Automation of Attendances in Classrooms using RFID

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Abstract— This paper automates the design and implementation of students' attendance management system, taken into consideration easy access and time saving. The system will be used in faculty of computing and information system (FCIT) at King Abdulaziz University (KAU). Radio Frequency Identification (RFID) and wireless technology are two technologies which will be applied as infrastructure in the indoor environment. University Based Services (UBS) and tag IDs of the RFID are being used in this paper, in order to determine the attendance list for academic staff. Once the academic staff enters a classroom, he will be able to register student's presence. Therefore, an academic system for identifying and tracking attendance at computing college at KAU will be described, and hybrid RFID and Wireless LAN (WLAN) technologies will be implemented in FCIT academic environment.

Index Terms—Attendance, Classrooms, RFID Technology, Tags and Readers.

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1 INTRODUCTION

THE internet applications are widely used, due to the success of mobile technology, wireless networking, and location-based portable devices. Within the new generation of pervasive and ubiquitous computing devices, two research topics are challenging: real-time localization and mobility solutions [1].

The localization problem has defined to know where objects are, and therefore many Location Based Service (LBS) are being initiated. Consequently, network planning, such as mobility management, load balancing and network functionality are very useful in location based services.

The rest of the paper is organized as follows. Section 2 discusses related and previous work. Section 3 describes the motivation of the current paper. Section 4 presents modeling requirements and the system architecture. Details of designing and automation will be discussed such as; functional requirements, entities of lectures, time attendance, implementing attendance registration, testing and results. Section 5 summarizes and concludes results and future work.

2 RELATED WORKS

Radio Frequency Identification (RFID) technology is applied in many locations, like in museum services [2], [3], [4]. Museum services, museum security and visitors, tracking systems have been presented in Korea [2] , [3]. Other works illustrated in several academic and educational related services [5], [6], [7] to support attendance, tracking and monitoring at university, using NFC and RFID. Also, an automation of contactless university examination system is implemented to elaborate the business use case of the attendance monitoring system [8]. Additional papers focus on implementing and using RFID, Bio-metric, Fingerprint and GSM modem in attendance management, and industrial applications [9] , [10]. The paper of [11] proposed a participant managerial prototype system by

using user IDs (SNS ID) in actual event site. Therefore, such paper presented a method to use NFC to connect online SNS IDs and online meetings in actual meeting rooms.

Many location objects in outdoor environments have been addressed and created; technologies have been studied, such as Global Positioning System (GPS) [12]. Using RFID technology, the tags can be embedded in small packages, and each tag can store a serial number for every product [13]. The RFID tags can be read as long as they are within the domain of a reader device [14].

RFID is used in many researches, developments, and applications that attempt to take maximum advantage of such technology [15],[16],[17],[18],[19,[20]. Therefore, RFID technology is widely used in commercial, governmental sector and personal applications as demonstrated in [15-17]. RFID technology is often used for object tracking in business and manufacturing applications, such as in supply chain control [15], tracking management [16], [20], indoor location-based [21], [22], [23] and baggage transportation.

Our current research goal of the presented paper at FCIT is to provide RFID and Near Field Communication (NFC) technologies for measuring the student attendances, participations and monitoring in academic teaching inside classrooms. However, manual attendance process during lecture time consumed valuable time and hard maintenance task. Additional and miscellaneous applications include: electronic surveillance, protection of valuable equipments against theft, controlled access to vehicles, Electronic Road-Pricing (ERP) systems, controlled access of personnel to secure or hazardous locations, time keeping systems, animal and automatic identification of tools, identification of product variants and process control in flexible manufacturing systems.

3 MODELING REQUIREMENTS AND SYSTEM STRUCTURE

An overview of the fundamental requirements of the attendance system will be described in this section. Two main objectives will be taken into consideration. The first objective is to build a reliable system to access students' data of computing faculty via ODUS at KAU server. Detailed information about the ODUS can be found at http://odus.kau.edu.sa. The second objective is to monitor and report students' attendance percentage in each class.

3.1 Functional Requirements

Faculty of computing and information system holds more than 900 (nine hundred) students for males and more than 800 (eight hundred) students for females sections. There are three departments; Computer Science (CS), Information System (IS), and Information Technology (IT). Each department has equal number of students as the others. The faculty of computing contains 15 classrooms and labs; each class can hold up to 40 students. At the beginning of the day, 13 lectures can be held at the same time. Therefore, to meet this requirement, an average attendance registration process should consume less than 2 seconds. Furthermore, the attendance system should provide an efficient service way for communicating with On-Demand University Service (ODUS) or ODUS+ (the new version of ODUS that contains all the KAU academic services). Such service will be used by the academic staff for aiding attendance registration process, and helping the student to examine his/her exam results in the future. Therefore, it is necessary to provide an easy way to take attendance. So, the automation of attendance and monitoring system should present high robustness and reliability.

3.2 Entities of Lectures

The entities of each lecture consist of students within the classroom, that is, the academic staff member can attend. The academic staff member may be male or female, and such member is selected through the academic boarding at each department.

Let C be a classroom assigned by the academic student affairs, let the computing faculty includes several classrooms (15 classes in our case); c1, c2 … ci; therefore:

$$C = \{ c_1, c_2 \ldots c_i \}, \text{ where } c_i \in C \qquad (1)$$

Each class has program of lectures and academic staff as meta-data, such as staff name, department name, date and time of lectures.

Each department has group of lectures, let L_{jk} be an element in the set of all lectures L; where j represents department name and k represents the lecture number for that class. Consequently, the set of lectures at room (C_i) is a subset of L and is written as L_{jk}.

$$L_{jk} = \{ (l_{11}, \ldots l_{1k}), (l_{21}, \ldots l_{2k}), (l_{31}, \ldots l_{3k}) \} \qquad (2)$$

L_{jk} represents the three departments; computer science (CS), information system (IS), and information technology (IT).

3.3 Time of Attendance Registration

At each classroom, an event should be taken at specific time to register students' attendance. This event procedure requires two methodologies; automatically or manually through the academic staff by (clicking attendance button). Therefore, the attendance registration proceeds as follows: (1) manually by academic staff and (2) automatically by the system.

This article will design and implement the attendance solution. The solution is based on RFID technology, its different components and its related methods of operations. The student card should be tagged with RFID tag. RFID reader will be installed in each classroom, and all the readers are connected to the staffs' LAN. At last, a computerized academic system will automate the attendance recording of the students.

When the academic staff enters a classroom, he will be able to take student's attendance. The reader gives a sound when the system successfully finishes reading all the students' tags in the classroom. Therefore, the RFID reader sends a complete attendance list to the server. Figure 1 shows the system architecture.
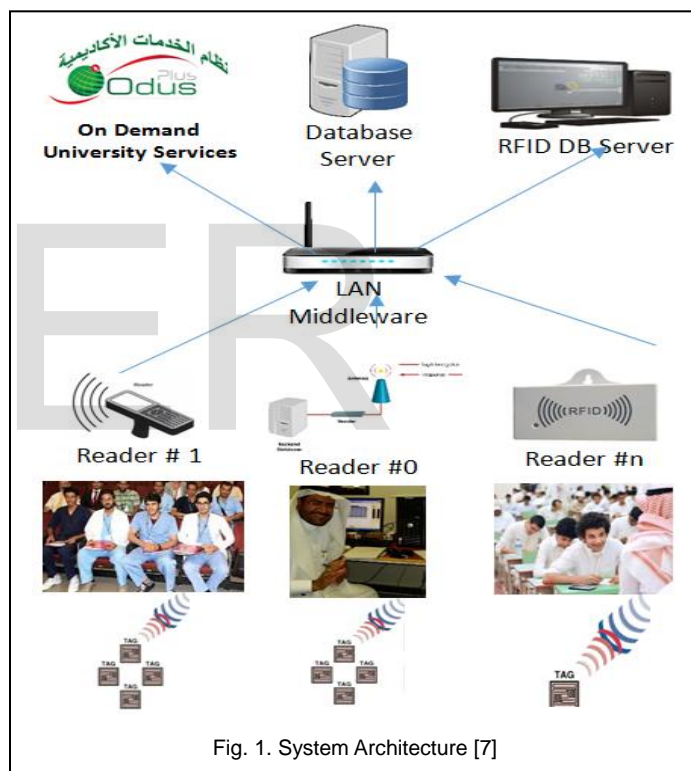

Fig. 1. System Architecture [7]

The solution consists of three category layers. The first layer consists of various RFID readers installed in the different classrooms and practical labs of faculty building. The second layer includes middleware as a communication bridge between the first layer and third layer by using the wireless LAN (WLAN) of the computing faculty. The third layer contains RFID server with the academic database to record the attendance of students, in addition to the ODUS application that supports all the academic services in KAU.

Therefore, the RFID database servers are connected to the WLAN; one at FCIT (building 31) and another at building 125, to manage and establish communication between different readers and handle received data from these readers. Once the RFID server receives the data from the reader, it inserts a new

record of attendance in the RFID database server according to that reader (classroom is known with course at scheduled time).

The RFID database server stores the academic attendance of students. Such attendance data includes student Ids, course Id, staff Id, date/time, and the reader Id (that carried out the reading). Also, the RFID database server stores all readers' information and readers settings (IP address, port no., classroom no., and building no.).

The database server is used to collect the attendance data from all the faculties and generate attendance report for university manager, staff and student. Such data is collected periodically at the end of day. The database server is used to store attendance data for the whole semester. Therefore, such server generates attendance report for every student and also for every section, staff and course. Consequently, by analyzing such reports with respect to other evaluation of staffs and students, the decision maker can decide strategic actions.

The ODUS or ODUS+ is running on separate server, and therefore it is independent of the readers. The student database management system of the college includes all the data related to students, subjects or courses, staffs, building, classrooms, and time scheduling of each course.

3.4 System Implementation

The automation of the FCIT attendance will be presented in this section. The academic attendance software has been integrated into the client(s) device, as well as into the server device. Therefore, all the requirements were standard in wireless communication (TCP/IP), reasonable reading range, and fast identification time for the RFID reader.

The automated system uses a reader (RFID tag reader) and so, the software toolkit is used to derive the planned equipments. The system can access all the required information through the ODUS database at KAU (student, staff, administrator, parking, etc.). RFID's SDK supplies built-in functions to communicate with readers and collect data when any events have taken place. The following steps describe RFID features and event handling:

1. "Reader data" is initiated as an instance of RFID class.
2. "IP address" will be handled using set and get methods.
3. Reader's port number and location can be recognized using get and set methods. So, antenna can be specified and the system will know which antenna is being used.
4. "Tag List" of students' attendance is represented as array of tag information.
5. "Discovery Time" represents time of tag found using read and writes methods.

The database defines and establishes the data of students, staffs, and administrator. Therefore, the system has the following functions:

1. Add method is used (via administrator) to add reader for each classroom by choosing building number, class numbers, the IP address and Gateway. Also, delete/update methods can be used to amend any updated information.
2. Show/Display students' attendance by course subject, classroom, department, or building.

3. Save/Store the students records in the academic database per course subject, classroom, department, or building.

Consequently, *security* is a very important issue which should be considered. So, the students' tagged card ID can be renewed every year [6], [7], [23]. The automation system was made in the college of Computing and Information Technology at KAU, male building 31 and the new implementation is related to building 125. The physical building of the new RFID readers and WLAN are shown in the floor plan diagram (Figure 2). There are nine locations for RFID readers at each floor, and many locations to cover the Wireless LAN (building 125).
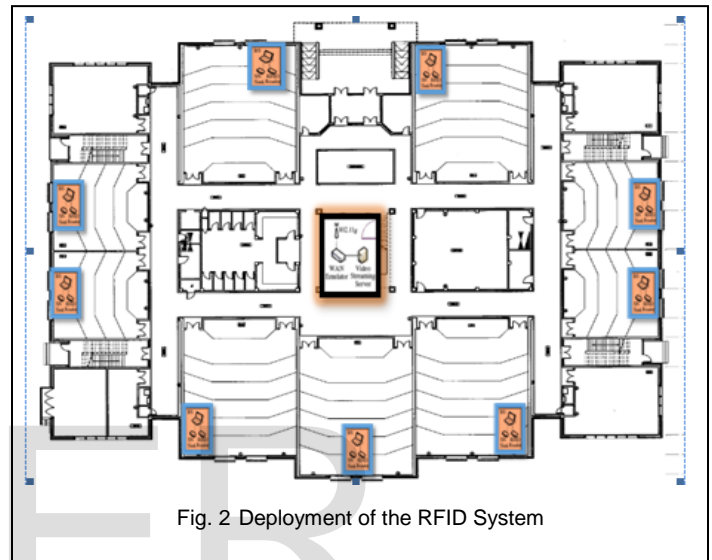

Fig. 2 Deployment of the RFID System

3.5 Attendance Registration Methodology

As we said in the previous section, the academic registration is classified into manual and automatic registrations. The common difference between the two methods is the usability of student identification card, with embedded student tag. Figure 3 illustrates the academic attendance system workflow as sequence diagram. Accordingly, assuming that, all the students of the meeting have student's card with embedded tags. The deanship of registration and admission (DRA) at KAU prepares the student identification card with the RFID and NFC tags assigned with student information. The students' tags information is stored in ODUS database. The students fill and prepare their courses and register their academic schedule of courses they are needed to study. Such students attend the meeting with their ID cards at a scheduled classroom that has a wireless reader.

Figure 4 shows the workflow of academic attendance as a sequence diagram. On this scenario, the academic staff takes the attendance process that will be considered automatic or manual at specific lecture's time. Consequently, students' IDs within the class can be registered and sent to the ODUS database, with the related students meta data $\{< C_i, L_i >\}$. Therefore, the academic staff application sends a message to the ODUS database server telling that the student is in the classroom, and so, the attendance process takes place.
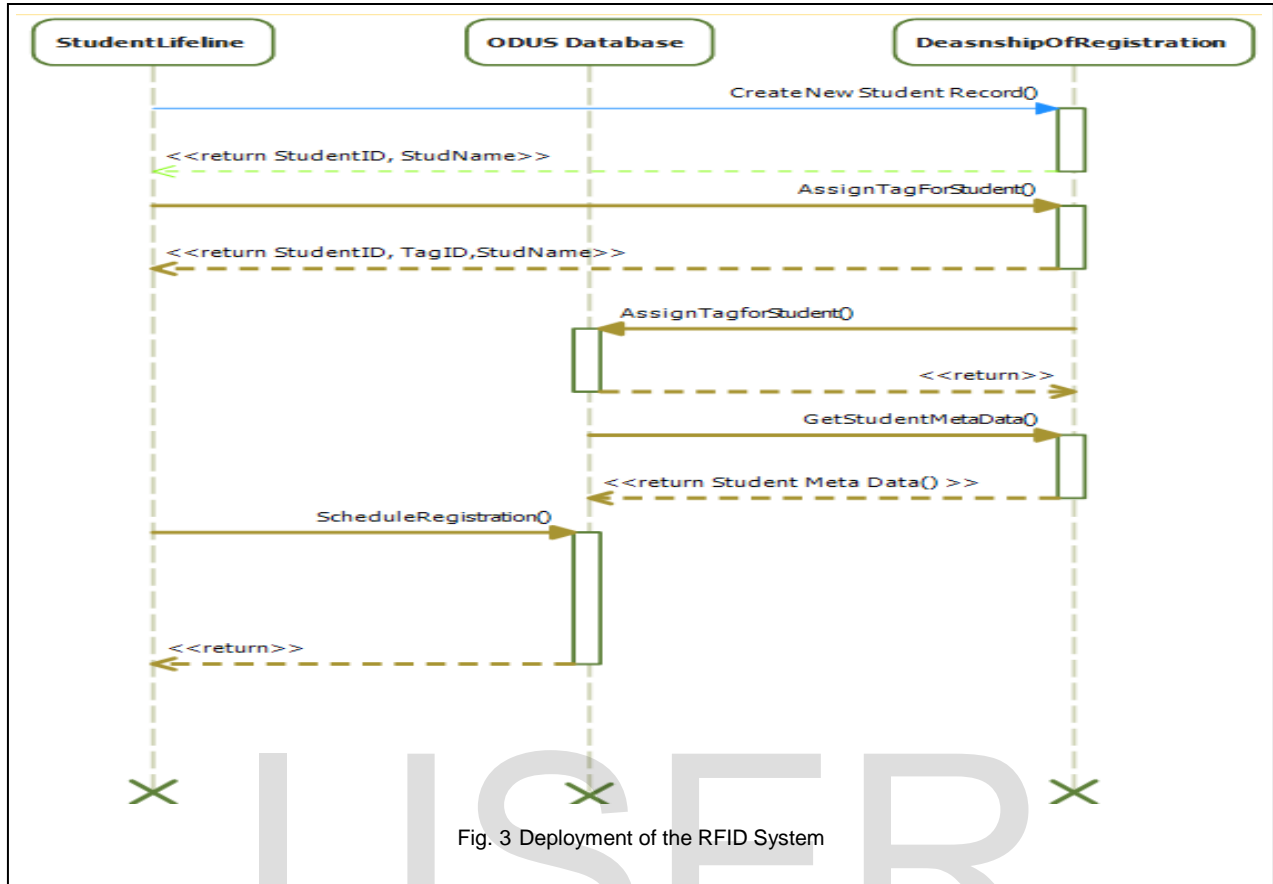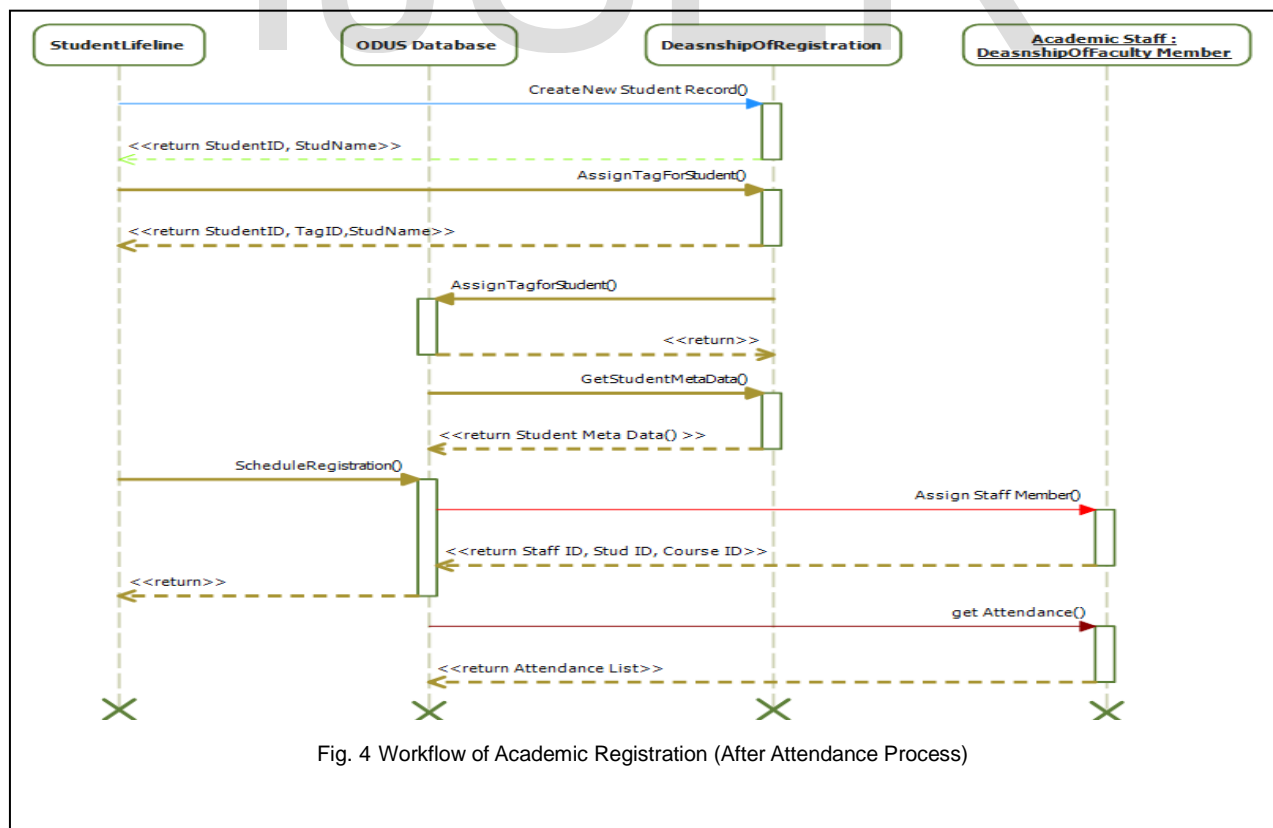
Fig. 3 Deployment of the RFID System

Fig. 4 Workflow of Academic Registration (After Attendance Process)

4 SYSTEM TESTING AND RESULTS

The system is tested according to the following scenario. The scenario was to install RFID reader(s) in classrooms for the three departments. All departments are connected to the faculty's WLAN, the RFID server and the ODUS academic application; therefore a group of RFID students' tags are employed. The software system is implemented using C # to manipulate the ODUS system added to register new student data, using direct connection to the SQL database. First step to run the system, a login page is displayed to authorize the academic staff to access the system. Attendance recording will be started to provide "course information", staff member, and students' course registrations. Therefore, any absent student can be recognized. A sample of the system attendance will be tested, Figure 5 shows a screen shot of students' attendance triggering for courses. The main screen of the system includes: instructor, student, Information technology deanship, admission and registration deanship, and exit buttons (Figure 5-a). If the "Instructor" button is selected, the login screen will be displayed (Figure 5-b).
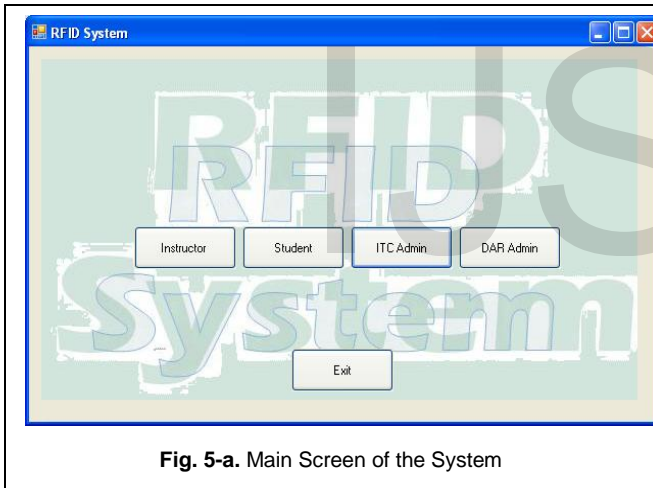

Fig. 5-a. Main Screen of the System

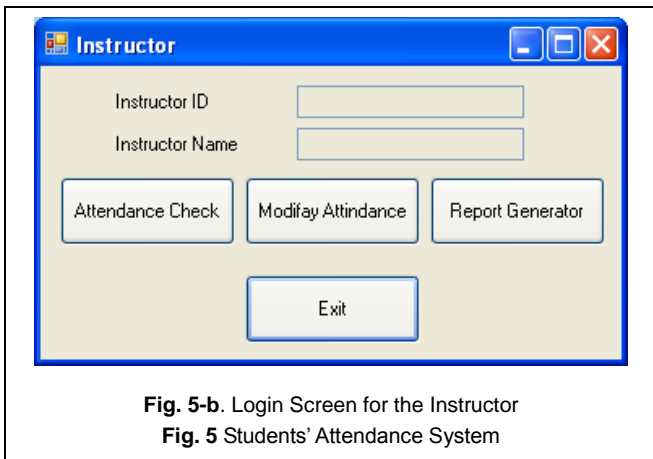**Fig. 5-b**. Login Screen for the Instructor
Fig. 5 Students' Attendance System

The instructor services can be categorized to check,

modify or print attendance. In case of selecting "Attendance Check"; the following screen will be displayed, (Figure 6).
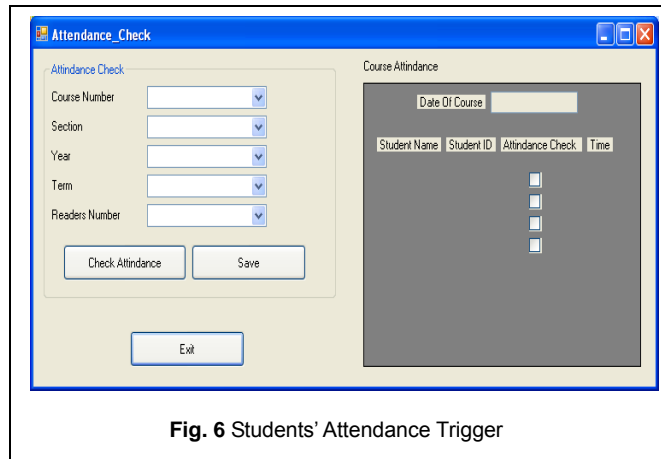

Fig. 6 Students' Attendance Trigger

The final report of the system provides an attendance information sheet, as shown in Figure 7. It includes the course title, instructor name, Student Ids, lectures arranged over the semester, and percentage of presence and absence.

Fig. 7 Students' Attendance Sheet [7]

5 FORMAL DEFINITION FOR EVALUATION

The automated attendance is based on rules to detect attendance of students' events and process them using the academic services provided by ODUS. The formal definition of such events is similar to the definition in [23].

Definition 1: Student event- is a set of attendance events, as the following description: (Student Id, Location, Time, Student Info <Student. Level, Courses … >).

Definition 2: Academic Staff event- is a sequence of defined staff information events, settled by the deanship of DAR, as follows: (Staff Id, Location, Time, Staff Info <Name. Title, Courses … >).

Definition 3: Mapping event- is used to map between staffs and students events, based on the academic regularity rules of the FCIT.

The three definition rules can be defined according to the following operations:

1. Any Event ϵ Student Event (SE);
2. Any Event ϵ Academic Staff Event (AE); and
3. Any Event ϵ Mapping Event (ME)
4. *If* Mapping Event (SE , AE) ***Then*** attendance should take place; i.e.; ME →SE and AE
5. Student Events: S_1, S_2, .. S_N.
6. Academic Staff Events: AS_1, AS_2, .. AS_M.
7. Constraints: S_i .ID → AS_j.ID *and* S_i .Location → AS_j.Location *and* S_i .Time → AS_j.Time
8. Rule *If* Event (E) and constraints ***Then*** Response action.

To prove the effectiveness of the solution, figure 8-(a) and 8-(b) differentiate the performance of traditional solution with the automated attendance solution.
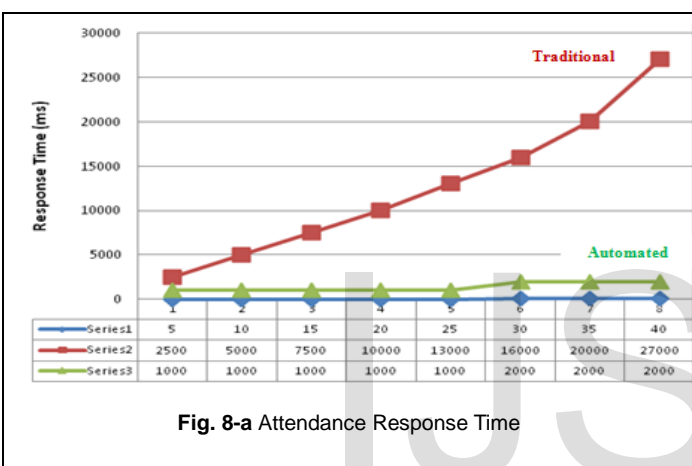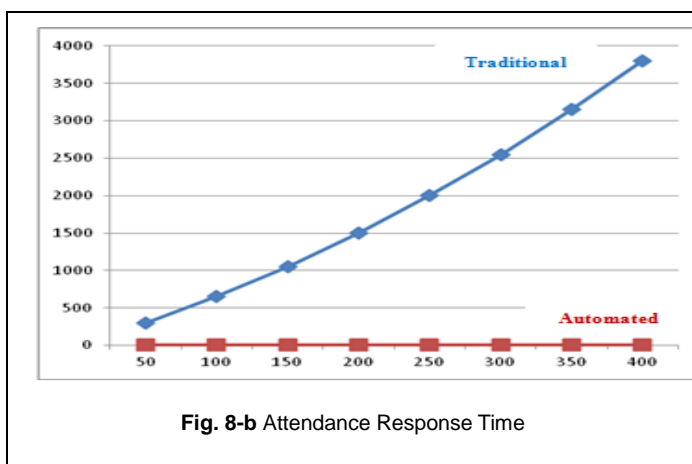

Fig. 8-a Attendance Response Time

Fig. 8-b Attendance Response Time

Figure 8 illustrates that when the number of students in the attendance increases, the response time of the traditional solution rises much more quickly than that with automated system.

The system reflects a positive feedback of academic saving and studying times. The feedback is performed according to the calculated saved time. The calculated time formula is as follows:

Total Time = No of weeks x No of lectures per week x Duration of Lecture (minutes) …   (3)

According to formula (3), we have two categories of lectures; according to the following two formulas:

Total Time $_{3\ lecture\ per\ week}$ = No of weeks x 3 x 50 (minutes) …………………………   (4)

Total Time $_{2\ lecture\ per\ week}$ = No of weeks x 2 x 80 (minutes) …………………………   (5)

Table (1) illustrates such calculations in case of the two modes of lectures: three lectures in week and two lectures in week, taken into consideration the duration of the semester (15, 14, or 13 weeks).

TABLE 1. RELATION BETWEEN TOTAL CREDIT TIME AND WASTED TIME FOR COURSES (3 and 2 days per week)

Courses	Total Time (Minutes)			Wasted Time (Minutes)			%
	15 Weeks	14 Weeks	13 Weeks	15 Weeks	14 Weeks	13 Weeks	
3 Times per Week	2250	2100	1950	225	210	195	10
2 Times per Week	2400	2240	2080	150	140	130	16

While, the total wasted time can be calculated by equation (6):

Total $_{Wasted\ Time}$ = No of weeks x No of lectures $_{per\ week}$ x 5 (minutes) ………………………   (6)

In faculty of computing, FCIT College, each class consists of 25-30 students for each instructor (academic staff). Therefore, to take students' attendance, each class takes between 4-5 minutes, the total spent time during semester (15 weeks with 3 credit hours) = 15 x 3 x 5 = 225 minutes = 3.75 hours (wasted time). Also, to calculate the total academic study time for each class in case of 3 lectures per week = 15 x 3 x 50 = 2250 minutes = 37.50 hours. Figure 9 illustrates the relation between total semester time and the wasted semester time in minutes.
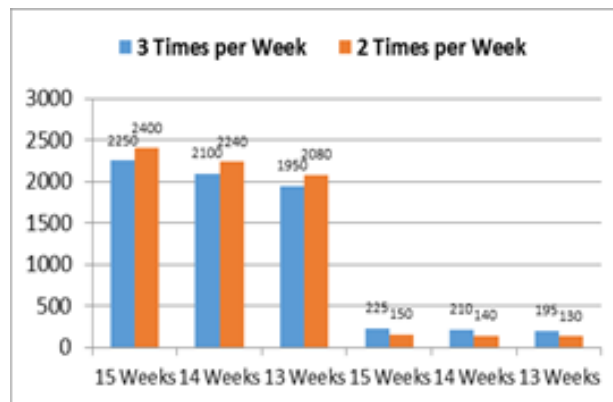

Fig. 9 Relation between Total Semester Time and Wasted Semester Time in Minutes

The total score of the saved time is expressed by the following formula (7):

$$\text{Score Saved Time} = \sum^{N} \text{Time Penalty (Course } (W_N)) \quad \text{………………………} \quad (7)$$

Where N represents the number of courses in academic semester and w is the weight of the academic hours (2, or 3 lectures per week). Time penalty represents the saved time (function of wasted time) as shown in figure 10.

Fig. 10 Saved Time Penalty in Percentage (%)

The total relative penalty formula is as the following equation (8):

$$\text{Penalty (Course }_i) = \text{Score Saved Time }_i \Big/ \sum \text{Score Saved Time} \quad (8)$$

To calculate relative error, between the two methodologies of the two categories of study (3 or 2 lectures per week), the following absolute deviation is used, as shown in the two formulas (9 and 10):

ΔT = True value - Measured value = $T - T_o$; so,

$\Delta T_{3 \text{ Times per Week}} = 50 - 5 = 45$ Minutes   (9)

$\Delta T_{2 \text{ Times per Week}} = 80 - 5 = 75$ Minutes   (10)

Therefore, the relative error between the two categories = 45/75 % = 60 % improvement.

6. CONCLUSION

This paper introduced the design and implementation of academic attendance in classrooms using indoor localization of the RFID and WLAN network in faculty of computing- at KAU. Although, interconnected network of the RFID readers with academic attendance have been demonstrated, a generic middleware component is created, and it can be easily installed in other classrooms within the same faculty or in other institutes. Such paper presented a pilot system. It was found that it reduces wasted time, human effort as man power, minimizes cost of printing, and eases the academic attendance procedures. Consequently, the system has low cost, flexible design, easy to install, control and monitor. The system can be used for other domains such as payment, animal tagging, postal tracking, airline baggage reconciliation, road toll management, control tracking and manufacturing systems.

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