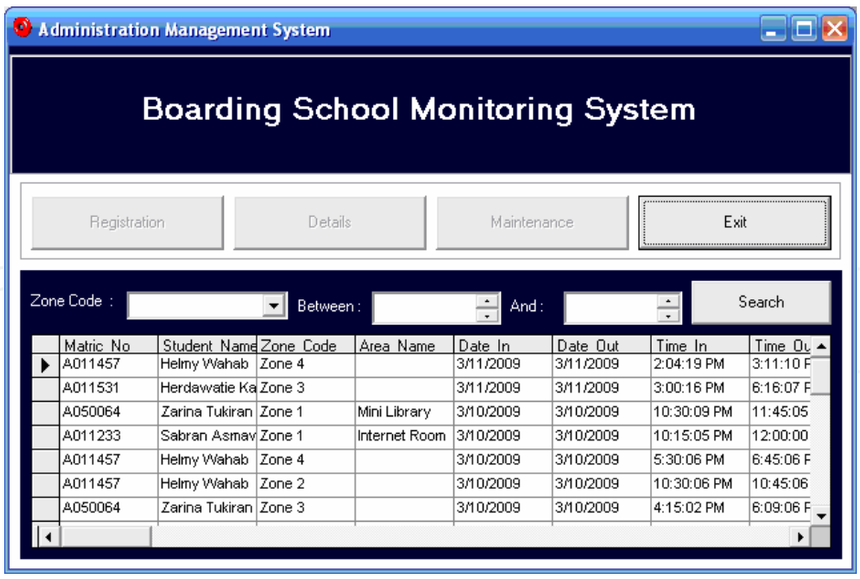


Fig. 15. View record on user's presence at hostel area

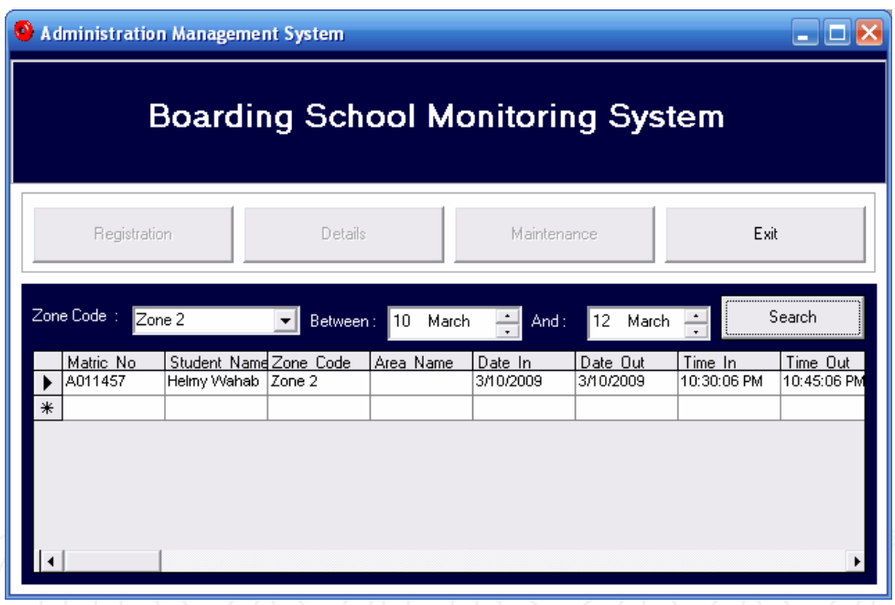


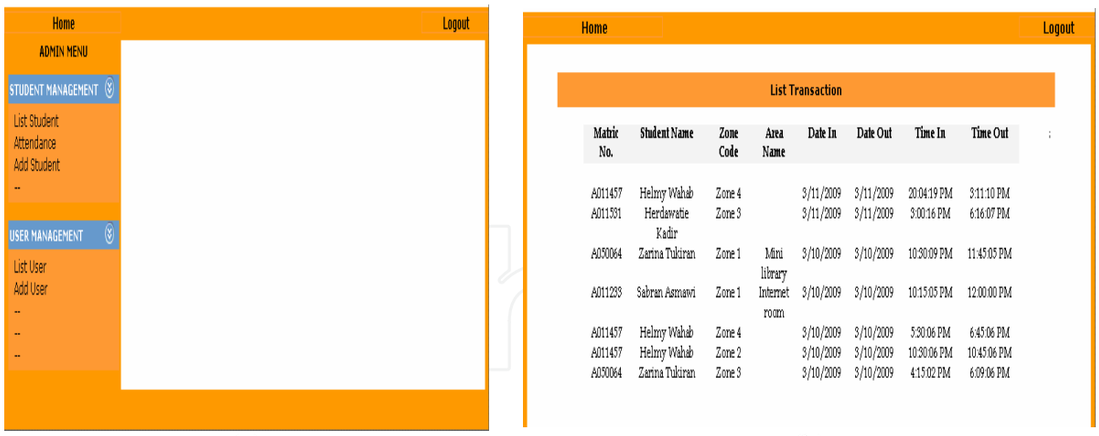
Fig. 16. Filtering information based on zone code and date

6.3 Online access

An online user interface has been developed to ease the management system to monitor the student movement and to search the student data easily. Some snapshots of the online system are provided in Figure 17.

7. Conclusion

In this chapter, we discussed the integration of RFID with boimetric technology to enchanced the security level in the boarding school managment system. First we discussed



(a) (b)

Fig. 17. Online system sample

the technologies used to develop monitoring systems. We found that by adding the second layer of authentication to the system enchanced the security level. Finally, based on the application scenario proposed we develop a monitoring system and discussed the flow of the overall system. The application of BoSs will improve school management procedure, monitor the interest group movements automatically and increase assets security thus offers an important implication for monitoring the BS assets and eases the workload of the school management and save time for various student activities.

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Sustainable Radio Frequency Identification Solutions

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Radio frequency identification (RFID) is a fascinating, fast developing and multidisciplinary domain with emerging technologies and applications. It is characterized by a variety of research topics, analytical methods, models, protocols, design principles and processing software. With a relatively large range of applications, RFID enjoys extensive investor confidence and is poised for growth. A number of RFID applications proposed or already used in technical and scientific fields are described in this book. Sustainable Radio Frequency Identification Solutions comprises 19 chapters written by RFID experts from all over the world. In investigating RFID solutions experts reveal some of the real-life issues and challenges in implementing RFID.

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