Attendance Monitoring System
Mobile And Ubiquitous Computing

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ABSTRACT
Students' lack of attendance can have detrimental effects on the overall academic performance and reputability of schools and universities [8]. To counteract this, instructors will often require students to attend class as part of their overall grade, but as class sizes continue to grow, traditional methods of tracking attendance are becoming more impractical; not only are they inefficient, but it is possible for students to impersonate one another. To counteract this, we developed a mobile application for tracking student attendance that could be integrated into a school's database. Currently, the app takes advantage of Georgia Tech's existing wifi infrastructure and weekly course schedule to mark a student as present.

INTRODUCTION
Technology continues to march forward in many aspects of our lives, but the methods we use to track attendance in classroom are still fairly basic. It is still common to observe students signing a physical attendance sheet, swiping a student ID card, or using a clicker to answer questions in class, and each of these methods is not without its flaws. Signing a sheet or swiping a card can create a bottleneck of students, and as class sizes increase, these methods become much more of a hassle. Instructors are often forced to decide between sacrificing in-class time for students to sign in or having students pass around an attendance sheet during class, which can be a distraction. Both of these methods are also prone to impersonation as students can forge signatures or borrow ID cards. Clickers helped to alleviate the problems concerning bottlenecking, but there is nothing preventing students from loaning their clickers to a friend.

We sought to develop a modernized approach for attendance tracking that takes advantage of the ubiquity of smartphones and a school's pre-existing WiFi network infrastructure to not only maintain the same level of efficiency as the clickers, but also introduce new security measures to minimize the amount of students falsely marked as present.

BACKGROUND
There is a representative set of previous work spanning across various methods and technologies to provide a solution for monitoring attendance, including the usage of special pass-codes [3], RFID systems [5, 1], biometric scanners including fingerprint recognition systems [11], face recognition systems [6], iris recognition systems [4], among others. In our background section, for the limitation of the length of this proposal

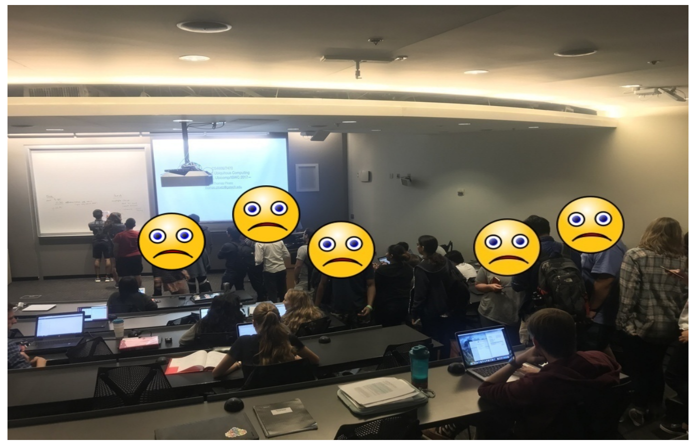


Figure 1: Line for Signing Attendance Sheet in MUC Class

we are only focusing on RFID-based, Biometrics-based, QR codes based solutions for attendance monitoring.

Biometrics-Based Solutions
Taxila describes a system where a fingerprint sensor along with an LCD screen is used at the entrance of every classroom. The students use the sensor to mark their presence and are notified that their presence is marked through the interface on the LCD screen. The system additionally provides a timeframe within when the students can mark their attendance [11]. A variation of fingerprint-based scanning system was proposed by Shoewu et al., which also generates reports at end of the term on the eligibility of students for attending exams factoring in their attendance. The results of the study indicate a marked difference in the average time it takes to mark attendance using manual sign sheets at 17.83 seconds/student as compared to fingerprint scanning at 3.79 seconds/student [10]. Saraswat et al. proposed a faster and more efficient minutiae based fingerprint recongition tecnique that uses major features of a fingerprint [9]. Kawaguchi et al. proposed a face recognition based system that uses two kinds of cameras affixed in the classrooms to continuously monitor the students present in the classroom throughout the duration of the lecture [6].

RFID-Based Solutions
The use of RFID technology have been explored for capturing and managing student attendance in a semi-automated manner by researchers [5, 1]. In such interventions, the students were required to flash their RFID-enabled student cards at the reader installed at the classroom's entrance. The records of

attendance were made available through a web-based system. A variation of such systems uses an RFID that is automatically invoked according to a predefined schedule and scans all the students' RFID tags [8].

QR codes Based Solutions

Usage of QR codes have been explored by researchers in the domain of attendance monitoring [7]. In the system proposed by Masalha et al, the instructor can display an encoded message in the form of a QR code at any point in the lecture, and the student would be able to login to a module on their mobile phones to capture the code. The module also captures a picture of the student's face, to verify the identity of the student, thus providing multifactor authentication [7]. Chaisatein et al discuss a QR code based approach for an easier communication system which also contains an attendance tracking feature. The system lets instructors download QR codes for attendance based on the student enrollment data provided by the instructor. This system also provides a way for the instructor to specify a limited time frame before when the students need to read the QR code and mark their presence [2].

While most of these previous works focus on a few of our goals, they do not necessarily provide a very well-rounded solution. All of these interventions highlight the use of an external device that showed promise for taking attendance of students in the classrooms. These devices might pose more challenges for the classroom environment at Georgia Tech such as incurring additional cost per classroom for fingerprint sensors or breach of privacy by using camera, among others. In our project, we are particularly interested in building a system to effectively monitor attendance that is fast, foolproof, non-intrusive, and convenient for the students as well as the instructor, ideally without introducing too many extraneous hardware requirements.

INITIAL IDEATION

In order to utilize the WiFi access points, we would need to establish partnership stakeholders in charge of maintaining GT-WiFi. Access points in close proximity to a given classroom space would make note of the GT-usernames (and their connected devices) that connect to those access points within the scheduled time of the class. This list of usernames would be cross-checked with the usernames registered in the student roster, resulting in a list of GT-usernames, and ideally a list of students, that were present during the class period. GT-WiFi connection surveys are reported to occur every fifteen minutes, meaning that if a student briefly steps out of class when a survey occurs, there will be another chance for them to be counted as present. Another possible approach is to leverage the client side information gathered from GT-LAWN.[1] We can scrape the information retrieved from the client side in order to match the registered number of students in the class. The students can be notified instantly if their attendance is not considered due to some technical difficulty (i.e., dead mobile phone, the device did not connect to one of access points in the class, etc.). After knowing this information, the students can directly let the instructor (and TAs) know about the discrepancy about the information that is reported by the system.

The RFID method would involve modifying the door frames of classrooms with RFID scanners that could automatically scan a student's ID card as he or she enters and exits the room. This method does not resolve the issue of impersonation and also has no way of measuring how long each student is present in class, meaning that students could easily walk in to be counted as present and then immediately leave.

Using QR codes is fairly self-explanatory; the instructor would post a QR code each day that students would scan with their phones to be marked as present. This method is much less automated, however, requiring the instructor to set aside time during each class for the students to scan the QR code, and the students must take the time to pull out their phones and scan it. There is also a chance that a student could briefly step out class and miss the attendance period even though he or she was technically present.

Biometrics would involve students downloading an app on their phone that could only be unlocked by fingerprint or by submitting a picture of themselves that is verified through facial recognition software. Biometrics would have the advantage of little to no false positives due to the difficulty of impersonation, but it is also the most invasive method in terms of privacy. It is unlikely that all students would be willing to provide their fingerprint solely for the sake of attendance, which would further complicate the situation by requiring the use of a secondary method of attendance tracking.

METHODOLOGY

We gathered responses from students at GT and non-students at GT at three different points of this project. Data was collected before the initial design of the system to understand what should be the features of the system, while the system was being demonstrated to the students during peer-feedback sessions, and then after the system was completely ready. We collected all data in a qualitative manner (i.e., interviews, surveys, among others).

Phase One

We took interviews from a varied spectrum of users following the guidelines of Stanford Design School [2]. We interviewed ten users (five men, five women). Among these participants, two were not GT students, six were current GT students, and two were recent GT graduates. We performed thematic analysis on the data gathered from the interviews and came up with themes that helped us understand the privacy implication of an attendance monitoring system. These insights from the interviews are shared under the results section.

Phase Two

We gathered feedback from peers in our class on the system after we demonstrated how it worked. Each demonstration took two minutes of time, followed by two minutes of questions and answers. We demonstrated six times in total. The prominent themes that emerged from these feedbacks are under the results section.

[1] http://www.lawn.gatech.edu/debug/

[2] https://dschool.stanford.edu/resources/the-bootcamp-bootleg

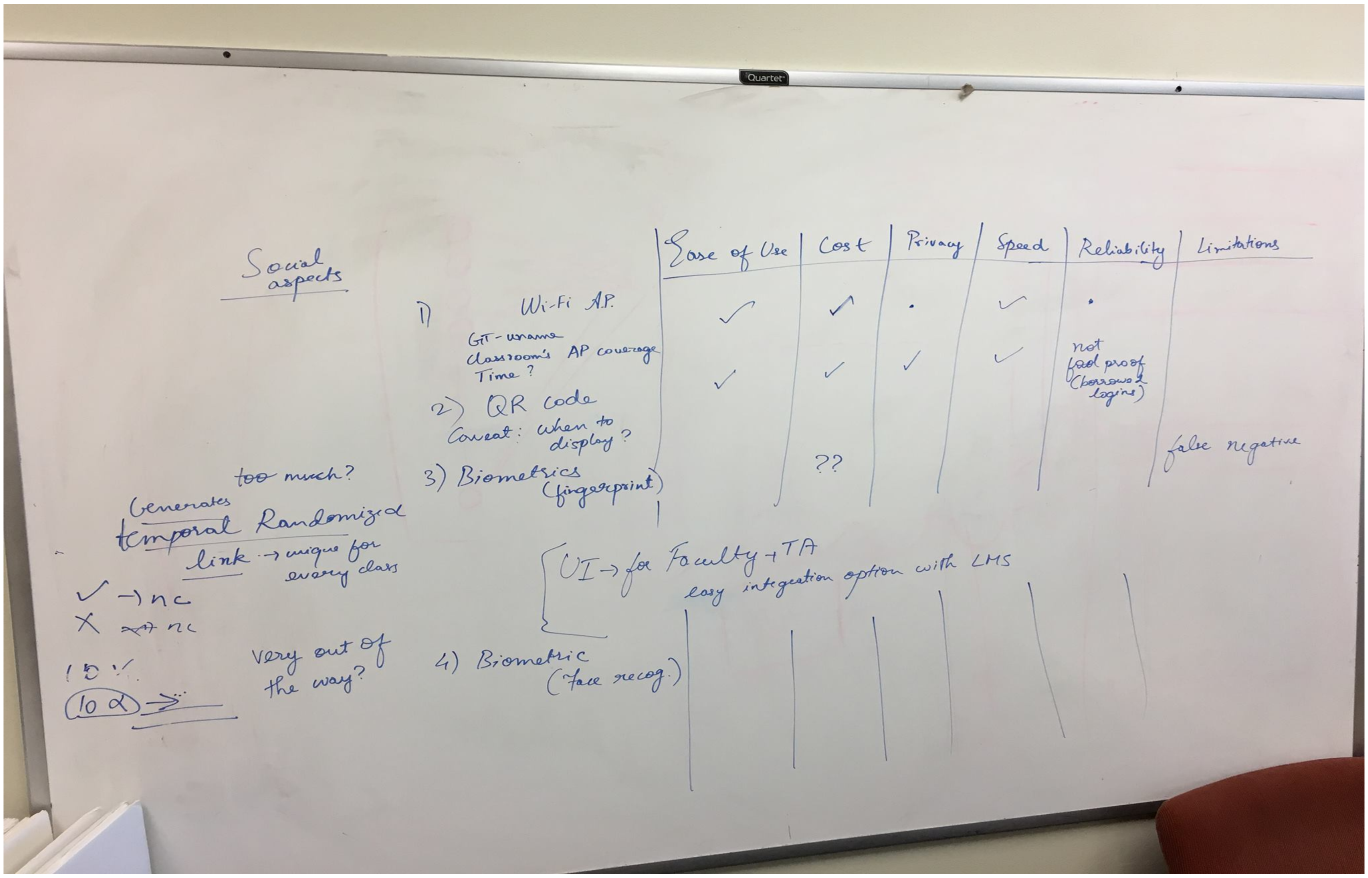


Figure 2: Brainstorming Session One

Phase Three

After our system was ready for demonstration, we did a final user-study with ten random people during the mobile and ubiquitous computing class time. For participating in this study, the students had to give their attendance using a provided android smartphone and take a short survey [3]. The interpretation of the survey responses are presented under the results section.

SYSTEM

To combat the shortcomings of the different approaches described in the background section, we developed a solution that leverages the existing wifi infrastructure on campus. Our solution takes advantage of the fact that almost every student possesses a smartphone that is more often than not connected to the Georgia Tech's wifi infrastructure. We used the details of this connection to localize a student's mobile device, and ideally the student, to a certain physical location on campus.

We built an android application supported by a firebase database on the backend. The reason we chose to begin with an android app is simply because none of the team members had any prior experience in building applications for iOS. We ensured that android-specific features were not used in order to make sure that this app could easily be ported to other platforms in the future.

[3]https://goo.gl/yatUjP

The following sections describe the two sides of the app, one that is used by the student's to mark their attendance and one intended for instructors to quickly monitor and oversee attendance.

Student's Side

For our solution, we assume that the campus database has information about all the courses, their locations on campus, and the students' enrollment in different classes. The first time a student uses the app, they will be able to set the device as their primary device. When a particular device identified by its MAC address is connected to a wifi access point, we use a parser within the android app provided by JSoup [4]. This parser reads the LAWN page [5] and parses the following information related to the device:

1. The user id (student's GT username)
2. The device MAC address
3. The particular access point the device is connected to at that given point in time,
4. The location on campus to which the said access point is tied to.

[4]https://jsoup.org/

[5]https://www.lawn.gatech.edu/debug/

Technology	Ease of Use	Cost	Privacy	Speed	Reliability	Limitations
WiFi Access Point	Easy	Low	Sensitive	Fast	Unreliable	- Need a device with Wi-Fi - Mapping the APs to classrooms - Consideration of buffer space for reliable detection
QR Code	Easy	Low	Not invasive	Slow	Reliable	- Small window of time for taking attendance - Disrupts flow of class
Biometrics	Easy	High	Sensitive	Slow	Reliable	- Complex - Costly - Invasion of privacy

Table 1: Challenges & Opportunities of Considered Solutions

Once we have the above information, the following checks are carried out to ensure that the user can push a valid attendance request for a particular class:

1. Is this a new student?
2. Is the student ID registered for this class?
3. Do the student's ID and device MAC address match what is registered in the database?
4. Is this device MAC address currently allowed to push an attendance?
5. Is the class currently in progress according to the course schedule?

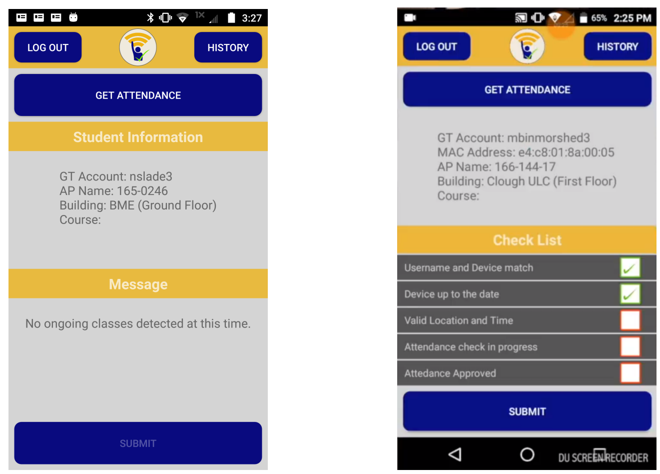
After these checks have passed, the user is prompted to provide a digital signature in agreement with the honor code provided by the institution. This action completes the process of submitting attendance, updating the database with the timestamped record of student attendance along with the signature that was collected and the time it took the user to write the signature. Please see the discussion in the future work section for more details about recording the signature data.

Instructor's Side

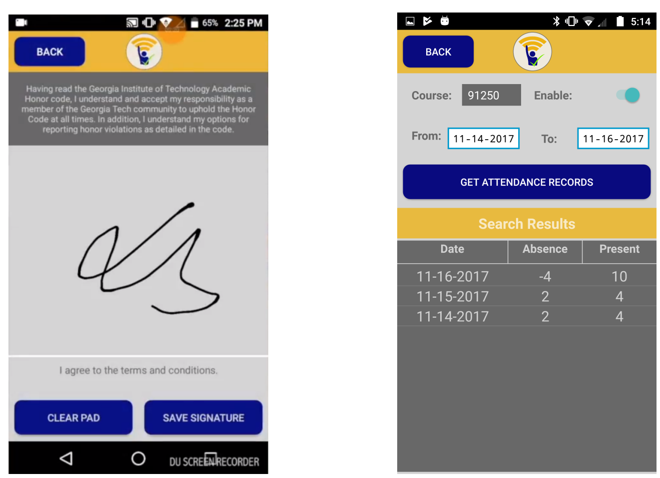
The instructor's side of the app lets an instructor login through a pre-registered login and password combination. The instructor can then access the courses they teach and choose to look at a certain date or a range of dates to get a quick overview of the number of attendees and absentees.

Upon looking up a particular date, the app presents a list of usernames whose attendance has not been recorded through the app. The instructor can override the system and manually mark a particular student as present for a particular day within the app. We wanted to make it easy for the instructors to quickly take care of attendance for students who are present in class but for other genuine reasons do not have access to their phones.

Due to the limited screen space that can be afforded on a mobile app, we offloaded the more data-heavy history views to a website to which instructors can have access. The instructors can check the attendance of their course during the span of a



(a) Left: Landing page of the student application while the student is not in the classroom; Right: Feedback from the application while the student is in his/her designated classroom



(b) Left: The application prompting the student for providing his/her e-signature; Right: Instructor side of the mobile application

Figure 3: Screenshots from the mobile application

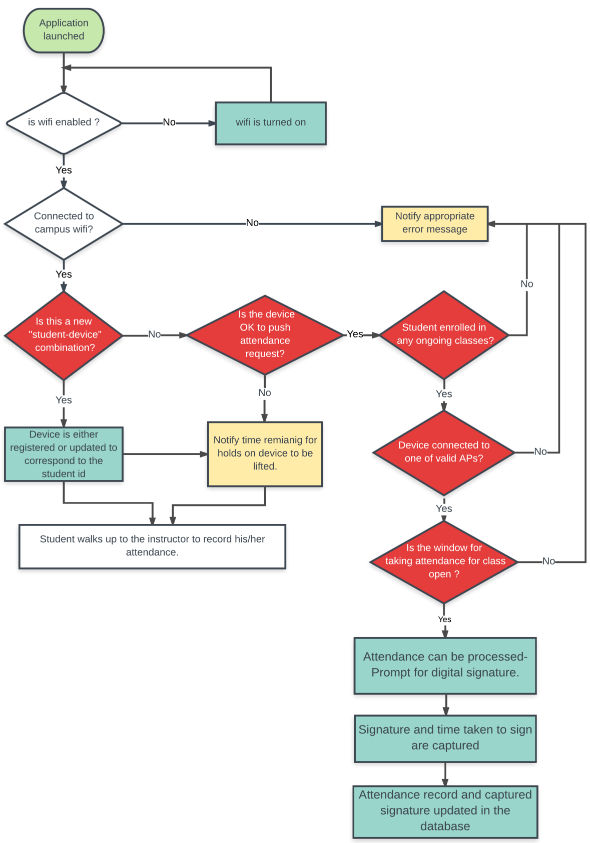


Figure 4: System Flow Chart

semester to see how many students were present on a particular day based on the data collected by the application. This information might already be available to the instructor, but to the best of our knowledge, it is not readily available to them.

RESULTS

Pre-Development Study

This particular user study informed us about what the challenges of current attendance monitoring system were inside and outside of Georgia Tech. One student shared regarding the current attendance tracking of Georgia Tech:

> *"Well, we have to sign sheets in the classroom. It is not a problem if the class size is small. But if it is a huge class like Machine Learning, then you can imagine how much time it might take for signing a sheet. Time is crucial for grad students. I am taking 4 courses this semester ... if there is not enough time between two classes, I will be late for the next class."* - Participant 4, 4th year undergrad student.

We found that minimizing time was one of the crucial requirements for the students regarding giving attendance. Students shared frustrations standing in lines 1, when they had to sign-up especially after class. One student shared in this regard:

> *"I missed my attendance on several occasions just because I didn't have the patience to stand in the line. Some classes have a strict attendance policy, and the instructors don't tell you when they are going to give you the sheet, and you might have something scheduled right after the class. In that case, what can you do?"* - Participant 1, 2nd year MS Student

We shared our ideas about our envisioned system and wanted to understand what would be considered a privacy concern for the GT-students. The responses varied from different students, however, they were okay with the information that was already visible to other people.

> *"If you are only collecting my GT-username, why would that be a problem? The instructors know that already, right? ... I won't be comfortable sharing my fingerprints with you, though."*

These insights helped us hash out the first design of our system factoring in the feedback that we got from talking to different students.

In-Class Feedback and Observation

While we demonstrated our system to our classmates, we got critical feedback about the system. Amongst these responses, privacy implication was a major theme. Several participants appreciated the idea of taking attendance with the press of a button. However, some wanted to know whether their tracking information would be gathered continuously. One participant shared:

> *"Are you going to check whether I am here all the time or are you going to take the attendance only once?*

Another student shared the following as a response to our question on what would they think is too much to ask for the validation of attendance.

> *"I think taking fingerprint is a bit too much. It is okay if that fingerprint is stored on my phone but if your app sends it somewhere then I think it is too much."*

However, we were not planning to store fingerprint data in our application. We did consider taking biometric information, however, we did not want to impose privacy concerns on the students. This question-and-answer session introduced another concern: we had to make sure that the functionalities of the application are visible to the participants such that it is not causing information overload. Hence, we iterated a couple of times to decide what we are going to show to the students. Another student gave us feedback on integrating this with an API of LAWN.

Post-Development User-Study

We collected responses from our participants on how easy it was to use the system and their willingness to use the system. Our primary focus from the course material in this class was to design a system that would not add burden the students or faculty with the investment of time or monetary resources. Hence, willingness to use the system was a significant focus during our study.

We found out that out of ten participants, seven were extremely (5/5) willing to use the system and three were moderately (4/5) willing to use the system. None of the participants shared either a neutral opinion or non-willingness for using the system. One participant shared regarding the signature feature on the application:

> *"I like it because I don't have to look around for a physical sheet of paper."* - Participant 2

We also wanted to understand the usability of the application, focusing mostly on the aspect of how easy or intuitive the application was to use. One participant shared neutral (3/5) opinion; five participants shared moderate (4/5) view; four participants shared that it was straightforward (5/5) to use. We wanted to understand the cause of the neutral opinion. We found out that the LAWN database takes time to refresh the information that is stored on its server. The particular participant who gave their information could see that it was not their GT-username. They became confused and did not know what to do at that point. Hence, they gave a neutral opinion on the system. The participant shared:

> "So it wasn't my GTID [username]. Wasn't sure it was supposed to have mine there. Tried to log out of app to change it. It didn't do that."

However, they were extremely willing to use our system. We also kept a separate question on whether the students had any issues with the signature they were providing for attendance. We did not ask a leading question for this response, opening up different possibilities for answers. Only one participant shared that they felt this feature was unnecessary, however, the participant did not have any issue with it. Among the other responses, we found that all the participants did not have any negative remarks against it. One participant mentioned that they felt secure giving signature to this application:

> *"I like how you don't have to enter GT login information into the app–makes the app seem much more secure."*

This validates our consideration for not having redundant features in the application. We were using the existing infrastructure that GT offered to us, hence, during our design decision we did not ask the students to enter their GT credentials.

LIMITATIONS

Our application assumes that every campus interested in adopting our software has a WiFi infrastructure that is similar to Georgia Tech's, which creates a barrier to the market for smaller or less developed campuses. Additionally, there is no functionality to determine whether a student's registered signature is complex enough. For example, if a student tries to submit a line as their signature, it could easily be replicated by another student, rendering the previous safeguards completely null.

The largest limitation is that there is no way to prevent students from purchasing a second phone solely for submitting attendance, lending the phone to a friend, and then registering that friend's signature instead, allowing the friend to attend the student's classes and pose as the student. This is similar to the problem with clickers, but it has a much higher monetary barrier as it requires the student to purchase another smartphone rather than a simple clicker. While this is an extremely unlikely scenario, we would like it to acknowledge that it is still possible.

FUTURE WORK

Currently, the application includes no handwriting recognition algorithm that can reliably detect whether a signature was forged by another student; at the moment the application simply tracks the time to complete the signature. A future addendum to this project would be to develop software that can compare the shape of the signature to previous samples provided by the student. Additional software could be developed to determine if a signature satisfies predetermined complexity to prevent students from submitting simple signatures that could easily be replicated by others.

CONCLUSION AND REFLECTION

In our initial project proposal, we received feedback from the instructor and the TAs that we would need to implement a three-tier system. We also committed to balancing the input from different relevant stakeholders. Hence, our expected outcome from this project was two-fold - technical and social.

We believe we have been able to utilize the existing GT-WiFi infrastructure on campus to achieve the technical milestone of our project. However, we have faced technological barriers and deviated from our initial system design. We wanted to come up with only one website that could take the attendance of the students. However, due to security issues and lack of API from lawn.gatech.edu, we could continue with our initial plan. Hence, we opted for a client-based mobile application.

The second commitment was social from our end, upholding the input from relevant stakeholders. We could not communicate with one of our critical stakeholders for this project because of his busy schedule. However, we expected that lack of time could be an issue for us and hence we made sure that we had contingency plans. We took input from all the stakeholders (*i.e.*, instructor, mentor, students, among others) and tried our best to reflect them throughout the semester with our project.

Regarding the user study, we knew that the Android mobile application could become an issue and hence we started a poll and asked for volunteers beforehand to see how many would be available for our final demo. We believe the most significant aspect about this project is that we thought about all failures beforehand and prepared ourselves for those failures. Hence, regarding technical and resource limitation, we were able to address most of the issues.

"The most profound technologies are those that disappear. They weave themselves into the fabric of everyday life until they are indistinguishable from it." [12] - was the vision shared by Mark Weiser on the nature of technologies in ubiquitous computing. Georgia Tech, one of the leading education and research institutes in the world, gave us the opportunity to work on a problem that looked deceptively simple. However, the process of taking attendance at this institute was very much "distinguishable" and "visible". We tried our best to come up with a solution that used the existing ecosystem and harnessed the "indistinguishable" technologies (i.e., always-on WiFi, smartphones, etc.). We believe we have come close to Weiser's vision regarding addressing this problem.

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