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Web-Based Solution for Student Attendance Tracking: Development and Evaluation

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Abstract - In present times, student attendance tracking systems are primarily based on contemporary identification technologies. These technologies comprise RFID, Bluetooth, Barcode and several biometric such as Fingerprint, Voice and Face recognition. Some solutions employ web technologies only, and offer attendance tracking services over the Internet. All the different types of attendance tracking systems are built on IP infrastructures, but exhibit different performance that make them more or less suitable for use in classrooms. This paper, at first, presents a review of existing systems and technologies for attendance tracking, identifying certain issues concerning their performance. For the most part, it appears that biometric systems exhibit insufficient accuracy, while RFID systems inquire higher implementation and maintenance costs. Barcode systems generally suffer from longer registration durations and Bluetooth systems are affected by distance. The focus of the research is put on the development and performance evaluation of a custom student attendance tracking solution, built on current, free and open source web technologies. The goal was to make an effort to surpass some disadvantages identified in other systems. The developed solution, entitled RENAP, is implemented at a University in Macedonia, whose performance assessment revealed that it excels at several aspects, including accuracy, swiftness, affordability, easiness of usage and flexibility.

I. INTRODUCTION

Managing attendance records can present quite difficult task for many organizations, and the maintenance of an appropriate attendance tracking imposes as an important factor, especially for educational institutions. The research of Newman-Ford, Fitzgibbon, Lloyd and Thomas [1] presents evidence of a significant correlation between students' attendance and their academic performance. Similar claims by Marr and Lancaster [2] suggest that the students who have poor attendance records generally link to poor retention. Furthermore, attendance tracking appears to be quite valuable to teachers who obtain important information about student's behavior, as well as to the managers as a support to their decision making.

Manual acquisition of attendance records and their long term maintenance became outmoded when many novel identification (ID) technologies have found applications in attendance tracking systems. In present times, the most commonly used ID technologies include Radio Frequency ID (RFID), Bluetooth, Barcode ID, and several biometric, such as Fingerprint, Voice and Face recognition. Some attendance tracking solutions are based on web technologies only and offered as services over the Internet. Regardless of the fact that contemporary attendance tracking systems share a common concept, i.e. the IP infrastructure, due to the ID technologies employed they exhibit quite different performance. For this reason, the first part of this research aims to determine the standard issues concerning their performance, regarding the implemented ID technology. The second elaborates the development of a web-based student attendance tracking system, entitled as RENAP. The main goal behind the effort to develop a new system was to surpass some performance issues exhibited by other technologies, and to provide custom solution according to the specific requirements of an academic establishment. As a final part, the presented evaluation provides useful insights into the RENAP's performance, and confirms that some of the intended goals are attained.

The rest of this paper is organized as follows. Section two presents the related work and includes a discussion about the performance concerns and drawbacks of the various types of existing attendance tracking systems. The advantages and disadvantages are summarized in a table of performance that are further used as an input for the design of the proposed attendance tracking solution. Section three describes the developed attendance tracking system and the technologies employed. Furthermore, this section presents the results of the RENAP's performance evaluation, provided by the analysis of a survey results. Section four gives the concluding remarks, with a brief elaboration of the system's future requirements and improvements.

II. RELATED WORK

The convenience of implementation of RFID technology has led to the present situation where the majority of modern attendance tracking systems are RFID based (Arulogun, Olatunbosun, Fakolujo & Olaniyi [3]; Chand, Meeran & Prabaharan[4]; Chiagozie & Nwaji [5]; Kassim, Mazlan, Zaini & Salleh [6]; Mohammed & Kameswari [7]; Patel, Patel & Gajjar [8]; Silva Filipe & Pereira [9]; Yuru, Delong & Liping [10]; Singhal & Gujral [11]; Saparkhojayev & Guvercin [12]; Tiwari, Tiwari, Ade, Sheikh, Patel & Khan [13]; Wahab, Kadir, Mutalib & Mohsin [14]; Yadav & Nainan [15]). Systems of this type impose certain expenses for equipment,

comprising RFID tags for attendees and RFID readers placed in each classroom. The attendance tracking process is usually managed by a software running on an application server that receives events, i.e. information about the tag ID, date, time, classroom location and other data regarding the class settings. Some efforts have combined RFID with other technologies, such as General Packet Radio Service (GPRS) and Web technologies (Tiwari et al. [13]), or Global System for Mobile Communications (GSM) (Yadav & Nainan [15]), in order to augment the system's capabilities. To alleviate the implementation expenses, Kassim et al. [6] and Mohammed and Kameswari [7] have augmented their RFID based student attendance tracking systems with web technologies (IIS, ASP.NET and Microsoft SQL or MySQL server) and have provided the teachers' with real-time access to the required reports. Some efforts even combine RFID with some form of face detection and recognition techniques to double check the number of registered students with the number of students present in the classroom (Saparkhojayev & Guvercin [12]). The experiences of usage are quite common among the different implementations, where the main conclusions are that RFID based attendance tracking systems work effectively and accurately and provide a convenient method for attendance tracking management.

Bhalla, Singla, Gahlot and Gupta [16] have proposed a Bluetooth based attendance tracking system that uses a software application installed on the instructor's mobile telephone, which enables querying students' mobile telephones via Bluetooth connections. The system is reported to be of low cost, low power and considered as a sufficiently robust solution. The main constraints include limitations of Bluetooth technology regarding the operational distance and, for this particular implementation, the restriction of students' registrations by the MAC addresses of their phones requires constant updates because the students are prone to changing their mobile devices quite frequently.

Subramaniam, Hassan and Widyarto [17] have proposed and developed a student attendance tracking system (SAS) based on Barcode ID. The authors report high user satisfaction after the initial implementation, compared to the traditional attendance tracking on paper. Apparently there has been some issues that required consideration in the next revision, but since it was in a construction phase the behavior has been considered as expected.

Some authors have proposed somewhat different approach for student attendance tracking by using biometric technologies. Joshi and Joshi [18], Nawaz, Pervaiz, Korrani and Azhar-Ud-Din [19], Potadar, Marathe, Khose and Kotkar [20], Shafi, Khan, Munir and Baloch [21], Shoewu and Idowu [22], Talaviya, Ramteke and Shete [23], and Verma and Gupta [24] have incorporated fingerprint recognition technology and, where, after a match is determined, the user (student) data is written in a database. For example, in the research of Shoewu and Idowu [22] the data transfer is realized via wired LAN network and written in a Miscrosoft SQL database, while in other systems the data transfer is realized wirelessly using ZigBee module (Joshi & Joshi [18]; Potadar et al. [20]; Talaviya et al. [23]). The main conclusion, as a drawback from these types of attendance tracking systems, confirms that the systems' accuracy is a bit impaired ranging between 94 % and 98.57 %, and the time required for each user to register is about 4 sec. Combinations with other technologies are also common. Integration of GSM modules for delivering reports to certain stakeholders (Potadar et al. [20]; Joshi & Joshi [18]; Verma & Gupta [24]) are also common. Some systems include Short Message Service (SMS) services for provision of various types of information to the concerned parents (Shafi et al. [21]). These systems are generally regarded as reliable, secure, fast and efficient.

Uddin, Rashid and Mostafa [25] and Reda, Panjwani and Cutrell [26] presented an attendance tracking solutions that are based on voice recognition technology, where the system by Reda et al. [26] is additionally supported by GPS location tagging. Uddin et al. [25] state that the percentage of accurate recognition when students pronounce their names is only 46,15%, which represents a serious performance constraint. Another issue of this type of systems is that students' registration is a serial process (sometimes a single student is required to pronounce its name more than once when misinterpretations occur) which leads to unwanted long durations of attendance registrations.

Concerning the face recognition technology, it is also implemented in many attendance tracking systems (Kar, Debbarma, Saha & Pal [27]; Patil & Shukla [28]; Patil, Karhe & Jain [29]; Tamimi, AL-Allaf & Alia [30]). Some usage reports show that such systems provide automatic attendance recording with zero wasted time, but, Kar et al. [27] report that their system's accuracy in detecting and recognizing faces is around 95 % for frontal face orientation, which drops to zero when the angle of the face toward the camera is 72 degrees. The system created by Patil et al. [29] is additionally equipped with GSM module and is claimed to be highly accurate, while the accuracy of the system of Tamimi et al. [30] is reported to be 94.75%.

Using the aforementioned technologies, many commercial systems are developed and offered as web services for a certain subscription price ("AccuClass" [31]; "Attendance Tracking for Colleges and Universities" [32]; "Register Attendees for Events" [33]; "Student Attendance Management System" [34]; "Student Attendance Tracking" [35]).

The system in "Attendance Tracking with Browsers" [36] represents a genuine web-based solution where each student registers her/his attendance using personal mobile device. The system is publicly available, and any institution that requires attendance tracking services can open an account. However, there are two negative sides of such paradigm. First, the system is dependent on Internet connection that may result in blocked registration when Internet connection is not in operation of various reasons. There are also possibilities for students' registration when they are not being present in the classroom, even though the system offers certain securities using GPS location. Second, the customizability of such system is not on an adequate level, since different institutions in different locations over the world have quite different requirements.

The system developed by Akhila, Prathyusha, PavanKumar and Amrutha [37] presents an IP networked solution that employs web technologies and databases for storing the attendance information. Its management interface is developed for the Android OS and installed on the teacher's mobile device. Similar systems are presented in ("Attendance Tracker" [38]; "BePunctual" [39]; "MyAttendanceTracker" [40]). These systems seem to be quite plausible for use in classrooms and appear not to be affected by the issues exhibited with the implementation of certain ID technology.

Thus, it is important to emphasize that all the aforementioned attendance tracking solutions share a common communication foundation, i.e. the IP protocol. But, different implementations regarding the ID technology contribute to different performance of the variety of attendance tracking systems. Table 1 summarizes the primary advantages and disadvantages of the diverse systems.

TABLE I. ADVANTAGES AND DISADVANTAGES OF DIFFERENT IDENTIFICATION TECHNOLOGIES

Implemented Identification Technology	Primary Advantages	Primary Disadvantages
RFID	Accuracy, Speed, Reliability	Implementation and maintenance costs
Bluetooth	Accuracy, Reliability	Operating distance
Barcode	Accuracy, Reliability	Speed, Implementation costs
Fingerprint recognition	Accuracy, Reliability	Speed, Implementation costs (Storing of personal sensitive data)
Voice recognition	Simplicity of usage	Accuracy, Speed, Reliability, Operating distance
Face Recognition	Speed	Accuracy, Reliability
Subscription Web-based solutions	Accuracy	Reliability, Subscription costs, Speed
Web technology	Customizability, Accuracy, Implementation and maintenance costs	Speed

III. WEB-BASED SOLUTION FOR STUDENT ATTENDANCE TRACKING – EVALUATION AND DISCUSSION

Taking into account the advantages and disadvantages of identification technologies presented in Table 1, we have developed a solution for tracking of student attendance to classes using free and open-source web technologies, such as HTML5, CSS3, JavaScript, PHP, MySQL. It is deployed since January 2016 in a local server, thus the stakeholders can access it regardless of the occasional problems with the Internet connection. The solution follows standard system of roles (administrators, teachers, staff and students), while special attention was given to the speed of attendance registration, in order to overcome the disadvantage. In this manner, prior to a lecture, the teacher needs to log-in and start the attendance registration for the particular lecture. Afterwards, the students are enabled to register their attendance using their personal mobile device, laptop or desktop, via a web interface. The system is called RENAP, which is an acronym for register of classes and attendance in Macedonian language.

In order to evaluate the proposed system for student attendance tracking, a survey was conducted that addressed the users' experiences of all educational system stakeholders, i.e. teachers, students and faculty managers. The research instrument consisted of several questionnaires, which were distributed and answered electronically by 84% of the statistical population. According to the analyzed and interpreted collected data, as presented in Fig. 1, RENAP is very easy for student's use (80.4%) and teacher's use (93.3%). The registration process takes a very short time according to 62.5% of the students and 86% of the teachers, and does not disturb classroom activities (73.2-students, 93%-teachers). 60% of the teachers and 59.8% of the student respondents consider that RENAP offers sufficient data safety. On the question whether they frequently noticed security breaches we received affirmative answers from 6.7% of the teachers and 5.4% of the students, while on the question about occasionally noticed security breaches, even 53.4% of teachers and only 12.5% of the students confirmed. The main negative remark on system's security is the possibility of student attendance registration when a student is not present in the classroom. This can be either performed by a student outside the classroom, or a student that has access to more than a single registration device. Despite of detected opportunities for abuse, only a small percentage of students (9.5%) reported that they abused the system and registered a colleague who was not present in a certain lecture. However, 60% of the teachers and only 31.2% of students consider that RENAP system offers a reliable and adequate security level.

In terms of registration and sign-in to the system, respondents generally expressed high levels of satisfaction. 53.3% of the teachers and 48.3% of the student reported that very rarely had any problems with registration, while only 13.4% of the teachers and 20.6% of the students reported frequent registration issues. The most common problem encountered by students was the inability to connect to the Wi-Fi network (93.3%), while 75% of the teachers reported the same issue. Further analyses revealed that the noted registration problems

were associated when students in higher densities attempted to access the system at the same time, and/or when the lectures/exercises were held in a particular classroom where the Wi-Fi signal was weak.

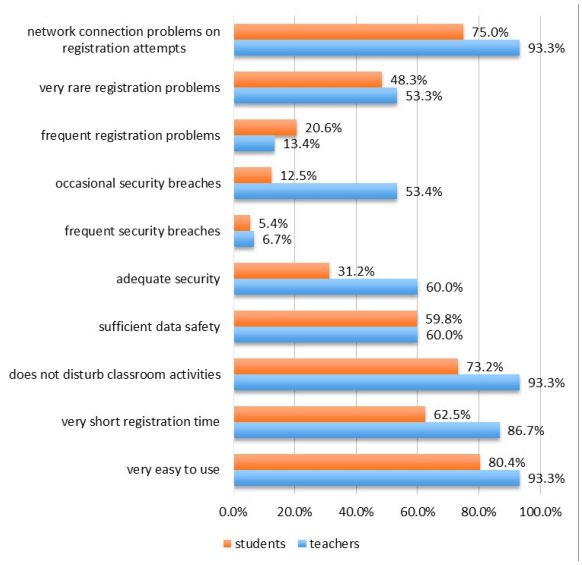

Figure 1 - RENAP's performance evaluated by teachers and students

Regarding the ideas for future addition of other functionalities, given in Fig. 2, students and teachers have suggested several improvements to the system, such as to improve the user interface (62.5%-students; 33.3%-teachers); to incorporate the log-in form for students and enable greater manipulation of personal data in the system (67%-students); to integrate with the university system (58.9%- students; 80%- teachers) and to strengthen the system's security (67%-students; 46.7%- teachers). Other noticeable frequent suggestions were to provide applications for various Android and iOS mobile platforms and many suggestions to improve the network infrastructure.

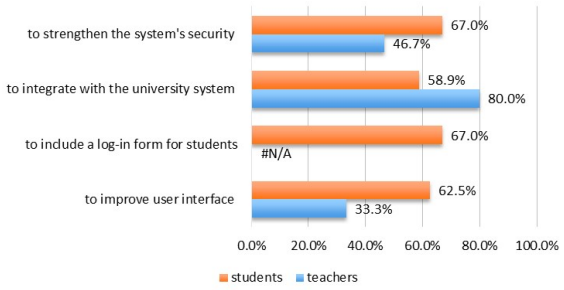

Figure 2 - Suggestions for improvement of RENAP's functionalities

As apparent from the presented evaluation results, the students and teachers appeared quite satisfied of the RENAP system, besides their suggestions for system's improvements. If we compare the results obtained, we can infer that teachers are a bit more satisfied compared to the students, but have almost the same suggestions for improvements. Concerning the satisfaction of the faculty managers, an interview revealed that they are quite satisfied with the system's functionalities as well, and find it very useful in the referred academic environment. The provided possibility to review all the teaching activities is regarded as important and essential for an educational establishment, and that it provides opportunities for better operational and strategic planning, as well as, a substantial support for making decisions.

IV. Conclusion and Future Work

Retaining a track of attendance records is an important aspect for the management of an educational institution. Nowadays, in order to improve and automate attendance tracking processes, many current technologies are employed, among which the most commonly used include: RFID, Bluetooth, Barcode ID, and several biometric technologies, such as Fingerprint recognition, Face recognition and Voice recognition. Yet, there are some that are purely based on web technologies and offered as Internet services. All the aforementioned concepts for student attendance tracking are built on an IP infrastructure, but exhibit different performance that make them more or less suitable for use in classrooms for student tracking purposes, according to the required system's features and functionalities. The analysis of their distinctive properties was an inspiration to develop a custom web-based solution for student attendance tracking that employs the latest and free web technologies. The developed system, titled RENAP, is designed to take into account all the pros of the existing systems and adhere to the defined criteria. RENAP is characterized with short registration times, and uses a simplicity approach where only few data fields need to be filled for attendance registration. It also prevents unintentional erroneous input and provides substantial level of security. The survey conveyed among the interested parties revealed substantial user satisfaction, and several minor deficiencies. The suggestions for future improvements mainly include the requirements from students to enable student's log-in form and provide native applications for the most popular mobile platforms.

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