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A SMART CLASSROOM APPLICATION: MONITORING AND REPORTING ATTENDANCE AUTOMATICALLY USING SMART DEVICES

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ABSTRACT

For recording attendance in a classroom, generally instructors collect signatures of the attendees. Then, at the end of the semester, those signatures need to be counted and reported. This process causes waste of time and effort for both instructors and attendees. Besides this process is very error prone. Moreover, in crowded classes, there could be some misuses of this process. In this study, a smart classroom application is proposed and developed in order to monitor the attendance of the students in a classroom environment. In the design, a low-energy Bluetooth device is located at each classroom. Identification number (ID) of the low-energy Bluetooth device and the name/number of the classroom that the device is located are matched and stored in a central database. In addition to this information, the name of the courses given in that classroom and their time tables are also stored in the central database. Thus, in the database, the weekly course schedule of the classrooms is available. In addition to this central database infrastructure, a mobile application is developed that can run on both in mobile phones and smart watches. The users first install the application on their own smart devices. Whenever an attendee enters to a classroom, the smart device and its application interacts with the low-energy Bluetooth device. The student's identification number (Student ID: SID), the identification number (ID) of the low-energy Bluetooth device located at the class, the day and time of the interaction are sent to the central database by the smart device. Using this information, the name of the attendee and the courses that he/she attended are matched using the SID of the attendee, the ID of the low-energy Bluetooth device, the day and time of the interaction. Those matching information are also stored in the central database. The records in the central database are used to create any automatic reports, i.e. the attendance status, the time and duration of the attendance, and the classroom (course) of the record. The advantage of the proposed system is that it is a fully automatic system that records the presence of the students, generates automatic attendance reports, does not require any extra device except installing a mobile application onto smart phones or smart watches of the student, and can be deployed with a low budget. The proposed system is tested in real classroom environment and it is proven to be operational.

Keywords –attendance control system, smart phones, smart watches, mobile computing

1. INTRODUCTION

In most of the universities and in high education institutes, the students are expected to attend the lectures. For example, according to "Atilim University Regulation Concerning Student Registration-Admission, Associate and Undergraduate Study and Examinations", the students have to attend the courses in the Atilim University [1]. This is stated in the regulations as follows:

ARTICLE 14- (1) Students have to attend courses, applied studies, traineeships and examinations. The attendance of students is followed by the instructor.

(2) Students must attend at least 70% of classes and 80% of applied studies. Students who do not fulfill the requirements of attendance no matter what their excuses are including disciplinary punishment and suspension, shall not be permitted to take final exams and shall receive the grade of NA.

(3) Nonattendance of students who have committee report for a long-term treatment and recovery, is evaluated with the decision of the administrative board of the faculty/higher school/ vocational high school.

(4) Except for applied studies, attendance is not required in courses which students have previously taken and failed, and which are taken by the students to increase their grades.

The same rule applies at most of the universities in Turkey, as well as in all around the world. According to this attendance rule, the instructors should follow up each student individually if he or she is present or absent. The instructors carry the student attendance lists with them when they deliver the lectures, and ask for the students to sign the attendance list when they are in the lecture. The instructors keep these attendance forms during the semester, and they also have to keep track of the attendance of each student individually to determine the students who didn't attend the classes with a ratio of less than 70%. Those students are not allowed to take the final exams at the end of the semester and they failed from that course. This manual attendance control system is very time and effort consuming for the instructors. Besides this system is very error prone. In order to solve this problem, an automated system is needed that will automatically monitor and record the attendance of the students when they are available in the lectures. In this study a smart classroom application is proposed and developed in order to get the attendance of the attendees in the classroom environment. The proposed system uses low-energy Bluetooth devices and attendees' smart phones/smart watches to get the attendance. Furthermore, a central database is designed to keep track of the list of the students, their course and courses' time tables, attendance durations of the students for each course.

The organization of the paper is as follows: in the remaining parts of the Introduction section the low-energy Bluetooth devices, their application areas and their advantages for the proposed method is given. In Section 2, the proposed system is explained. In the results section, the test conditions and test results of the proposed method is explained. The paper ends with the conclusion and discussion section.

The Bluetooth low energy technology is also known and abbreviated as Bluetooth LE, BLE, or Bluetooth Smart. It is a kind of wireless personal area network technology and it is used in many fields such as healthcare, fitness, beacons, industrial production, entertainment, and indoor and outdoor localization [2]. The main advantage of the Bluetooth low energy is its power consumption and cost when compared with the classic Bluetooth technology. On the other hand Bluetooth low energy also has the same communication range (~100 m) with the classic Bluetooth technology. The studies to develop the Bluetooth low energy started in 2004, and the final version is published in 2010 with the name of Core Specification Version 4.2 [3]. The operating systems including Windows, Linux, MacOS, Android and iOS many others support the Bluetooth low energy in a standard form, which means that devices running in these operating systems will be easily communicate with Bluetooth low energy devices.

Ibeacon is a special form of Bluetooth low energy technology. It was first designed by Apple and it allows applications (especially mobile applications) to communicate with low energy Bluetooth devices. The ibeacon technology is first introduced in 2013. Many vendors have developed ibeacon hardware, which are generally called beacons. Those hardware devices transmit their unique identifiers. The transmitted signals are captured by the electronic devices such as smart phones, smart watches, tablets, or laptops, which have Bluetooth receivers and which are on the range of Bluetooth communication. An electronic device may receive the Bluetooth signals up to 10 different beacons. The working principle of the beacons is shown in Figure 1. As can be seen from Figure 1, ibeacon hardware transmits its ID by the Bluetooth protocol, and the smart phone receives that signal and identifies the ID of the ibeacon hardware. Based on this identification the phone may get context information, the position of itself, some information about the environment, and so on.

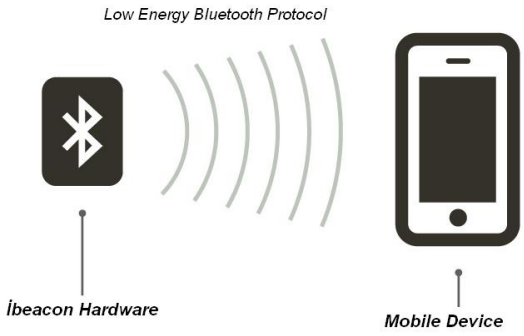

Figure 1. Operating principle of the iBeacon Technology

In general beacon devices implement Bluetooth low energy protocol to send a unique identifier and that transmitted id is received by an electronic device. That ID is used for many purposes such as to determine the device's position in indoor or outdoor environment [4-6], to follow up the positions and behaviors of the customers in the shopping environments [7], or location based actions on the electronic devices [7-9]. Ibeacons are 1-way transmitters, which mean that Ibeacon transmits its ID, and it is received by the device. The devices should have the necessary application installed on it. This means that only the related application on the receiving device may get the ID of the ibeacons. This ensures the security and privacy issues of the system.

2 THE PROPOSED SYSTEM

In this study, an automated system is proposed in order to get the attendance of the students in the smart classroom environments. The main components of the proposed system are the smart phones of the students (or smart watches), ibeacon devices located in the classrooms, and a central server to keep the database of the records. Bluetooth technology is available on the all smart phones. Besides in the recent years the ibeacon devices that transmit a standard ID are introduced and become available. Ibeacon devices transmit their unique IDs in a low frequency periods (once in a second). In the proposed system a mobile application that works on both the smart phones and smart watches is developed. In the application an account is created for each student. The students are able to access their accounts by using their usernames and passwords. An ibeacon device is located in the classrooms. Whenever a student joins a lecture in a classroom, his/her mobile application receives the ibeacon signal transmitted by the device in that classroom. In that received signal the ID of ibeacon is present. The student's mobile application creates and information packet including ID information of the ibeacon device, the student number of the student, and the time of the interaction. That information packet is transmitted to the central database via the wireless connection or the Internet. By using that information a record is created in the database including which classroom the student is attended, and the time and duration of that attendance. The block diagram of the proposed method is given in Figure 2.

Figure 2. The block diagram of the proposed method

The proposed method required integration of wireless communication technologies and hardware and software components. Those components are explained below.

Hardware components of the proposed method: The proposed method uses three hardware components, namely smart phones or watches of the students, the low-energy ibeacon devices are located in the classrooms, and a server that runs the central database. For the proposed method MySQL database is used. The only restriction about the smart phones or smart watches is that they have to support the Bluetooth 4.0 protocol; otherwise they can't receive the signals originating from the ibeacons. There are many ibeacon manufactures around the world and we have chosen the one produced by EasiBeacon Company [10]. The general characteristics of the selected IBeacon are given at Table 1. As seen at Table 1, EasiBeacon devices consume less power, affordable and have a reasonable battery life. Besides they provide a communication range of 30 meters, which is suitable for a standard classroom environment.

Table 1. *The characteristics of the selected IBeacon [10].*

Property	Value
RANGE	Around 30 meters
BATTERY LIFE18 months	
BATTERY LIFE	18 months (max. 2+ years)
DIMENSIONS	2.7 cm x 2.7 cm x0.7cm

Software components of the proposed system: For the proposed system, we developed two different pieces of software, one for the smart devices and second for the central server. The software running on the smart device is responsible to receive the signals originating from the ibeacons, to extract the ID of the ibeacons, to add time label (time of the interaction) and student number to the ID information, and to send that information to the central server. The central server software is responsible to keep the records about the student attendance, namely the interaction time and duration between the student's smart device and the ibeacon located in the classroom. Besides the central server software is also responsible to generate the reports about the attendances of the students. The details of the report will be presented in the next section.

3 PROOF OF CONCEPT

The proposed system is tested in two courses given by the authors in the Atilim University Computer Engineering Department. For this reason, two ibeacons are located in the classrooms that the lectures are taught. The students are asked to install the developed software. Only voluntary students installed the software and tested the systems. The system has been tested for 3 weeks (a total of 9 hours of lecture for each course) and it is shown that the system is capable of tracking the attendance of the students. The students didn't report any problem about the usage of the system.

The developed server software recorded of the students' attendance during the test period. It is seen that the server software is also capable of performing the required operations about the students' attendance. Besides keeping the records about the attendance, the server software also generates the necessary reports about the records. The records can be generated based on the course, lecture hour, and student attendance status. For example, for a given lecture hour, the software is capable of generating a report listing all the students (including the entrance and exit times). Besides the software also generates a weekly or semester based summarized report including total attendance rate. If the student-based report is asked, the software generates a report based on student statistics. Those statistics include total attendance rate, the dates and hours that the student didn't attend, and the dates and hours that student attended.

4 DISCUSSIONS AND CONCLUSION

In this study we proposed an automated system that will collect the attendance status of the students to the lectures. The proposed system consists of a central server, beacons located in the classrooms, and an application that is installed on the students' own smart phones or smart watches. The proposed system is tested in two lectures for 3 weeks and we got promising performance. But in order to get more realistic results, the system should be tested on more complicated environments, with higher number of courses and students.

The main advantage of the proposed method is that it is cheap and it does not require much hardware components. The system requires an ibeacon to be deployed in each classroom. Ibeacon devices are cheap (around 10 $ for each one) and this is an affordable price for a university or high school. For the user side, the students use their own smart devices (smart phones and smart watches) to install the application software. Nearly all the people use smart devices nowadays, so there is no need for an extra budged to buy new devices.

Another advantage of the system is that it minimizes the man power spent by the instructors. In the traditional system the instructors keep the attendance records of the students and they generate the attendance report manually, which is a time consuming, boring and error prone process. By the proposed method those disadvantages can be eliminated by the proposed method.

On the other hand there are some issues that need to be taken into consideration. First of all the maintenance of the system should be carefully done in order to preserve any attendance records of the students. The backups of the records should be recorded on another machine.

Another issue that needs to be considered is that legal regulations should be made to be able to use the proposed method. Besides there can be some misuse of the system (such as students may give their phones to others who join the course, etc) and those misuse cases should be carefully investigated. Another issue about the law is, the

recorded information about the attendance is also somehow the private information about the students. So privacy issues should be considered before using the proposed system.

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