CREU 2016-2017 Final Report: Efficient and Cost-effective Class Attendance Management with a Smartphone-based System

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I. Goals and Purpose

Student attendance rates have been consistently found to be positively correlated with better academic performance. Many professors record daily attendance in lecture classes to encourage higher attendance, but taking attendance traditionally presents several problems. For sufficiently large classes, taking attendance by roll call may take a prohibitively long time. Taking attendance via a sign-in sheet or a short in-class assignment may also allow absent students to ask a student who is present to fraudulently mark the absent student as present. Electronic devices such as i-Clickers are time-efficient to use and not as susceptible to fraud, however, when students are required to buy expensive proprietary hardware. Our research involved the development, deployment, and user experience testing of a smartphone based attendance tracking system that can quickly and accurately track class attendance in a cost-effective way.

II. Related Work

The traditional way of taking attendance is the roll-call method, where each present student must respond to an instructor calling their name from a list. A study examining the time spent taking roll for a 54-student class found that over 70% of roll calls took more than 4 minutes (R. Mahato, 2013). For classes of this size and larger, taking attendance through roll call cuts into valuable class time. Alternative methods of taking attendance for large classes include seating charts, sign-in sheets, and unannounced in-class assignments (Ives, 2000). However, these present their own problems: marking a seating chart requires the instructor or a TA to spend time walking through the classroom and restricts student freedom, signatures on sign-in sheets may be easily forged by friends of absent students, and unannounced assignments require attendance for a grade, which students have described as ”cheap” and ”mean” (Clay & Breslow, 2006). Additionally, tardy students require a completed seating chart or sign-in sheet to be revised, using additional time. Mahato’s research encouraged a roll-token system, where each student collected a token with their name at the beginning of class, allowing the instructor to collect attendance without spending class time, but this requires the instructor to spend time after class tabulating this information.

New techniques requiring specific hardware have been proposed for automatically taking class attendance. Scanlan (Scanlan, 2009) proposed an attendance tracking system based on RFID which can take attendance, manage attendance records, and mail attendance records and messages to students. In (Tucker, Darcy, & Stantic, 2014), Tucker et al. compared three attendance tracking approaches including manual recording, barcode scanning and RFID in

terms of the price, efficiency and user acceptance and found that using an RFID reader and tags is favored for user acceptance in addition to the drastically reduced recording time compared with manual recording. Although RFID technology has been adopted by several universities in North America for attendance tracking, the cost is an issue because of the additional hardware required for tracking. For example, the RFID-based tracking system used by Northern Arizona University cost about $85,000 (Townsend, 2010). Zhi, Ibrahim, and Aris (2014) used Near-Field Communications (NFC) to cryptographically sign an attendance record, providing assurance that the attendance record was not falsified.

Recently, smartphones have been used for attendance tracking due to their increasing popularity. Without the need of additional hardware, such a system can track the class attendance in a cost-effective way. Class120 is a smartphone application that is specifically designed to allow parents and instructors to monitor college attendance. However, it has been shown that the app has technical flaws due to the use of smartphone location information for tracking purposes (Seitz, 2015). Students can fake GPS locations using spoofing in a trivial fashion. Quick Recognition (QR) code based approaches have also been proposed (Deugo, 2015; Masalha & Hirzallah, 2014) which allow multiple students to sign in simultaneously. Biometrics based approaches were also used for attendance tracking (Agulla, Rua, & Castro, 2009; Mccune, 2015). A smartphone application utilizing facial recognition was proposed by a group of researchers in Missouri S&T University to track attendance using the smartphone camera (Mccune, 2015). Biometrics-based approaches may not be able to correctly identify every student in a class.

Besides tracking attendance, many efforts have been made to reduce absenteeism and assist frequently absent students in addressing their attendance patterns. Understanding Truancy (Malcolm, Thorpe, & Lowden, 1996) proposes that absenteeism works in a cycle wherein students miss class, perform poorly as a result, and feel less compelled to go to class in the future. In a study conducted on employees, individualized feedback on the number of days each employee missed and a comparison to their peers was correlated with higher attendance rates (Gaudine & Saks, 2001). In another study, a phone call informing students of their professor's concern with general attendance was correlated with reduced absenteeism (McCutcheon, 1988).

III. Process

The system consists of a mobile application for students, a web application for administrators, and a central server. Instructors use the web application to create an attendance session, and set a start time, a time after which students are considered tardy, and a time after which students can no longer report their attendance. When the session is created, a session-specific secret code is generated. The type of this secret is set by the instructor, and is either a short numeric password, an alphanumeric password, a pattern, or a QR code. The instructor then posts this secret in a location visible during their lecture, such as the bottom corner of their slides or on a whiteboard. Students register their attendance by sending the code shared with them to the server using the smartphone application. To effectively prevent attendance fraud, the system verifies that submissions were submitted within the time window and records unique device identifiers.

The mobile application was developed using the Qt5 graphical framework, and was compiled for both Android and iOS. Both the web application and server were developed using Apache Tomcat 8 and Java, and hosted on a hardened Debian 8 server. Communications were secured using an Nginx reverse proxy in order to communicate using TLS 1.2. Student data is stored in an anonymous format in order to preserve confidentiality. The system was planned and developed from September 2016 to March 2017 and evaluated for usability and time-efficiency from March 2017 to May 2017 by students in two classes at the New Mexico Institute for Mining and Technology.

At the beginning of this usability study, students were issued an entry survey to assess their familiarity with technology and experience using learning management systems. Attendance was then taken using both roll call and sign-in sheet methods for two class sessions to provide students with a point of reference for their use of the application. For each method of authentication, one to two sessions were held where students could ask the researchers any questions about the application. This was done to control for the effect unfamiliarity with the application could have on students' response times. Then, for each method of authentication, two sessions were held where students were asked to use the application without the ability to ask questions to simulate real-world use. Finally, participants were asked to complete an exit survey designed to determine whether students felt that the application was usable, and whether they would use this application in the future.

IV. Results and Discussion

As a result of this project we have created a system that can streamline the attendance-taking process. We built a cross-platform application (links below) and server that communicate with each other. We have yet to analyze the experiment data and report our findings, however, we have performed some some analysis on the time-related data. From this analysis we found that, across all sessions, the average of the median time taken for students to open the application and successfully submit their attendance was 123 seconds. On average, around 10 students were present on time in each session, an average of 0.2 students were tardy, and an average of 8.5 students were absent each session. This matches with our expected results, since the data set includes several early sessions and optional lab sessions, iOS support was not added until midway through the experiment, and 27% of students were using iOS.

In the final session for the QR, PIN, and Password methods of authentication, when students had the most familiarity with each method of authentication, the mean times taken to submit attendance were as follows. Among the QR authentication, the mean time was 110.5 seconds. For Password authentication, the mean time was 189.2 seconds. For PIN authentication, the mean time was 65 seconds. These results closely match the expectations made while proctoring the attendance sessions, since PIN authentication sessions appeared to progress much

faster than others. We are eager to analyze the results of the exit survey to determine whether or not students preferred PIN to the other methods of authentication.

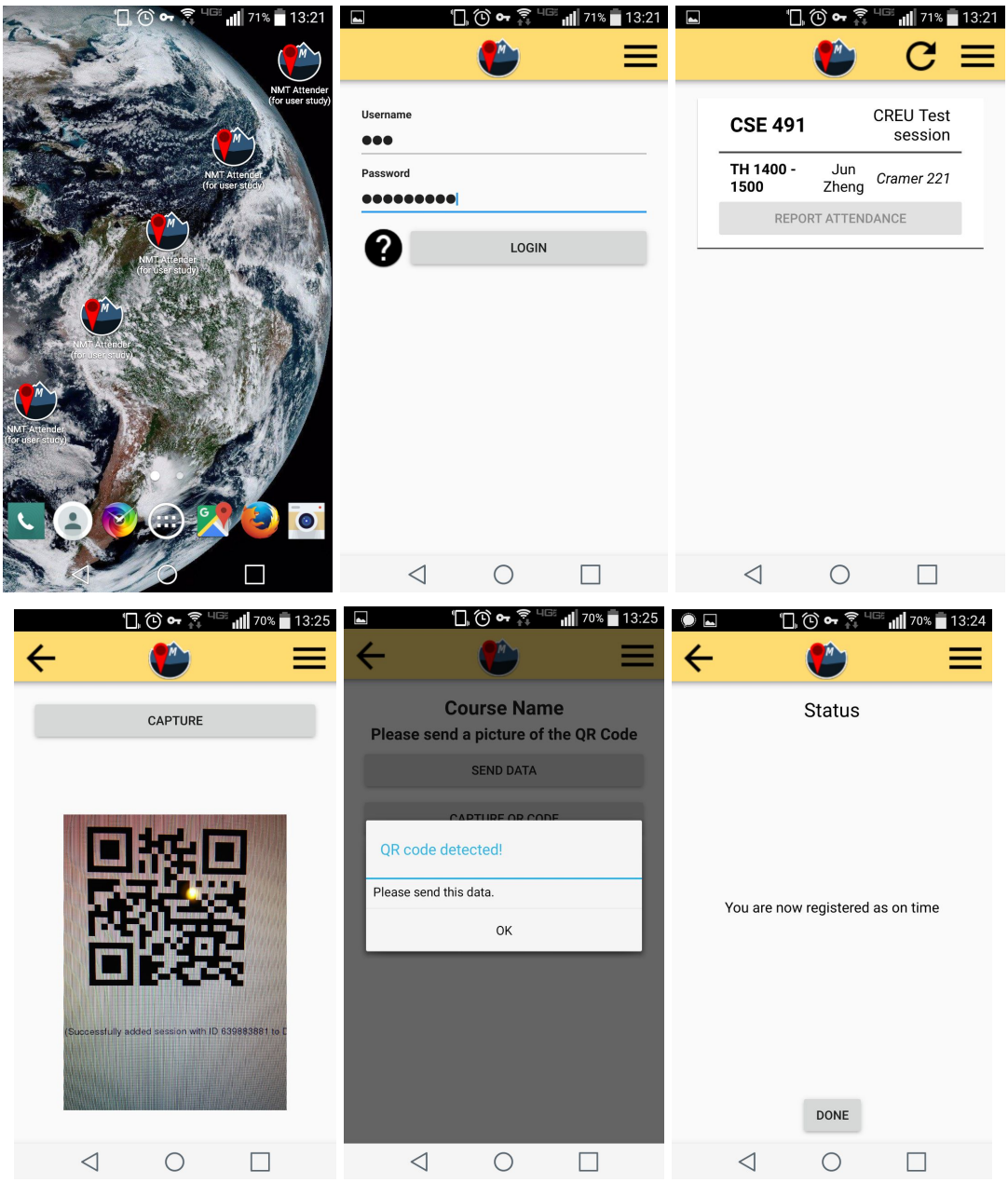

Figure 1 (from left to right): This is a sequence of screenshots taken as the user performs the most important actions on our attendance tracking Android application. (1) The user taps on the app's icon to start the attendance reporting process. (2) The user logs in with their anonymous ID and password. (3) A list of courses shows up. Students may either swipe right on the course or tap "Report Attendance" to send an attendance log to the server. (4) In this case, the user is submitting a QR code to report attendance for a test session that uses QR code authentication. (5) The user may send data once a valid authentication key is entered. (6) The user will be marked on time, late, or absent depending on the time at which the user receives their attendance log.

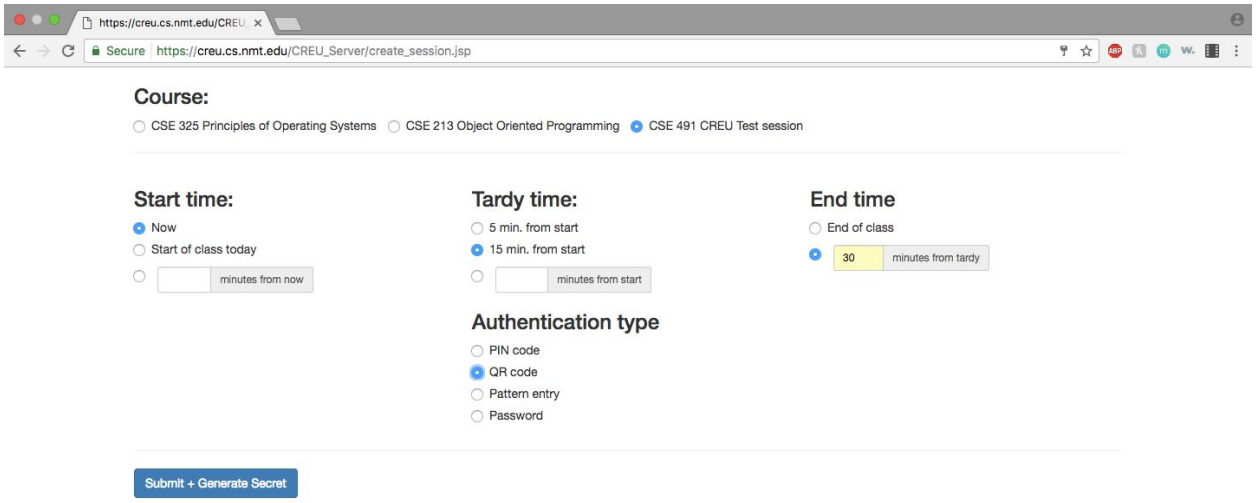

Figure 2: The instructor session creation page. The instructor can choose the class, create session times and pick the desired authentication type.

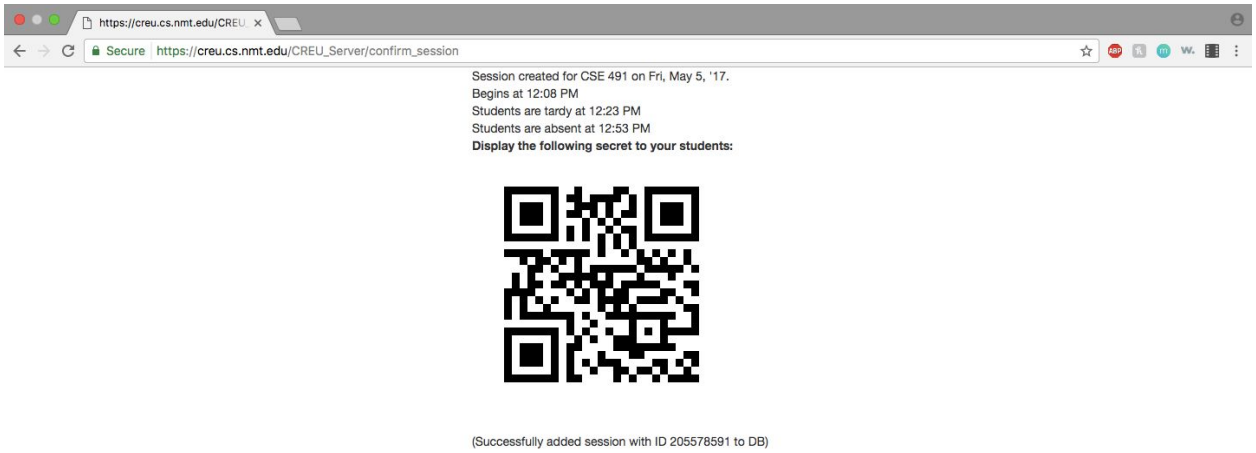

Figure 3: The secret generation page, demonstrating QR in this case. Students use the secret displayed on this screen to authenticate inside of the application.

Figures 4 & 5: An example of checking student attendance logs from the instructor's web application.

The Android version of our application can be found on the Google Play Store at: https://play.google.com/store/apps/details?id=com.nmtcreu.client

The iOS version of our application can be found on the the Apple App Store at: https://itunes.apple.com/us/app/nmt-attender/id1221739517?mt=8

V. Future Work

Over the course of the experiment, the researchers have received multiple requests for new features from both instructors and students. Several additional features were intended to be implemented, but were not able to be completed before the experiment began. Multiple instructors requested the ability to issue multiple-choice quizzes through the application, much like the i-Clicker system. The researchers had planned to implement facial recognition, to prevent students from fraudulently recording their attendance by having a present student use their phone, and to implement Wi-Fi location determination, to prevent students from modifying their GPS location. Students requested to be able to view their attendance records, which was a feature the researchers had planned to implement but did not have time to. All of these features have the potential to be added and evaluated in the future, but one feature stood out as an exciting topic for future research.

As mentioned earlier, individualized feedback on the number of days a person has been absent and a comparison to their attendance rate to their peers has been correlated with higher attendance rates (Gaudine & Saks, 2001; McCutcheon, 1988). The researchers had planned to implement push notifications reminding students to attend class shortly before each lecture, as well as individualized push notifications including a comparison to peers for students whose attendance rates fell below a certain threshold. Both instructors and students were enthusiastic about this set of features when asked about their initial feelings, and the researchers received multiple unprompted requests for these features from instructors. The research group feels that a study with a control group who do not receive notifications and conducted over a longer term will help to determine student and instructor feelings about reminder notifications, as well as whether regular reminders and individualized feedback is positively correlated with increased attendance rates for users of the application.

Since the experiment has finished very recently (05/03), some participants have not yet had the opportunity to complete the exit survey. As a result, we have not tabulated any data from to the two surveys. We have performed some preliminary statistical analysis on the time-related data stored in our database. After more data analysis, we will have detailed results and user feedback that will be included in our next paper, which will be submitted to the CCSC Conference by May 31.

VI. Web Links

Research group members made regular and detailed blog posts detailing our progress at: nmtcreu.blogspot.com

The Google Play Store link for our application is: https://play.google.com/store/apps/details?id=com.nmtcreu.client

The Apple App Store link for our application is:
https://itunes.apple.com/us/app/nmt-attender/id1221739517?mt=8

The source code for our server and client are available upon request.

VII. Presentations and Publications

Publication: Garcia, E., Rivera, H., Ponder, N., Kuo, R. & Zheng, J. (2017). Efficient and Cost-effective Class Attendance Management with a Smartphone-based System. In P. Resta & S. Smith (Eds.), Proceedings of Society for Information Technology & Teacher Education International Conference 2017 (pp. 965-972). Chesapeake, VA: Association for the Advancement of Computing in Education (AACE).

Presentation: Efficient and Cost-effective Class Attendance Management with a Smartphone-based System, Society for Information Technology & Teacher Education International Conference 2017, Austin, TX. Presented Mar. 8 2017

Presentation: Efficient and Cost-effective Class Attendance Management with a Smartphone-based System, New Mexico Institute for Mining and Technology, Student Research Symposium, Socorro, NM. Presented Apr. 20 2017.

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