NFC BASED ATTENDANCE: MORE THAN JUST A TOUCH

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Graphical abstract
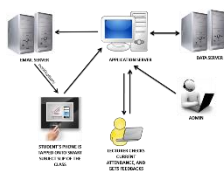
Abstract

The use of NFC technology is growing rapidly and implemented in various applications. It aims to reduce the steps needed to perform tasks by the user in day to day operations such as payment, electronic ticketing, attendance system, and other office related tasks. In this study, university smart environment is implemented using NFC for attendance monitoring system to reduce the need of tedious tasks. The application involves several different concerns in access control and managing physical and virtual components. These concerns are studied to create an easy-used attendance monitoring system using NFC to be applied in a smart university environment. A survey is conducted to measure students and lecturers acceptance in using NFC as an attendance monitoring system. The results provide insights on students and lecturers acceptance in using this technology. Additionally, it shows that both students and lecturers agree on the NFC attendance system should be implemented to ease attendance monitoring in the university.

Keywords: NFC, mobile devices, smart environment, sensor networks

1.0 INTRODUCTION

A smart environment evolves from ubiquitous computing with an intricate network of sensors, actuators, virtual feedback and computing components to enhance our interaction with physical objects. Common activities can now be done efficiently by seamlessly representing physical objects as virtual objects. Near Field Communication (NFC) technology can also be used as a sensor to allow interaction with other physical objects simply by a touch. NFC is commonly embedded into modern day devices such as a mobile phone while physical objects can be tagged with NFC stickers embedded with important information needed to identify the object and keep various forms of data. For example, a paper based application form can be tagged with NFC stickers containing information necessary for a NFC device to recreate the form virtually and allow a user to automatically fill up the form based on personal data on his phone. This virtual form can then be submitted immediately to relevant parties via the Internet.

The university institution contains mainly a large population of administrative staff, faculty members and students. Each individual performs specific activities and requires the interaction of many individuals. These activities are often trivial but require exhaustive user interaction, for example, keeping track of students' assignments or checking and signing a stack of documents. This makes simple

activities to be cumbersome, strenuous and time consuming for most individuals. To simplify the activities and processes performed by the university stakeholders, most universities implement web application technologies to automate these activities. Nonetheless, such automation in most cases still requires a lot of user interaction, for example to fill up information in a form. In some other cases, physical objects are necessary and are not easily translated into a digital form as the case for exam slips, certified documents and etc.

The tasks required to be done usually consist of numerous steps in a workflow involving university stakeholders (administrative staff, academic staff and students). An interaction between stakeholders may result in an unnecessary bottleneck that could affect the whole university performance. Therefore, the current system in any university can be described in 3 words; extreme workload, wasteful, and slow.

In this paper, we concentrate on implement NFC technology in a smart environment designed to help university stakeholders, such as administrative staffs, academic staffs, and students. Our main focus is in improving class activities. The motivation for this study is to replace some of the physical objects used in class and subsequently reduce the tasks needed in university operations. We like to define such implementation as a smart university environment where NFC technology is implemented to work with the university existing computing and network infrastructure. The result of such implementation is to reduce the time spent on executing tasks, decrease the expenses spent on resources, decrease cost on skilled man power and create an environmental friendly system.

The rest of this paper will be organized as follows, section literature review discusses various implementation of NFC technology in different kinds of environments and different approached used in NFC-based attendance system. The research methodology section describes the research design, data gathering and proposed NFC-based attendance system in detail. The implementation chapter explains how the processes take place for each stakeholder, mainly students and lecturers. The results chapter presents the results from the questionnaire conducted in this research and finally, the conclusion section discuss limitation of this research, future advancement and concluding remark regarding this paper.

2.0 LITERATURE REVIEW

Near Field Communication (NFC) is a contact-less short range communication technology. NFC consists of two main components, the tag which contains the information and the reader or/and writer that is able to extract information from a tag as well as to put information into a tag. NFC enabled phones can act both as a tag, and as a reader or/and writer. NFC tags can be in the form of stickers, wristbands, and chips. There are three operating modes that NFC technology can perform. Read and write, peer-to-peer and card emulation.

As previously mentioned, NFC works in three ways; Card Emulation mode, Read/Write mode, and Peer-to-Peer mode. Nasution, Husni, and Wuryandari [10] implemented these operating modes in their NFC-based e-ticketing and e-payment system for train ticketing in Indonesia using NFC-enabled phone. The phone's credit balance acts as the money to purchase the train ticket and the NFC tag inside the phone stores the ticket information which includes destination, departure and arrival time. Nasution's research in NFC technology reduces the time for a passenger to purchase and check a ticket. It also managed to reduce the rate of illegal ticket purchasing and eases the train company to record activity logs. The survey to several correspondents conducted on this study resulted in more than 50% rate of satisfaction.

Borrego-Jaraba, Ruiz, and Gómez-Nieto [4] proposed a city navigation application using NFC technology in Cardoba city. By waving a NFC-enabled phone to a NFC-based smart poster, information such as "where I am", "what's there, around me?", "what is", and "how i can find" cursors will be displayed on the phone with graphical map and text information. The implementation shows how NFC technology can provide flexibility to tourist in acquiring tourist information points and other information regarding tourist attraction centers.

In another paper, Mantoro and Milisic [7] introduce a method using NFC to ensure that every individual is who they claim to be for authentication, non-repudiation, confidentiality and integrity of data. Since NFC enabled mobile phones comes with a registered SIM card, NFC enabled phone takes advantage of the SIM card to provide additional strength on top of public key cryptography for security and portability.

2.1 Smart University

One of the focus of smart environment is in the education environment. Dekdouk [6] integrated mobile and ubiquitous computing in creating smart classroom for elementary and post-secondary school students. By using the tablet as the main device, it allows the student to load their own workspace into the tablet. Students can access the notes, lab's materials, and exam and quiz solutions. Three main factors were used to measure the efficiency and effectiveness of the method; the student performance, the easy-to-use technology, and the information security. Similarly, in this paper, we measure the ease of use to measure efficiency and effectiveness.

Rehman, Abbasi, and Shaikh [13] discussed several implementations of RFID technology in the university. He implemented RFID as a student's and a staff's

identification, where RFID chip stores the information of the student and the staff. This identification will be used to record their attendance. Another usage of RFID is to track the person or the equipment. It is mentioned that it will reduce the theft rate in the university. A major drawback in using RFID is that, the RFID equipment, which include its tag and reader are expensive. The university has to spend a huge amount of money to provide RFID tags for every student, staff, and their belongings. And the university has to spend more in providing the RFID reader in each room or entry. Furthermore, the range of RFID's accessibility can be up to 100 meters, which means that there is a high possibility for a man within that range to hijack the network or the communication process between the RFID tag and its reader to manipulate its data [12].

2.2 NFC-based Smart University

NFC-based Smart University is the implementation of a smart university using NFC. The common functionality proposed and implemented are ID card, payment, and smart poster. Miraz, Ruiz, and Gómez-Nieto [8] proposed utilizing NFC technology as the student's ID card in University of Cordoba. The same thing was also implemented with a different scenario in the Budapest University of Technology and Economics as mentioned by Benyo, Sodor, Doktor, and Fordos [3]. Benyo *et al.* implemented additional authentication measurement which is the fingerprint as the reliable link between the student's card and the person who is holding that particular student's card.

Another implementation of NFC-based attendance monitoring system is discussed by Bueno-Delgado, Pavón- Marino, De-Gea-García, & Dolón-García [5] in the paper, where NFC-based attendance system was used to replace manual attendance system that used paper or web-based system. NFC beam is one of the methods used in NFC technology to transfer information by simply tapping or touching two NFC-enabled devices. This method was applied in this system where student's NFC-enabled phone touches lecturer's NFC-enabled phone. However the student still needs to key in his/her login ID and password before sending his attendance record to the server. Considering the big number of students that one class may have, typing login ID and password doesn't seem efficient. It may reduce the rate of a student impersonating other students, but it is still time consuming. Miraz *et al.* [9] saw NFC technology as the opportunity to implement e-payment for other services in the university. NFC-enabled phone was proposed as the payment device for photocopy service, vending machine, and transportation within campus.

Another common implementation of NFC technology is a smart poster, where a poster contains digital information that can be accessed by the users, by simply touching the phone to the NFC tag which is placed at the back of the poster. Ayu, Mantoro, Ismail, and Zulkifli [1] implemented the smart poster for the online academic calendar of the university. It shows that it offers simpler way to manage the information, where there is no need to change the poster every time the information changed. Instead, it is done by updating the information in the system. It can also be implemented for SMS and Call, where by touching the phone to the NFC tag, the information stored inside the NFC tag will instruct the phone to make a phone call or send a sms to a particular number stored in the NFC tag. Another scenario of the implementation of a smart poster is to store the technical and administrative service information, such as class schedule and class cancelation, class enrolment, as mentioned by Miraz *et al.* [13].

Benyo *et al.* [2] in his paper gave another scenario of using smart poster for the subject registration, where students register themselves to certain class by touching the phone to the smart poster, according to which class they would like to enroll. The smart poster was also used for the examination registration purpose. However, the concept requires the student to be physically in the area where the smart poster is located. Unless the smart poster is located in many places, it will not be convenient for the students.

In another paper, Sodor, Fordos, Doktor, and Benyo [11] discussed about a contactless examination system named CUE (Contactless University Examination). This system is used for the examination completion procedure, student identification process, and managing and publishing examination date and place. In order for a student to be eligible to attend an examination, that student should fulfill some requirements, where he has to be registered for that particular subject, has certain percentage rate of attendance, registers for the examination, and attends the examination. Those procedures are managed by the CUE system. If the students fulfill the requirements, then they are allowed to sit for the examination. They can either complete the examination by using their phone or the terminal. However, the type of examination question is not discussed in the paper. For some essay questions, it is not convenient to answer on the phone, especially on the small screen. And even if the students choose to do it on the terminal, it forces the university to provide a big number of terminal, and in the end, it eliminates the initial advantage of NFC technology, which is cost saving, compared to other ranged-communication technology.

A summary of previous NFC research for smart environments is presented in Table 1.

Table 1 A summary of NFC research for smart environments

Author	Environment	Application	Limitations
Ayu, M. A, Zay, A. Z.Z (2013)	University	I-Tick: NFC-based Attendance Monitoring System I-Sit: NFC-based Automatic Form Submission System	
Ayu, M. A, Zay, A. Z.Z (IRIEE 2013)	University	TouchIn: NFC-based Smart Attendance System (IRIEE 2013, Gold) & (ITEX 2013, Silver)	
Nasution et. al (2012)	Public Transportation	E-ticketing: Train e-ticketing	The record of itinerary stored on his phone is temporary
Borrego (2010)	Public places	Smart Poster: Supporting Tourism Application	Dependency on smart poster at every junction
Miraz et. al (2009)	University	Smart poster: Class Schedule and Venue, Schedule Changing/Cancellation, Exam Time Table E-payment: Tuition fee, printing/photocopy fee Access Control: access to university facilities	No mention of process flow and security measurement of the payment system
Bueno-Delgado at. al (2012)	University	Attendance Monitoring System: Implementing NFC Beam Access Control: Access control for available resources in university; class, laboratory, library. Smart Poster: Subject registration, Examination Registration Library System: Reading Book Information	Students still need to key in their login ID and password (time consuming)
Sodor at. al (2011)	University	CUE (Contactless University Examination)	No mention of the type of questions. Essay questions are not convenient to be answered on the phone
Ayu et. al (2012)	University	Smart poster: Dynamic Notice Board, URL redirection, Call and SMS	No relation to university flow
Benyo et. al (2012)	University	Smart Card: Identification Card E-payment: Tuition fee	Fingerprint sensors are costly

3.0 METHODOLOGY

This study involves investigating on the system workflow, which includes the process of collecting the information, authenticating the information, recording the information, and managing the system. The experiments in this study are conducted to test two scenarios; students' scenario and lecturers' scenario. Most of the time, a system will be convenient for the front-end users, while the managing factor is often missed out. Thus, this study will also review how easy the workflow is for the back-end users to manage the system.

The procedure of recording student's attendance is implemented in different ways for different

universities. Some universities still implements manual attendance record where students are required to sign the printed attendance sheet during the lecture session. A few universities use student's ID card to record the attendance, where ID card is scanned to record student's information and attendance.

However, some issues regarding its accuracy in recording student's attendance arise. There is high possibility that the student signs for other students who are not attending the class. Even though few universities use student's ID card, there is still a possibility for the student to give it to their friend to perform the digital signing process.

The NFC-based attendance monitoring system is proposed and designed aligned with the purpose to

overcome such problems. The NFC-based attendance monitoring system is an NFC based application system that records student's attendance in a way that prevent student from attempting to perform illegal attendance-signing activity. Figure 1 shows the system design of the NFC-based attendance monitoring system.

Figure 2 shows the workflow of the NFC-based attendance monitoring system. The NFC-based attendance monitoring system application is installed in student's phone that will grab student's specific information for the authentication process. The NFC tag on the smart subject slip contains information or code to identify the course as well as the server URL. It will be brought by the lecturer to the class. Student will simply touch his phone to the smart subject slip. The identification parameter will be sent to the attendance system server. The server system will look for that particular student in the student list of that particular class, and match the identification parameter with the one that has been stored in the database before. If the student's verification and validation are affirmative, then the student's attendance is recorded. This NFC-based attendance monitoring system only records the attendance during the class time. This would mean that the students will not be able to digitally sign the attendance outside of the class time.
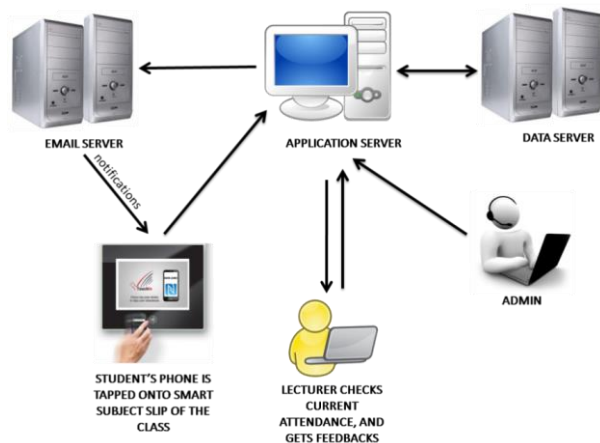
Figure 1 NFC Attendance Monitoring System relies on a PHP application back end, with an Android front-end. NFC device interacts with a smart subject slip (an ordinary paper with embedded NFC sticker). Lecturers are then able to monitor attendance via a web browser.

By implementing this system, it will simplify the work of lecturers in recording student's attendance, and it will also provide a reliable system that determines whether the student passes the attendance

requirement or not. This concept also reduces the possibility of mistakes, as the attendance will be automatically stored in database without having to key them in manually. It will also reduce the possibility of students signing other student's attendance, as the verification and validation measurement are stored in student's phone individually. Considering phone is a very personal belonging that less likely to be passed to other people. This application system is also environment-friendly, as it uses no printed paper. Figure 3 show the pseudo-code used to develop the student's system.

There will be another mobile application that specifically developed for the lecturers. The lecturers can monitor the attendance system by touching their phone to see the list of students who are present in that class. In order to give flexibility for lecturers, in case there are some replacement classes which are not held at the usual time, lecturers are required to key in the class schedule, including the date and time, at any time before the class begins through its web based system. The lecturer is allowed to access the server system through the web based system to get the list of attended students of different class times. Figure 4 below shows the workflow diagram of the attendance monitoring system. Figure 5 shows the pseudo-code of the NFC-based attendance monitoring system for the lecturers.

In this study, a survey was conducted to a controlled group of students and lecturers. The test was designed for two scenarios; students' and lecturers'. 30 participants participated in the students' scenario, and 15 participants participated in the lecturers' scenario. Each participant was briefed on how to use the application. And each one of them would perform the steps following the student's scenario and the lecturer's scenario. At the end of the test, they would be presented with the result of their action, for example, the attendance that has been recorded for the students, and the list of students who attended the class for the lecturers. Several questionnaire in a liker scale of 1 to 7 (1 being strongly disagree and 7 being strongly agree) were given to the participants.

Essentially the questionnaire covers the following scopes:

- How clear, quickly, and easy the steps are to perform.
- How delighted and content the users are with the system.
- And how likely they will recommend the system to others and whether they are willing to continue using the system.
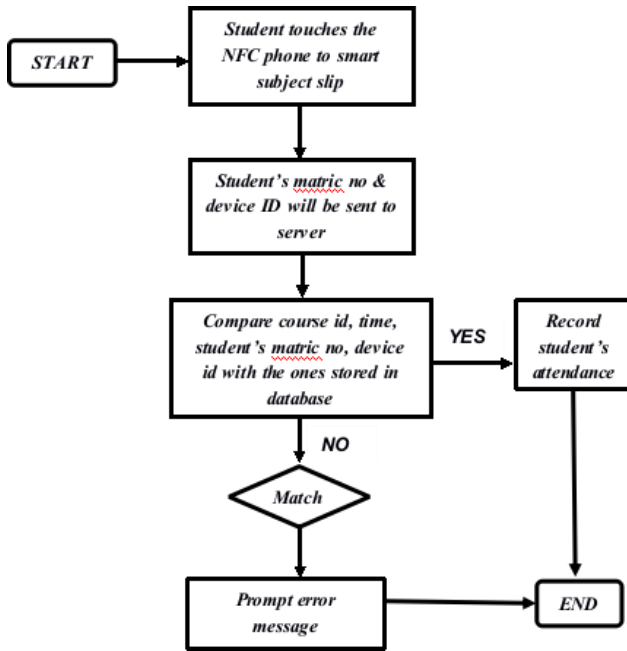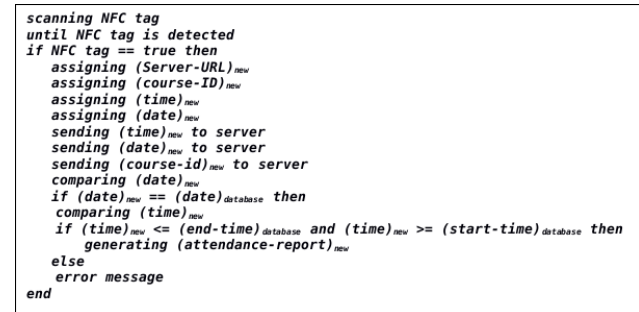
Figure 2 System Workflow of Attendance Monitoring System (Student)
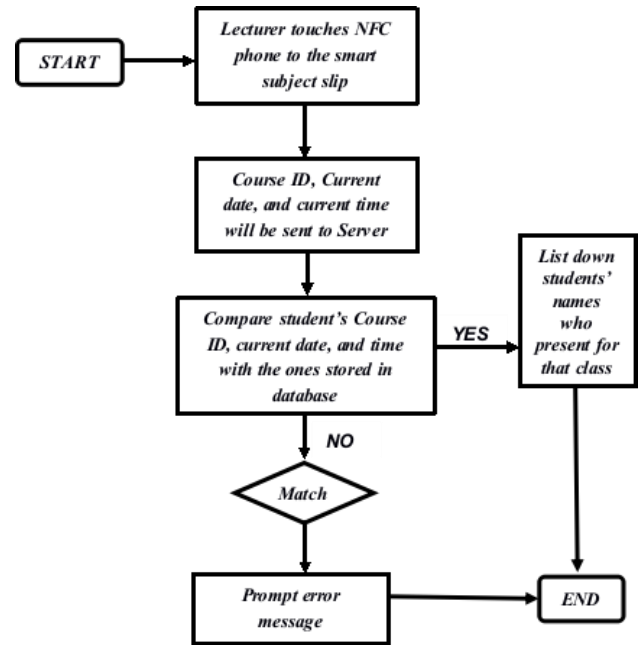
Figure 4 System Workflow of Attendance Monitoring System (Lecturer)
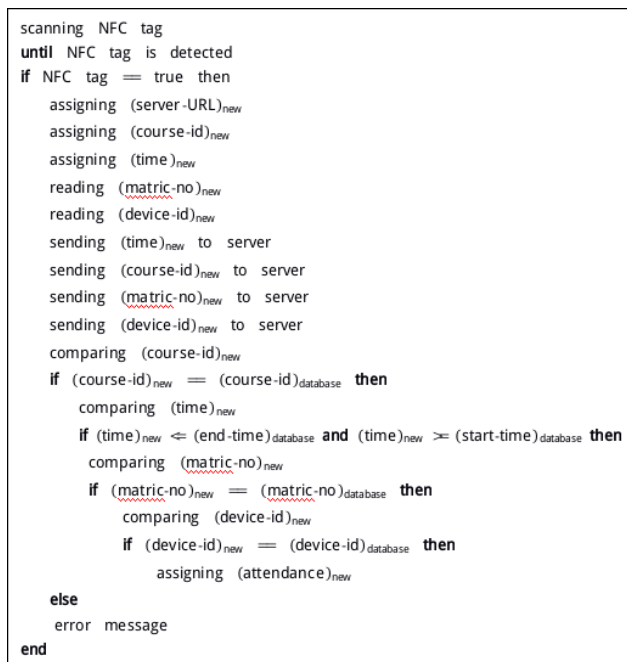
Figure 3 Student's attendance system pseudo-code

Figure 5 Lecturer's attendance system pseudo-code

4.0 IMPLEMENTATION

Our focus is in the implementation of two major stakeholders which is students and lecturers. Therefore the current implementation of this NFC-based attendance monitoring is divided into two scenarios of the university stakeholders: Students and lecturers (academic staffs).

4.1 Students

Students do the least steps in this scenario. They need to register once in the beginning of their enrollment in the university. This registration is done to record their device information and match it with their profile in the database. If they wish to change their device, they are required to contact the system administrator to register the new device. In this case, the device is their NFC-enabled mobile phone.

In every class, they are required to bring their mobile phone and tap it over the smart subject slip

carried by the lecturer. By doing so, their attendance will be recorded if only they sign the attendance within the class time. If they fail to sign their attendance, they will need to contact their lecturer.

4.2 Registration

The registration is done by the student and the enrollment committee. Students will need to download the registration application from a certain link. When they access the application, they will get the screen as shown in Figure 6.

They are required to enter their matric number. The application will get the matric number and store it in .dat file in the phone. And at the same time, the matric number will be used to match their records in the system. The device ID will be extracted and stored in the database based on their matric number.

4.3 Attendance

In every class, the lecturer will bring the smart subject slip. The students will need to tap/swap their phone over the smart subject slip. The smart subject slip has an NFC tag attached on it. It stores the server URL and the course ID. Each course ID refers to a specific class section in a specific semester of a subject enrolled by the students.
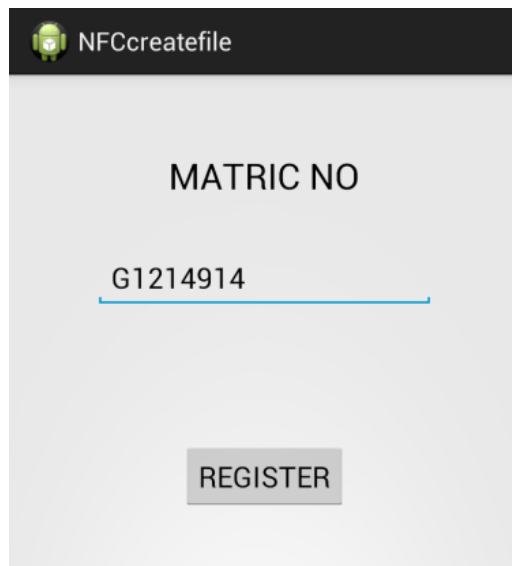
identify the schedule ID of that particular session of the class for attendance record purposes. The time of signing the attendance will also be verified. If the time is still within the class time, the presence of the student is considered valid, and the attendance will be recorded together with prompting the attendance confirmation message as shown in Figure 7. While a rejection message will be prompted if the time is out of class time, which, in this case, the student need to contact their lecturer individually.

4.4 Lecturers

The scenarios of lecturers are divided into two; updating replacement class and generating attendance report. Lecturers start the semester with the assumption that the classes have been scheduled in the system. Each lecturer will know the class ID which is different for every subject, every academic year, every semester, and every section. The lecturers will be given the smart subject slip for each class they teach.

Figure 8 shows the login page of the Attendance monitoring system for the lecturers. Once the lecturers login, they will be directed to the menu page, which gives them two options; whether to register the new class schedule or to generate attendance report for any of their classes as shown in Figure 9.

Figure 6 Registration Application

When the student taps/swaps his/her phone over the subject slip, the application will grab the matric number stored in the phone, the device ID, and the class ID stored in the NFC tag attached to subject slip. These information are sent to the server URL stored inside NFC tag. Using matric no and device ID to validate if that student is registered for that particular class. The course ID and time are used to

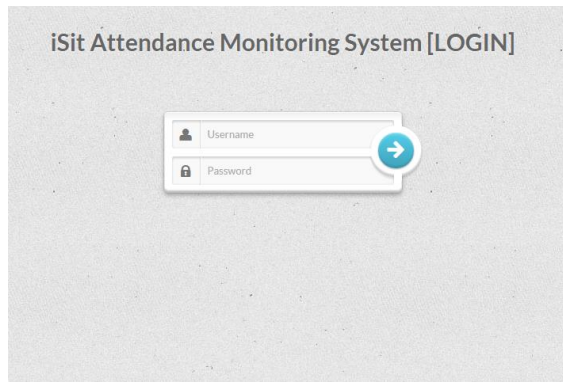**Figure 7** Attendance recorded
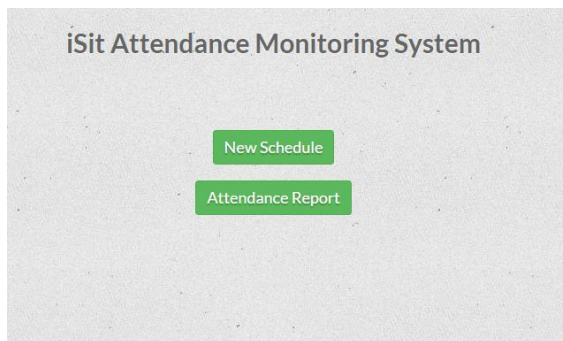
Figure 8 iSit Login Page

Figure 9 iSit Menu Page

5.0 RESULTS

In this section we provide a summary of the results from the survey given to students and lecturers.

5.1 Students Results

Students perform the least number of steps. The main steps are registering their device and signing the attendance. As of Figure 10, 80% of the participants strongly agree that the steps are clear and understandable, while 16.7% agree and the remaining 3.3% slightly agree on this. More than 73% also strongly agree that it requires a shorter time to learn the steps, which also shows how easy the steps are. Looking at the process of signing the attendance, 70% strongly agree that the recording process is quick. This is measured by the time it took to record the attendance from the time that the student tapped their phone to the smart subject slip.

Looking at the overall experience of the students as shown in Figure 11, 60% strongly agree that they are pleased, content, and delighted with the system. 66% of the participants strongly agree that this system is recommended to be implemented in university environment. And 60% of them are also willing to continue using the system for attendance system. The rest of the participants who are neutral and slightly agree to recommend this system to be implemented

conveyed their reasons of depromoting the system. This is mainly because the NFC-based attendance system does not offer them the flexibility to ask their friends to perform illegal attendance signing, as they are less likely would pass their phones to their friends for it. This shows how the system is aligned with one of the research's objectives, which is to reduce the percentage of illegal signing by the students.
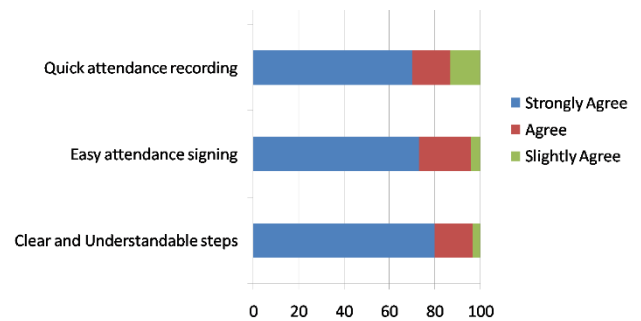

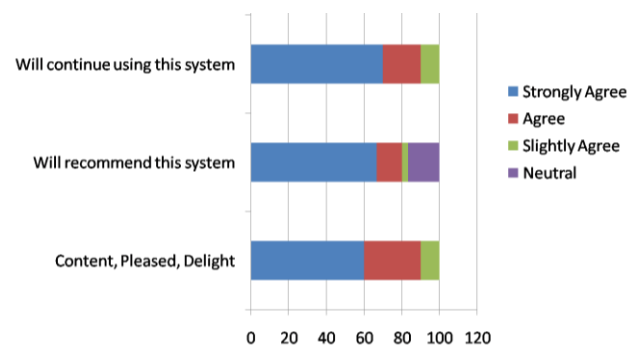**Figure 10** Students response to registration process

**Figure 11** Overall Students response to the system

5.2 Lecturer Results

Lecturers are responsible to add the new class schedule when there is any additional class outside the scheduled time. On this case, the lecturer would need to add the new schedule to the system via the web system. The lecturers have two options for retrieving the attendance list. They can do so by tapping their phones to the same smart subject slip of they wish to retrieve the list within the class time. While they can also retrieve the attendance via the web system, if they wish to get the attendance list for other schedule.

On the lecturers' side, Figure 12 shows that 74% agree that the steps are clear and understandable. The same percentage also agrees that the steps are easy to learn. Looking at the performance of the system, more than 53% strongly agree that it took short time to add the new class schedule into the system, and it also took short time to retrieve the attendance list. 60% of them also strongly agree that

the processes of adding the new schedule and generating the attendance report are easy.
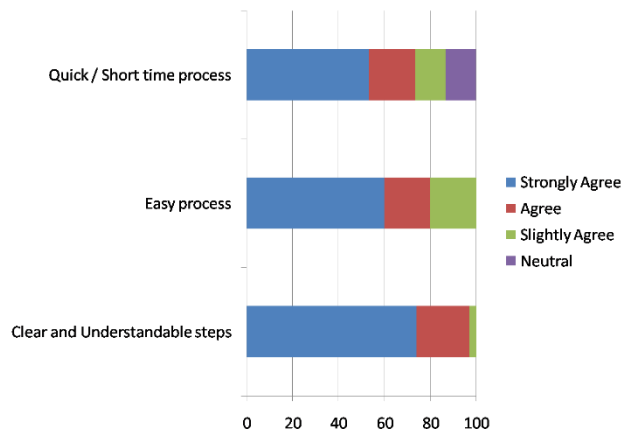
Figure 12 Lecturers response to attendance monitoring system

Looking at the overall experience, 53% of the participants strongly agree that they are pleased, content, and delighted with the system. More than 56% strongly agree that this system will improve the attendance monitoring process if it is implemented in the university environment. 60% of them strongly recommend this system to be implemented in the university, and they are also willing to continue using this system if it's being implemented. This is as shown in Figure 13.
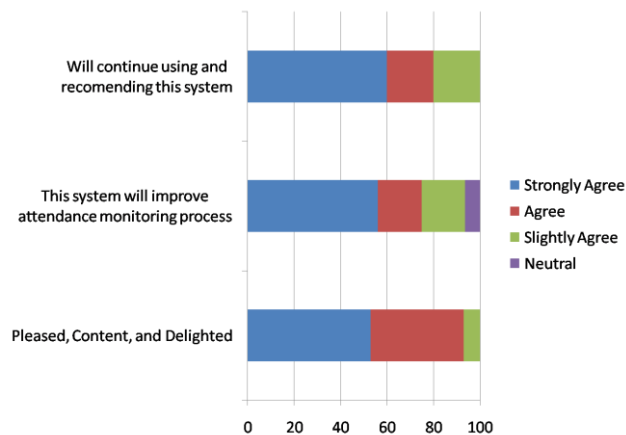
Figure 13 Overall Lecturers response to the system

The results clearly show how the NFC-based attendance system is developed aligned with the objectives of this study. The system is not only easy to learn for students and lecturers, but it also takes lesser time to complete the tasks.

6.0 CONCLUSION

By implementing NFC technology in the university, it will significantly reduce the workload of administrative staffs, academic staffs, and students. Most of the workload will be done automatically by the system itself. Consequently, this will reduce the expenditure on skilled man power and resources. It leads to environmental friendliness and most importantly it is time efficient. The authentication process will prevent attacks from happening, and will ensure accountability. The performance will be easily recorded and easily evaluated by the university management. Clearly the use of this touching paradigm provides more than just a touch to the university. Furthermore, the results conducted in this study shows that that lecturers and staff are ready to accept and use this technology.

This paper also provide researchers and system developers with the technical guidelines in developing an NFC application as a service in a university. While the scope of this research is limited to an attendance system mainly for students and lecturers, it can also be applied to various business workflows with similar benefits. We leave it to the research community to explore further use of this technology.

Acknowledgement

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