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A Review of Student Attendance System using Near-Field Communication (NFC) Technology

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Abstract. The rapid growth of system development is no longer subtle and continuously improving today's system. In education sector, the student attendance system is able to be applied by Near-Field Communication (NFC) technology. NFC can be referred to as a device that can detect information and/or command from a tag by bringing them together in a close proximity or even by touching together. Traditionally, the manual attendance system would require a lecturer to pass around an attendance sheet for students to sign beside their names and another method would require the lecturer to call out the students' names one by one and register their attendance. The attendance system based on NFC is meant to improve the manual attendance system and therefore the aim of this paper is to review the existing research

Keywords: NFC, RFID, attendance system, systematic review

1 Introduction

Near-Field Communication (NFC) has been growing and developing endlessly throughout the globe. It has been introduced and used in several modern educational institutions where its services are proved beneficial [8], [9], [12]. The intention of applying NFC in an educational institution is for the purpose of observing and improving student's attendance. Applying NFC could function as a platform that drives institutions towards a modern environment through innovative solutions.

There are various inventions that allowed NFC to become a powerful tool which only needs proper requirements and installation. In this regard, related work around the globe has innovatively provided direct and indirect realization in creating NFC. Biometrics, web-based attendance, and bar scanning are some of the earliest inventions that functions almost similar as NFC[1], [3], [4],

The traditional process of taking student's attendance is time consuming and takes too much effort especially to record and to maintain it. Lecturers are required to call out the names of each student one by one and this process would consume time especially for a large class. Another method is to distribute an attendance sheet where students can check their credentials and sign it. However, the only drawback is that students can be dishonest by signing on their friends' behalf. In general, the manual or traditional way in recording attendance is usually time consuming and may distract the teaching process [5].

In creating NFC-based system, the two main components required are "reader/writer" and a "tag" [5]. NFC covers standard communication protocol and data exchange formats that is based on Radio Frequency Identification, also known as RFID [5], [6]. The introduction of NFC technology in students' attendance system will likely have a significant impact on the teaching and learning environment [21]. The expectation of using NFC based attendance system is also to utilize the two items that students always have and should always bring; i.e. their smart phone and matric cards.

This paper review previous researches made for a variety of purposes related to the use of NFC in registering attendance. To achieve this objective, we have carried out a systematic literature review to identify all existing research evidence that is relevant to this topic. This study can contribute to the body of knowledge of the use or adoption of NFC in education institution in particular for managing attendance or participants in an event/class. Section 2 describes the related work contributing to NFC research and Section 3 describes the review method that we have followed in our research. Our review and analysis on existing research are available in Section 4. Finally, Section 5 concludes our study.

2 Related Work

NFC technology and student attendance system has existed for quite some time. We refer to NFC as a system that transfers data in a short distance wirelessly and the standards communication protocol are based on existing RFID standards [5]. The introduction of NFC technology allows developers to write applications such as attendance system, ticketing, cashless payment, and membership authentication [6].

Biometric is another contactless technology that has been successfully commercialized worldwide where it uses the physical and behavioral aspect of a person to secure authentication. Using retina, voice, and/or thumbprint allows the biometric system to uniquely distinguished one person from the other [4]. However, one of the issues with implementing biometric in student attendance system is that its high-tech nature requires quite an expensive tool; therefore their implementation might not be cost-effective for an institution.

One of the oldest technological break-through was the barcode system [4]. It is far more affordable than the biometric system and is still effective in certain aspects. Barcode uses unique identification of retrieving data and make use of symbols gener-

ally, like a bar, vertical, space, square and dots which contains different widths. Some institutions use this method but it was reported to be less reliable [4].

The most promising research conducted by several different researchers is about Radio Frequency Identification (RFID) [4], [1]. It has been reported that RFID is one of the most suitable technology for a student environment particularly for an attendance system. For instance, Mohamed et al. [1] report that the innovation of a system that records data automatically in universities using RFID is a suitable solution to their problem in recording students' attendance.

One of the examples from existing projects related to NFC is the TouchIn NFC supported attendance system [5]. The system focuses on using NFC for improving the manual approach of recording attendance. The system is equipped with NFC tagging that keeps the attendance record using web-based method. The system components included the reader unit and server unit; reader unit reads the tag (student's credentials) and the server unit records it.

Another project that consists of using NFC for attendance is the *Attendance System using NFC Technology and Embedded Camera Device on Mobile Phone* reported by Subpratatsavee et al. [6]. In their study, they have increased the level of security of the previous research by making use of the camera located on the back of every smartphone. To avoid students passing around their NFC tag for attendance, the camera is used for verification that whoever tags it must be the same person as in the photo, which of course would be monitored by the lecturer or administrator. This project uses the concept of one centralized server to store its data efficiently while all related mobile phones connected to the server. Users can also import and export data effortlessly.

Bucicoiu & Tapus (2013) [7] propose a location-based authentication for attendance system using NFC technology integrated with Moodle. The system exploits both NFC and pictures to ensure double verification on student attendance. The unique part about this project is that it uses a Moodle, which is one of the most popular e-learning platforms. By applying Moodle, lecturers can verify their students more effectively and a lot faster than verifying them individually.

Enabling various functions and creative uses of NFC will further improve and enhance previous research in terms of what is lacking in certain fields for instance in the security and performance aspects [2]. Extracting information on what these researches are providing and what they are lacking are the key to pushing ourselves towards innovatively implementing and improving NFC-based student attendance system. In the next Section, we describe about the method we used in identifying studies related to the use of NFC in managing students' attendance.

3 Research Method

We used a systematic literature method to systematically identify, evaluate, and analyze all available studies on NFC technology on attendance system in the education sector. The research question addressed in this paper is "What studies are available regarding the use of NFC technology in university/school attendance system?" As suggested by Petticrew & Roberts [23], the formulation of the research question was

based on the five elements known as PICOC – *Population, Intervention, Comparison, Outcome* and *Context* (see Table 1).

We followed the guidelines by Kitchenham & Charters (2007) in conducting this SLR [10]. The search process involves the use of five online databases: IEEEExplore, ACM, Scopus, Springer, and ScienceDirect. The search terms used were “*NFC AND attendance*”. The breakdown of literature searches from online databases is shown in Table 2.

Table 1: PICOC Elements

Population	Studies reporting about attendance system
Intervention	Use of NFC technology
Comparison	N/A
Outcome	Implementation or proposed attendance system
Context	Research conducted within academic setting

Table 2: Breakdown of Literature Search

Database Name	# Studies for screening (A)	# Excluded Studies (B)*	# Relevant Studies (A – B)
IEEEExplore	10	0	10
ACM	10	6	4
Scopus	5	2	3
SpringerLink	50	49	1
ScienceDirect	66	63	3
TOTAL	141	120	21

(* after screening of Titles and Abstracts)

Our major inclusion criteria is to include studies that have included NFC technology in their research paper relating to monitoring students’ attendance or participants. We excluded studies that were not conducted in academic setting or commercial based attendance system. Additionally, we excluded research that appears as work-in-progress, posters, and papers not written in English.

During the initial phase of search, we found a total of 21 studies related to NFC and attendance system. However, after reading the full text articles and removing duplicates, only 17 studies can be included for analysis. Note that this review only included published studies indexed in online databases including conference papers and journal articles. List of studies included in this review is shown in Table 3.

Table 3: List of included studies

Author(s) & year	Title	Country
Chavira et al. (2007) [8]	Spontaneous Interaction on Context-Aware Public Display: An NFC and Infrared Sensor approach	Spain
Ervasti et al. (2009) [9]	Bringing Technology into School – NFC-enabled School Attendance Supervision	Finland
Rahnama et al., (2010) [11]	Securing RFID-Based Authentication Systems Using ParseKey+	Turkey
Ervasti et al. (2009) [12]	Experiences from NFC Supported School Attendance Supervision for Children	Finland
Isomursu et al. (2010) [13]	Evaluating Human Values in the Adoption of New Technology in School Environment	Finland
Ninomiya et al. (2012) [14]	Bridging SNS ID and User Using NFC and SNS Design of NFC and SNS based event attendance management system	Japan
Ninomiya et al. (2012) [15]	Near Friends Communication Encouragement System Using NFC And SNS	Japan
Benyo et al. (2012) [16]	Student attendance monitoring at the university using NFC	Hungary
Bueno-Delgado et al. (2012) [17]	The Smart University experience: A NFC-based ubiquitous environment ()	Spain
Benyo et al. (2012) [18]	University life in contactless way - NFC use cases in academic environment	Hungary
Ichimura & Kamada, (2013) [19]	Early Discovery of Chronic Non-attenders by Using NFC Attendance Management System	Japan
Bucicioiu & Tapus (2013) [7]	Easy Attendance: Location-based authentication for students integrated with Moodle	Romania
Subpratatsavee et al. (2014) [6]	Attendance System using NFC Technology and Embedded Camera Device on Mobile Phone	Thailand
Ayu & Ahmad (2014) [5]	TouchIn: An NFC Supported Attendance System in a University Environment	Malaysia
Isomursu et al. (2011) [20]	Understanding human values in adopting new technology—A case study and methodological discussion	Finland
Fernandez et al. (2013) [21]	Control of attendance applied in higher education through mobile NFC technologies	Spain
Shen et al. (2014) [22]	Developing a NFC-equipped smart classroom: Effects on attitudes toward computer science	Taiwan

We reused some of the questions available in the literature to identify the study quality assessment. Table 4 shows the criteria used to evaluate the quality of the included studies. Each question was rated based on the following ratio scales: 1=partially; 0.5=Partially; 0= No. We used a score scale of 0 to 6: Very Poor (Score < 2), Poor (Score of 2 to <3), Fair (Score of 3 to <4), Good (Score of 4 to <5), and Very Good (Score of 5 to 6).

Table 4: Quality criteria

Item	Answer
1. Are the aims clearly stated? [10]	Yes/No/Partially
2. Is there an adequate description of the context in which the research was carried out? [10]	Yes/No/Partially
3. Was the data collection done very well? [24]	Yes/No/Partially
4. If the study involves assessment of a technology, is the technology clearly defined? [10]	Yes/No/Partially
5. How well has the approach to, and formulation of, analysis been conveyed? [10]	Yes/No/Partially
6. How has knowledge or understanding been extended by the research? [10]	Yes/No/Partially

4 Review Findings

Our analysis discovered that NFC technology has been implemented not only in higher education institutions, but it is also used in primary schools mainly in Finland [9], [12], [13], [20]. From the literature we found that NFC technology has been equipped in controlling attendance system in various countries including Spain [8], [17], [21], Japan [14], [15], [19], Hungary [16], [18], Romania [7], Turkey [11], Thailand [6], Malaysia [5], and Taiwan [22] (see Figure 1).

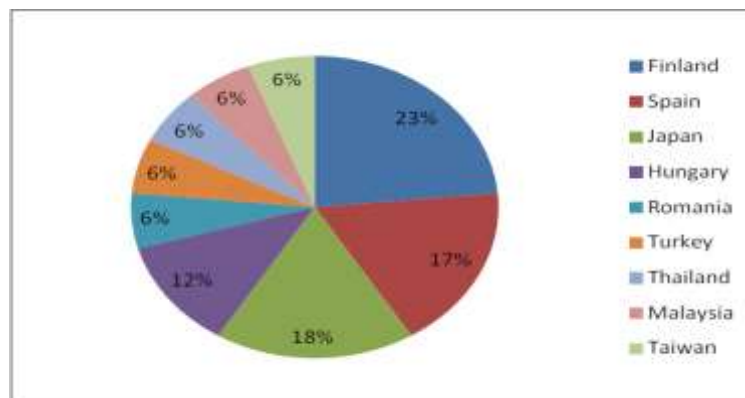


Figure 1. Breakdown of Countries

There have been various kinds of system design based on existing researches. In each application, the design aims to interact with other components of the system effectively; based on multiple background study of previous designs. The architecture was design to ensure that each component is used optimally. General overview of the students' attendance system using NFC technology can be seen in the Figure 2. In the following, we discuss the findings from our systematic review regarding the use of NFC in student attendance system.

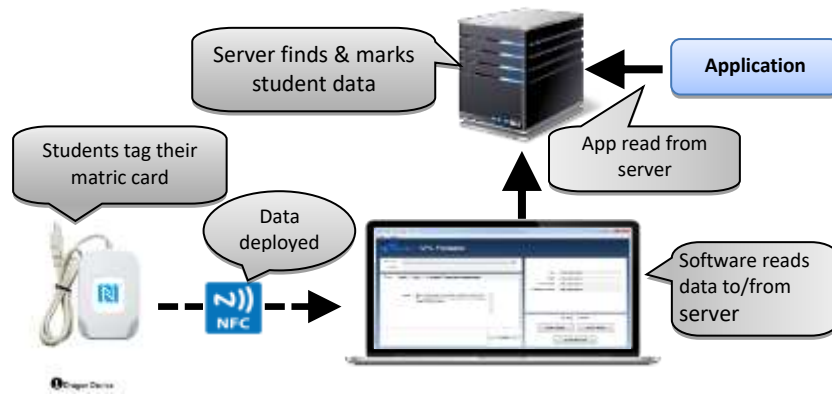


Figure 2. Overview of NFC-based Students' Attendance System

Ayu & Ahmad (2014) [5] reported their research work that utilize NFC-enabled device to allow students to register courses that have been set up by the lecturers. The system known as *TouchIn* is equipped with two main components: the *reader unit* and the *server unit*. The reader unit is responsible for reading the NFC-enabled smartphone or a tag/card that can store information. If a student is using an NFC-enabled device, then the student ID will be stored in a file stored in the device; tagging it will allow the NFC reader to retrieve that particular file. The web server unit acts as a dedicated server for storing the students' credentials who tagged and display them on a website for recording and verification purposes.

In Thailand, Subpratavee et al. [6] described the implementation of NFC technology in the attendance system by incorporating a smartphone's camera capabilities. The system consists of a dedicated server for mobile devices and database. The smartphone/NFC-enabled devices can be connected to one particular server at all times, thus allowing unlimited access and mobility. The system allows lecturers to place their smartphone (acting as NFC reader) and the students can tag it with their NFC-enabled smartphone or NFC tag/card to register attendance for the current class. While tagging, the lecturer's NFC reader will quickly verify the tag and capture a picture of the person who is tagging. The reader will then send both the student's ID from their NFC-enabled device/tag/card along with the captured photo to the server. The server will be able to be accessed by the user depending on their access level (i.e. student, lecturer, or admin). The data stored on the server can be used for various purposes such as record-keeping and verification of student attendance.

Bucicoiu & Tapus (2013) [7] have proposed a location-based authentication method (based on NFC) and using a photo as an authentication in the attendance system. They utilized the existing learning management platform known as Moodle as their backend server. Moodle is an educational platform that enables services like learning on the web. It already provides a stable platform that lecturers could use for online assessment, projects, or even assignments. Combining it with the student attendance system will coherently bring online education to a whole new level. Monitoring becomes effortless, synchronization is on-the-go, and the mobility is limitless. When the first contact of tagging has been made, a session will be created between the lecturer and their students. Moodle will act as their platform for the sessions. Such a system easily facilitates interaction between students and the lecturers. The researchers have implemented the design using a prototype; Samsung Galaxy S3 with Android 4.0.4 against Moodle 2.3.1 plug-in that uses PHP language. Communication between phone and server uses XMLRPC over HTTPS. Moodle uses two-way authentication; either token or username-password in order to ensure the security and integrity of data. The GUI on client side was programmed using Java programming.

Chavira et al. [8] propose two approaches in interacting with context-aware public display: an NFC-enabled phone and infrared sensor. They have implemented a Vi-MOS system to test both approaches and they suggested that NFC-enabled device is a more viable and effective option.

In 2008, an NFC-based attendance system was implemented at primary school in Finland involving 23 pupils [9]. The system allows parent to receive real-time information on children's attendance. The results of the study show that NFC based attendance system bring positive experience to the end-user groups (i.e. children, parents, and teachers).

Rahmana et al. [11] proposed RFID authentication system utilizing ParseKey++ multi-way authentication scheme for the purpose to strengthen the security of the system. The algorithm was implemented on RFID based attendance control system. Such a secure authentication system is needed for highly secure environment for example to access confidential resources on computer network or authentication to access high security locals.

In 2009, Ervasti et al. [12] reported a study that describes user experience in adopting attendance supervision system at primary school in Finland. The same authors have reported their work in [9]. Data were collected through classrooms observation, interviews with children and teachers, and phone interviews with parents. The findings showed that adoption of such system clearly benefits parents, children and teachers.

A similar study was reported by Isomursu et al. [13]. In this study the authors presented results from a case study of elementary school children in using attendance control system based on NFC technology. Using the same model of human values from social psychology, and based on their analysis of subjective perceived values, the authors found that children were the most satisfied user group of the system compared to parents and teachers.

While in Japan, Ninomiya et al. [14] have developed a system that matches real ID of a person with online SNS ID using NFC-enabled smart phone. The aim was to bridge the gap between an online identity on SNS and the real identity. To achieve this aim, the authors have designed an event attendance management system based on

NFC and SNS using Twitter. Another study that is also conducted in Japan and reported by the same authors [15] have proposed a participant managerial system that makes use of human relation in SNS to an actual event site. The approach is to use NFC technology and linked with SNS ID and during the event day, the organizer as well as the participants can understand background and interest of each participant based on SNS information. This could aid in promoting exchange between participants in an actual event site.

Benyo et al. (2012) [16] described the design and implementation of student attendance monitoring at Budapest University of Technology and Economics in Hungary utilizing the NFC technology. The system was implemented in a highly autonomous distributed environment comprising NFC enabled contactless terminals and a scalable back-office. The terminals also support biometric identification by fingerprint reading to enhance the security aspect. In the pilot project, more than 1000 students had tested the system and they become accustomed to use the system properly.

Bueno-Delgado et al. (2012) [17] presented the overview of implementation of an ubiquitous computing platform based on NFC known as *Smart University* in Technical University of Cartagena, Spain. The two major projects development were NFC-attendance registering system and NFC administrative fee payment system. Prior to the development, data collection through opinion poll was conducted to study the impact of the use of NFC technology in a university environment. The results showed promising use of NFC applications among the university community.

Benyo et al. (2012) [18] have summarized uses of NFC applications in a contactless infrastructure at the Budapest University of Technology and Economics. These include enrolment at the University, registering attendance during lecture, registration of end-of-semester exam and access to University resources. These contactless services have shown to be beneficial for students and lecturers. The same authors have presented similar works in [16].

A more recent work was reported by Ichimura & Kamada (2013) [19]. In this study, the authors describe the functionality of Attendance Management System (AMS) build upon NFC technology. They have developed the AMS for the University and tested using Nexus 7 devices connected to each other via peer-to-peer network. From the implementation, they found out that the number of absentees in nearly all classes was decreased and this could be due to students' conscientiousness that they are being observed.

Isomursu et al. (2011) [20] described a case study that explores the adoption of attendance control system in the school environment. The system was implemented using networked technology components, including smart cards, NFC enabled mobile phones and card readers, a web portal, and SMS messaging. Using Schwartz's value model adopted from social psychology as a framework, the study analyze the technology adoption from the viewpoint of three end user groups, namely children, parents and teachers. The study presented value analysis to help understand user experience perceived by different user groups when adopting technology-supported attendance system.

Fernández et al. (2013) [21] provide description of an attendance control system based on NFC technology developed and implemented at Pontifical University of Salamanca, Madrid, Spain. The project was carried out as Final Degree Project and developed in collaboration with Samsung Electronics. The aim was to ensure contin-

uous assessment so that lecturers' teaching time will not be affected by the manual way in recording attendance. Results from the survey of the pilot project indicate that students and lecturers perceived high level of satisfaction and usefulness of the project.

Shen et al. (2014) [22] presented the most recent work in the area of NFC usage in classroom. In this study, the authors proposed the NFC-equipped smart classroom system to automate attendance management, to locate students, and to provide real-time feedback to students. The positioning feature of the system shown to be very useful to users; particularly for large classes. The study also evaluates the effect of the proposed system by measuring the students' attitude towards computer science education. Using a 5-point Likert scale questionnaire, students' attitude was measured based on five aspects: i) self-concept in computer science, ii) learning computer science at school, iii) learning computer science outside of school, iv) future participation in computer science, and v) importance of computer science. The results showed that students' attitude toward computer science is generally improved and the students perceived computer science as interesting, exciting, beneficial and helpful after experiencing the proposed system.

5 Conclusions

The innovation and perception of using Near-Field Communication technology for student attendance has been and always will be supported by many researchers as shown in our systematic review [3]. As can be seen from our review, we found a total of 17 studies that have presented various system design and architecture in implementing NFC-based student attendance system for University and school children. The earliest study found was published in 2007 and the latest was in 2014. Hence, we believe that research will continue to bloom and fork on various paths in this area of research.

The developing idea and prototype of Student's Attendance System using NFC is on the verge of introducing worldwide institutions into an automated way of recording student's attendance. It will, by far, improve the current manual process of tracking and recording student's attendance. This system promotes a way for students to 'sign' their attendance on a digital form and in contactless mode. For lecturers, implementation of such system would ease their effort in tracking students who are missing from class as well as reducing effort to verify students' attendance.

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