Undergraduate Project Example: LizardTag

An NFC-based System for Attendance Management

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Abstract **- Studies have shown that attendance plays an important role in students' academic performance. However, attendance management has become more and more difficult due to limitations in a classroom setting. In this paper, we present a real-world wireless project for undergraduate students to enhance their learning through hands-on experience and applying technical skillsets to the project. Because many student ID card systems already have a built-in NFC tag and many mobile devices have implemented NFC read and write functionalities, our project idea can be easily adopted and extended for different scenarios, such as workshop or conference events. Our tests show that the system can easily be used in a classroom setting.**

Keywords **-** NFC, Attendance Management, Undergraduate Project.
Submission Type **-** Short Research Paper

I. INTRODUCTION

Our tried-and-true methods for taking attendance in a classroom setting are becoming inefficient by today's standards. Instructors dedicate valuable lecture time to taking roll call, which is quite a tedious process. Others pass out attendance sheets for students to sign, which distracts them from the lecture. Neither method scales well, as in large classrooms the teacher must endure either a lengthy roll call or the monotonous task of copying over an attendance sheet into a database.

After finding this real-world problem, we wanted our computer science and networking undergraduate students to solve this problem by using Near-field communication (NFC) technology. Through this project, students can learn all problem solving techniques and achieve high-level learning goals [1]. Throughout dealing with realistic and complex problems, students develop skills for integrating theory and practice, applying knowledge to develop a feasible solution, and conducting research [2]. In order to achieve these objectives, many diverse methods and examples have been proposed. Cabre et al in [3] introduced a project-based learning case example of controlling an educational robotic arm with a computer vision system. Throughout the example project experience, authors showed that the development of the project-based learning example contributed to increase students' motivation and interest. Ho et al in [4] presented how project-based learning helps engage students in the design of a complicated system. Throughout a semi-autonomous vehicle project, the authors showed that the student learned problem-solving techniques for practical controller design such as planning, literature survey, reading technical datasheets, trouble-shooting, and experimental testing and evaluation. Martinez-Mones et al [5] presented a multiple-case-study project design for a computer architecture course at undergraduate level. The introduction of multiple case studies carried out simultaneously in the same computer architecture course by different teams of students can broaden the set of concepts studied, but collaboration at different levels must be strongly enforced to achieve effective learning. Throughout the evaluations, the authors presented that students achieved a deep learning of the concepts required in their own case study and developed a number of collaborative skills and attitudes as a result of the proposed environment based on multiple levels of collaboration. Chang et al [6] proposed a progressive design approach in applied electronics course to help students develop system design skills through an optoelectronic sensing project. The authors showed that students have developed the required knowledge and skills for a future professional capacity through their well-designed project. Lammer et al [7] presented two projects - the design and construction of a switching-mode power supply prototype and the static study of a dc-dc converter topology – in order to encourage students to apply the knowledge they had acquired in theory classes by putting into practice all the power electronics concepts they had met throughout the course. In response to this movement as well as the increasing demand for wireless networking and mobile application development skills in almost all industries, we present an example project for computer science and networking undergraduate.

NFC is a set of communication protocols that allow two devices to exchange data wirelessly in a short distance. Theoretical distance can be from 10 cm to 20 cm, which is far shorter than 10 m for Bluetooth and 50 m for Wireless LAN (WLAN) [8]. The short range of NFC could make it seem inferior to other wireless technologies – but actually, this is advantageous to some issue, such as attendance checking. If attendants were able to sign in an event with remote access, such Bluetooth or WLAN, then they could easily deceive the system by making a connection from outside of the event venue. However, since using NFC technology requires the attendant to come in close contact with the registration

device, it is difficult to cheat their attendance.

The NFC limitation inspires us to think of it as an advantage to resolve existing challenges, such as attendance management for different conditions. The main research question we have is: how do we design a scalable system with NFC technology to manage attendance, which can be used in either a classroom setting or a conference setting. Since smartphone penetration rate is expected to grow from 72.47% in 2018 to 80.57% in 2022 [9], we propose to design an Android mobile application system to achieve the goal. In the following of the paper, we will introduce system and user interface design at the beginning. Database design and NFC standard and implementation will be discussed next. We will conclude the paper with a conclusion and future work.

II. System and User Interface Design

Based on the analysis, we believe that the limitation of NFC technology can be used as an advantage for some situation, such as attendance management. To demonstrate the idea, we developed an NFC-based attendance management system, *LizardTag*, which is on the Android platform to allow the instructor to receive data for the class, such as who attended the class, who was absent, and who was late. In addition, the application allows the instructor to see what day the student registered and when the student attended.

The advantage of using the Android platform is a much lower entry barrier for instructors in terms of cost. Aside from NFC tags, an Android device has everything required to get the system up and running. On the other hand, a Windows application would require a dedicated reader/writer which can turn out to be quite expensive. The application was tested using Tagstand NTAG213 NFC bubble stickers (Fig. 1) and the LG G4 smartphone.

Fig. 1. NFC Bubble Stickers (*Tagstand NTAG213*)

A. Add a Course

Instructors can add courses by pressing the "Add Course" button ( ) on the top menu of the main screen. The add course screen contains text fields for course name, ID, and section, which allows the instructor to fill out information about their class. (Fig. 2 - Left)

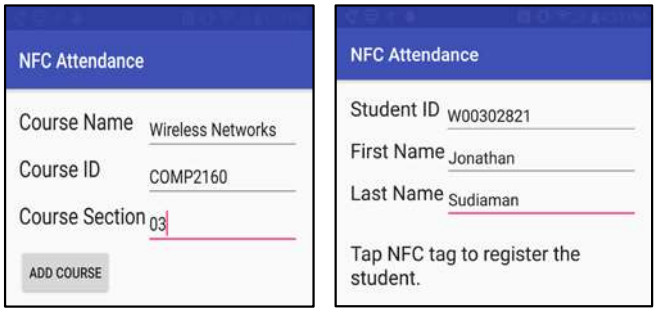

Fig. 2. (Left) Add Course scree. (Right) Add Student screen.

B. Add a Student

The add student screen (Fig. 2 - Right) is used to enable students' NFC tags for use within the application. Once the student fills out the requirements, including first name, last name, and student ID, it will require the student to tap their NFC tag to the device to complete registration. At that point, the student will be fully able to use their NFC tag for course attendance and enrolment.

C. Manage a Course

Once the course is created, it can be accessed from the list courses screen. From there, instructors can enroll students by tapping their NFC tags and confirming the modal dialog (Fig. 3).

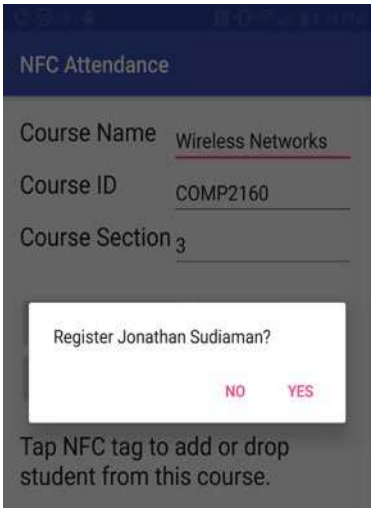

Fig. 3. Enrolling student in a course

The course management page contains four main buttons (Fig. 4). The first button is the attendance report, which generates a list of students who have attended since a certain date. At this stage, the attendance list is not very well formatted, but it contains all of the necessary data, including date and time of their attendances (Fig. 5).

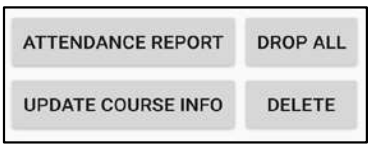

Fig. 4. Course management buttons

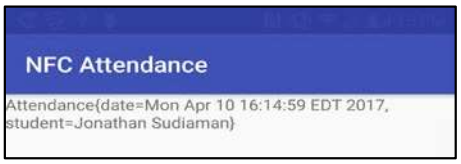

Fig. 5. Attendance report

The second button, Drop All, is used to drop all students from the course, e.g. to start a new semester. The third button is used to update course information, e.g. course name or ID. Finally, the fourth button is used to delete the course entirely.

D. Attend a Course

The main screen of our application is shown on Fig. 6. Here, the application waits for students to tap in to attend the class.

Fig. 6. Application main screen

Once a student taps their NFC tag to the Android device, the application will check if they are registered in the system. If they have not yet been registered, the main screen will show an appropriate error message (Fig. 7 - Left). Otherwise, it will welcome the student and record their attendance (Fig. 7 - Right).

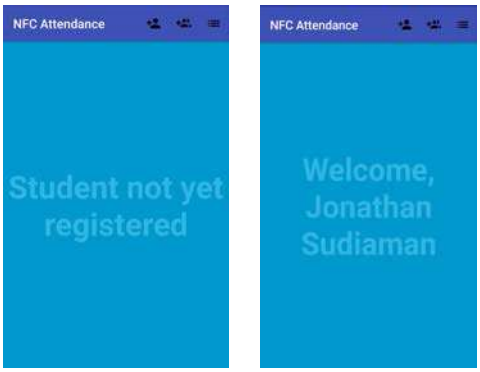

Fig. 7. (Left) Student taps in, but is not yet registered in the system. (Right) Student taps in and is registered in the system.

III. DATABASE DESIGN - SQLITE / SUGAR ORM

We use the Android SQLite database to store student and course information. Primary keys in the database are written to NFC tags, which are subsequently used to identify the student.

A. SQLite Database

SQLite is a database running in the mobile device rather than hosted on a server. This makes it possible to query without an internet connection. In this database, we have defined four entities – student, course, attendance, and register (as shown on Fig. 8). A student's NFC tag contains *uniqueId*, which is their primary key. When the student taps into our application, their attendance is persisted by generating a row in the *Attendance* table. When an instructor registers a student in their class, a row is created in the *Register* table.

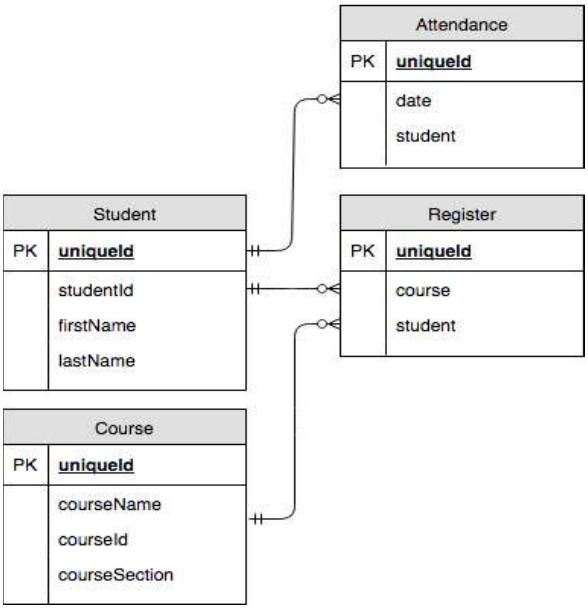

Fig. 8. Database schema for the SQLite database

B. Sugar ORM

Our application uses Sugar ORM [10], a lightweight object-relational mapping tool which makes it easier to manipulate the SQLite database. This allows developers to perform complex operations such as table joins without having to write them directly in SQL. For instance, the code snippet in Fig. 9 is used to list down the students who are registered in a particular course.

```
// Get a list of students
List<Register> registers = Register.find(
        Register.class,
        "course = ?",
        String.valueOf(getArguments().getLong("courseId"))
);
List<Student> students = new ArrayList<>();
for (Register r : registers) {
    students.add(r.getStudent());
}
```

Fig. 9. Query to list students in a course, written entirely in Java.

IV. NFC STANDARD AND IMPLEMENTATION

A. Tag Formatting

NFC tags are formatted in NFC Data Exchange Format (NDEF), storing data in plain text ("text/plain" MIME type).

Our application stores database keys on the students' NFC tags.

According to NFC specifications, one byte on the tag is reserved to store metadata (called a "status byte"), as well as additional bytes to store the IANA language code. Bit 7 of the status byte is used to define the text encoding. If it is zero, then the data is stored in UTF-8 format, otherwise it is UTF-16. Bit 6 is reserved for future use and for now defaults to zero. Bits 5...0 define the length in bytes of the ASCII-encoded language code [11]. Our NFC reading and writing procedures make sure to handle this data correctly.

B. Android implementation

Our application implements NFC reading/writing capabilities using *NdefMessage*, *NdefRecord*, and *NfcAdapter* from the Android Java library [12]. We have defined two abstract classes, *NfcReadable* and *NfcWriteable*, which are both subclasses of Activity. Subclasses of *NfcReadable* implement a call-back function to handle the payload (string content) of the NFC tag once it comes in contact with the device. Subclasses of *NfcWriteable* supply the payload to write to the NFC tag.

V. Conclusions and Future Work

Attendance has been considered as one important factor for academic success. However, managing attendance is tedious and time consuming, such as in a classroom setting where students enter and leave the room frequently. On the other hand, compared with existing wireless technologies, such as Bluetooth and Wi-Fi, NFC was not widely used and has a disadvantage of short distance coverage. We found this underexplored technology might be useful in some special case. In this paper, we present *LizardTag* which is a research project designed for undergraduate students to enhance their learning through hands-on experience. *LizardTag* is an Android mobile application that implements NFC read and write functionalities to facilitate attendance management.

There are three contributions in this paper. First, we identify a real-world problem and address it with an underexplored technology. Second, we redefine the identified problem as a research project for undergraduate students. Third, we design and implement an Android mobile application as a system to demonstrate our idea of applying NFC technology to the issue of attendance management. The current results show that the proposed system not only can be used in a regular classroom setting, but it is promising to be extended for other conditions, such as workshop or conference events. For the future work, we consider improving the system with a modularization structure and conducting a user study to enhance its usability.

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