MOVING TO AN ATTENDANCE CONTROL SYSTEM. DOES IT MATTER?

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Abstract

The scientific community not always agree when discussing the benefits or problems with using student attendance systems. Some refer that these systems are expensive, flawed and demotivate students [1], while others argue that one of the main factors for academic failure is not being in class [2]. Regardless of this discussion, there is the need for leadership to optimize higher education resources, such as staff, classrooms, laboratories and teachers. With the democratization of higher education and the opening of new opportunities, more students are pursuing education at a high level, leading to increasing number of students, with diverse academic backgrounds, economic status and culture. Universities have to adapt, within budget constraints and in the assumption of the commitment to their social and economic development mission.

In this context, it is necessary to separate “mandatory attendance”, in which a student is required, by regulations, to attend to a specific percentage of classes, from “attendance control”, which allows to get valuable information for management and allocation of resources. The choice of enforcing a minimum number of presences in class depends on the policy of the scientific and pedagogical bodies. However, the information about student attendance represents valuable management information that can be used for informed decision making regarding the university operation.

Regardless of this discussion, some universities, such as the Taraz State University, are currently performing manual registration of attendance. In each class, the teachers register the students’ attendance, and, after class, they transcribe this information to a digital platform, to be consulted by the faculties’ management body. This is a repetitive, boring and error prone process, taking valuable time from teachers and harming other scientific or pedagogical activities.

In this paper, we describe the design, development and implementation of a digital attendance control management system, adequately integrated with other university’s services, such as class timetables, b-learning platform, registration record office, and others. The system is based on open source programming languages, protocols and tools, and composed of hardware devices to be installed in the classroom and servers to receive and save the information in a database. Each student can use both an RFID card and smartphone to register attendance, that will be immediately accessible to the management bodies. Teachers can validate the students’ attendance in each class, ensuring that the information is correct and up to date.

Keywords: higher education, student attendance, academic success.

1 INTRODUCTION

Higher education institutions have adopted education, research and cooperation as their main missions. Students, teachers and non-teaching staff articulate for lecturing, researching and developing projects and internships, according to the institution goals and strategy. The research mission has always been assumed by higher education institutions in a way that governments, as well as private institutions, have begun to recognize the research role of these institutions, to provide them with research funding and to initiate various measures for enhancing research activities. Research remains the primary path not only for individual and institutional prestige but also to support teaching excellence.

The cooperation mission includes international, regional, social, culture and science promotion and cooperation with enterprises. In broad terms, cooperation aims to bring together higher education institutions and enterprises in order to promote entrepreneurship, creative thinking and innovative approaches as part of the curriculum for students and as a skill for teachers/researchers and to reinforce the link between studies and employment needs.

Embracing all these interconnected aspects introduces a workload and complexity that has to be managed in a way that does not compromise growth, stability and high levels of quality. It relies in well-supported management, using rigorous information, providing a sound basis for reasoning and improvement. Leadership must provide adequate work conditions for staff (teaching and non-teaching), as well as stimulating learning environments for students, considering budget restrictions and very dynamic world. In this context, information is fundamental. Access to updated and rigorous information allows leaders and management to make informed decisions and to optimize their implementation.

One aspect of the workload is the necessity to maintain records of the students and teachers' attendance in class. Within the university's regulations, it is necessary to keep this information to produce statistics that can be used to understand its impact in the teachers' success and optimization of resources.

It is clear that engagement and motivation have a fundamental role in the success of students. Skipping classes make the students disconnect from the regular flow of class, contributing to lower involvement and lower possibility of success [3]. Universities should provide mechanisms to stimulate students to participate, to be actively involved in class and to keep a regular attendance. The system described in this paper presents and discusses the development of an architecture and implementation of a system to both assess student attendance impact on their academic success and to regulate their continuous involvement in class. It relies on a card reader in each classroom with centralization of information in a data warehouse for decision making support.

2 METHODOLOGY

The design of the architecture started with the definition of questions that the system should be able to answer. These are pertinent to learning areas (classrooms) and class size (Table 1).

Table 1. Potential questions related to classroom occupancy and class size.

Question	Relevance			
	Students	Staff	Teacher	Manag.
Did a student attended the minimum number of classes?	X		X	X
How many classes where lectured?		X	X	X
Are the class size adequate to the classroom considering the effective number of attendances?				X
Are there free classrooms at a specific time?		X		X
How many students attend a specific class?		X	X	X

To retrieve and store this information, it is necessary to design a system that allows to record, transmit and store information. The design involved several layers, with different responsibilities and purposes, both technological and administrative:

- Hardware layer – design and develop devices that can be used to monitor attendance in class by students and staff;
- Network layer – increase the coverage of wired and wireless Local Area Network, supporting the security and performance requirements for data generation and storage;
- Server layer – Design and implement virtualized server architecture to support generation, storage and processing of information;
- Staff layer – Help teaching, and non-teaching staff to reflect on their work and how they can contribute to optimize it;
- Leadership layer – Discuss and agree on strategies that can contribute to the sustainability of the higher education process, in terms of resources, pedagogical quality, scientific and technological production and international recognition.

The workflow should follow a well-defined schedule, with the participation of all the involved actors, such as students, teachers, non-teaching staff and management. Within the university's strategic lines, it is necessary to cover four main dimensions:

1 Adapting the network and systems infrastructure in order to strengthen their security
2 Automating the access control of students and staff to classes
3 Modernization of the higher education offer in terms of computer engineering
4 Contribute to the standardization of course curriculum forms and credit recognition procedures

The process started with the simultaneous definition of data structure and installation of necessary databases, and the design and implementation of the hardware. After these two steps, followed the software development to gather and store information. Finally, the adaptation of processes to process, analyze and evaluate the system.

3 DEVELOPMENT AND IMPLEMENTATION

Until now, the attendance control has been performed manually, with a lot of effort and intervention of human resources. In addition, the time it takes to raise all the information is considerable and it is stored centralized, meaning that it is difficult to have immediate access anytime, anywhere. It is fundamental to provide an automated mechanism that allows constant and up to date gathering and processing of attendance information. This requires three steps:

1 Identification of the teacher in each class (opening classroom/class)
2 Identification of the student in each class
3 Crossing student/teacher and classroom information with the timetable information

The first two steps are related and can be implemented the same way and depend on a mechanism that allows producing a record containing who, where and when events. The last step depends on the correlation of the previous information with the timetable information, stored in a database.

Identification of teachers and students depend on three things:

- something they have, such as a card or a token
- something they know, such as a username
- something they are, such as fingerprint

In addition to identification, there is, usually, a related step: the confirmation (or authentication) of the person: is he really who he says he is?

In other words, identification is the ability to identify uniquely a user of a system or an application. Authentication is the ability to prove that a user is genuinely who that person claims to be. Of course, the more robust the identification/authorization process is, the more complex or expensive. For this reason, to support any possibility of authentication possibility, the system should be versatile to allow evolving the solution and providing a flexible approach.

Considering the most versatile system, it should support reading RFID cards presented by the student, as well as interacting with the students' smartphone (Figure 1).

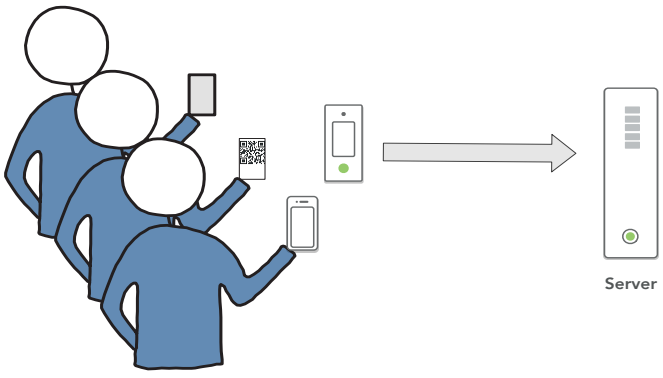

Figure 1. Attendance control system with multiple interaction.

To support these multiple possibilities of interaction, the hardware was designed to have both RFID card reading possibility, a display, a camera and a Bluetooth master node (unused, in this phase).

3.1 Hardware design

Hardware design depends on the hardware features that the system should support. According to the previous section, the information about attendance should be gathered in the classroom, to confirm the presence of both the student and the teacher. To allow high flexibility, the system was design to support registration through RFID and QRCode.

Radio-frequency identification (RFID) uses electromagnetic fields to identify tags or tokens, such as a card. A person carrying and presenting this card can be uniquely identified as the owner of this tag through a one-to-one association to the RFID number. The cards are passive, meaning that they do not need battery to operate, and the range of operation is short, about 1 to 10 cm. To be able to read a RFID card, the system needs a specific controller and, in this case, a Mifare compatible solution was adopted [4].

A QRCode is a visual matrix representation of text. It can be easily read by a camera and converted into a location, phone number, a Uniform Resource Identifier (URI) or others. A person carrying and presenting this picture to a card reader can be uniquely identified as the owner of this tag through a one-to-one association to embedded code. It is just a picture, meaning that they do not need battery to operate and can be stored in paper, card or mobile phones. Images are gathered through a camera, so the system should also support a camera to be able to read the students' QRCode.

In addition to be able to read RFID cards and images, the system has also to interact with the user, through a TFT display (3.5'' wide). In summary, the system is based on Raspberry PI with the following characteristics: Raspberry Pi 3 Model B+ 1 GB, PiTFT Plus 480x320 3.5" TFT+Touchscreen, RFID, Raspberry Pi PoE HAT, Raspberry Pi 3 Camera (Figure 2).

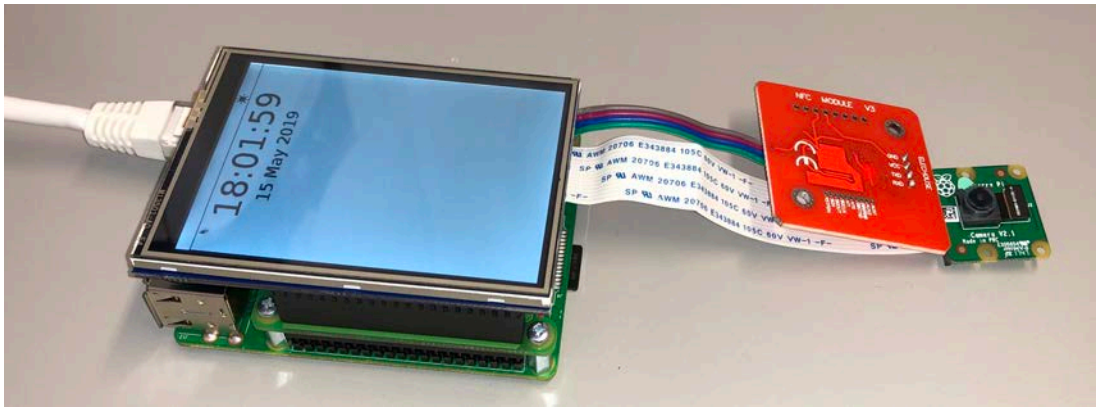

Figure 2. Hardware prototype.

Power and connectivity are provided by the Ethernet connection. The device is continuously reading the RFID and the camera to assess Mifare compatible cards and valid QRCodes, to register attendance in the central server.

3.2 Software

The software is designed according to a Service Oriented Architecture (SOA) [5], in which the services are interconnected through REST/JSON resources and clients run embedded in the browser, in Javascript [6]. In addition, the classroom card readers are connected with the server through REST/JSON as well (Figure 3).

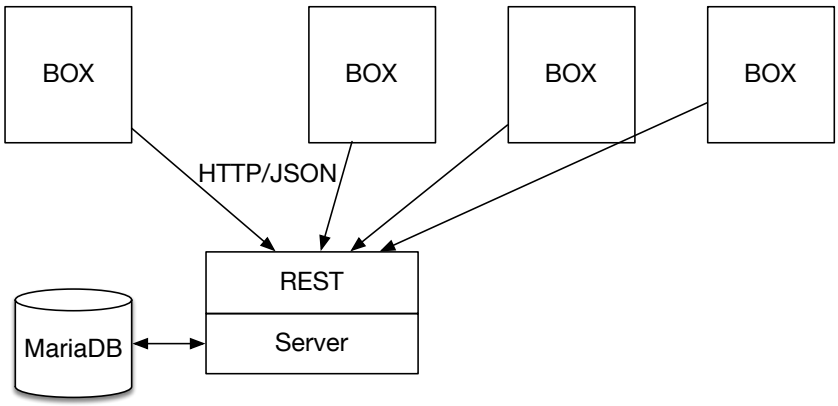

Figure 3. Interaction between card readers and server.

Each card reader has an interface for each device, namely, the RFID reader and the camera. If some connection issues happen, each reader will be able to store the events locally, in an embedded H2 database, until the network connectivity is restored (Figure 4).

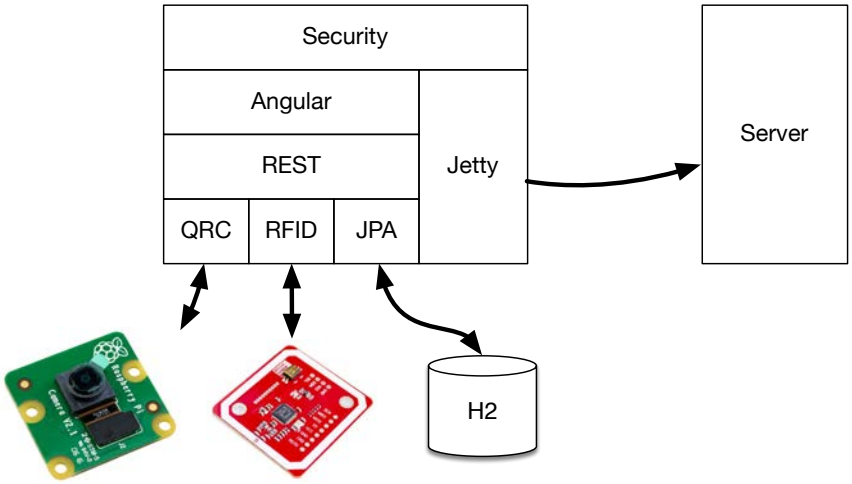

Figure 4. Card reader software architecture.

The security layer is responsible for identifying and authenticating the connections to and from the card reader. The administrator can also connect to each of the card readers to assess its state and operation (Figure 5, Figure 6).

Figure 5. Operation status of a card reader.

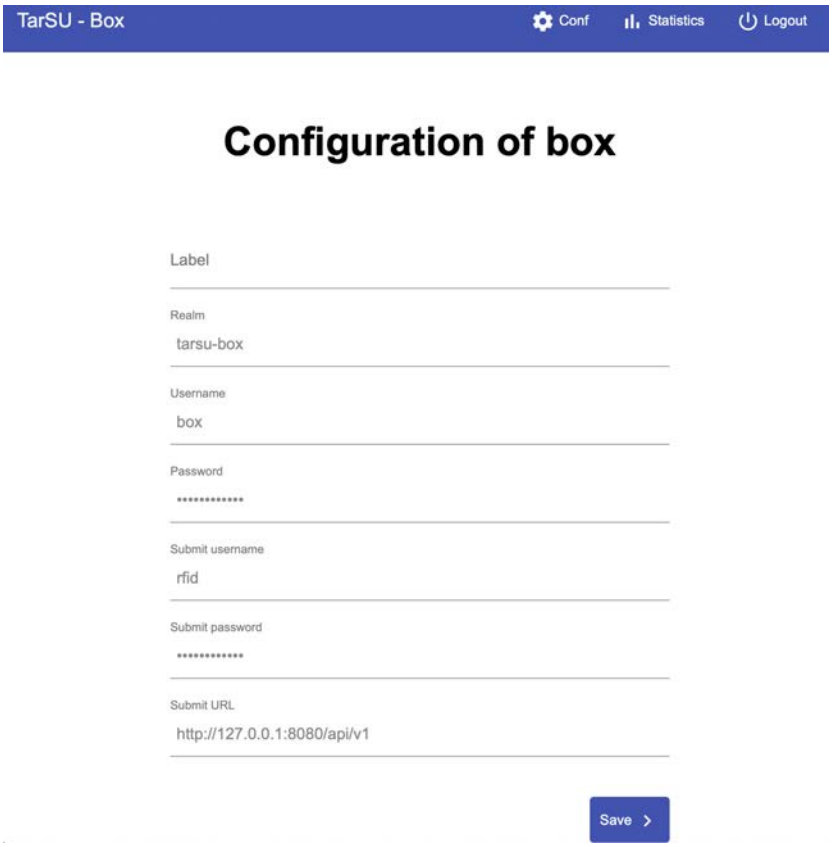

Figure 6. Configuration page for the card reader.

The students' cards are managed by the registration office, where they take a picture and receive a Mifare card to be used to enter the classroom (Figure 7).

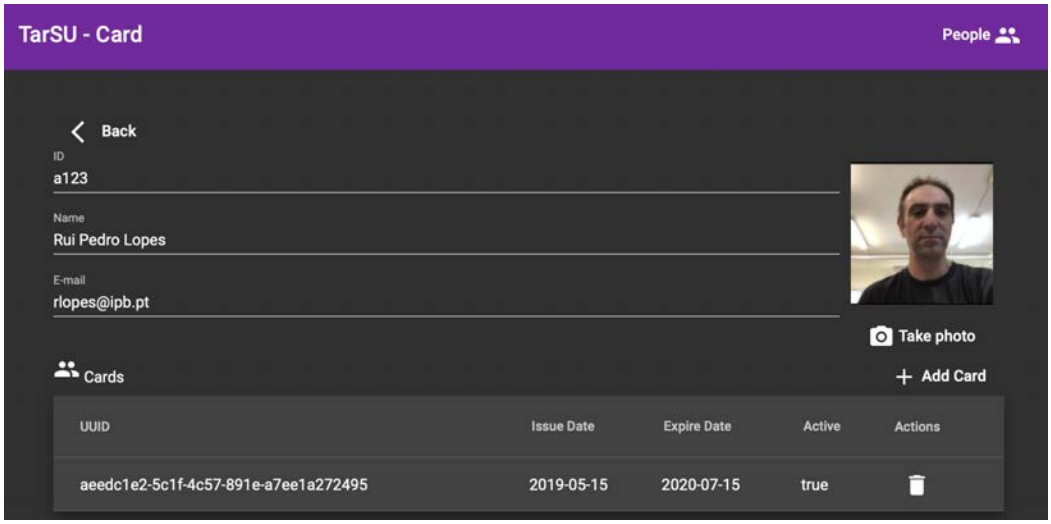

Figure 7. Student and card management application.

3.3 Systems and network

In detail, the installation of the devices requires the connection to each device and to the server. The server, in turn, has to provide dual access to the network, in which one is connected to the devices and the other is connected to the database (Figure 8).

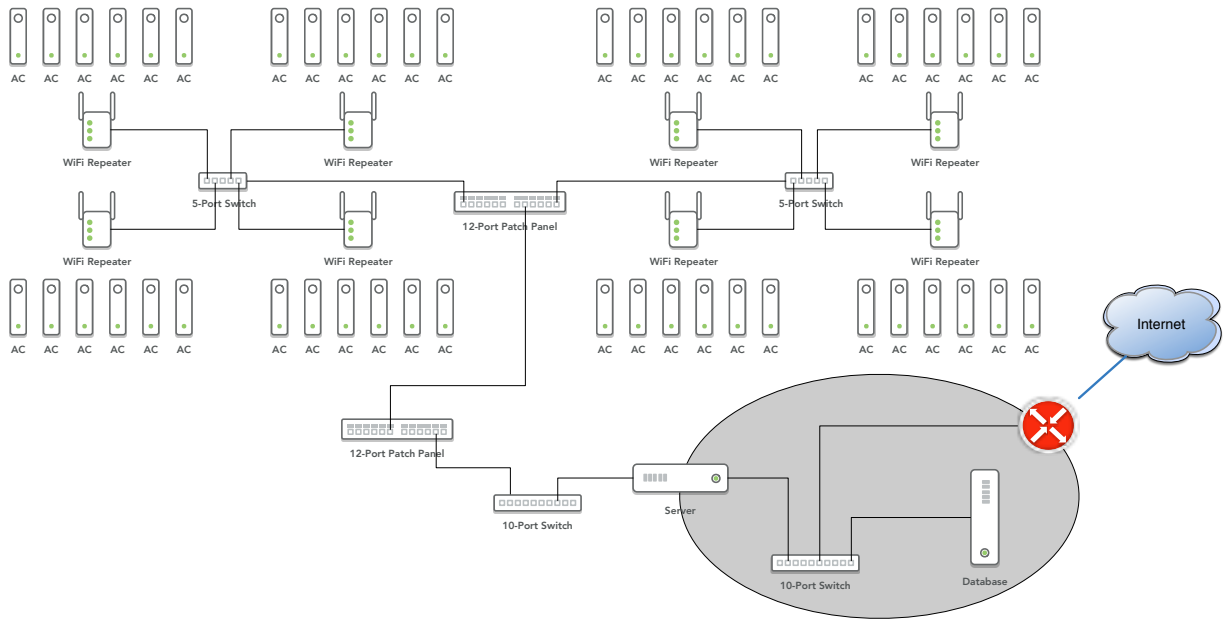

Figure 8. Detail on the Attendance Control system network.

The servers in the protected area should also be prepared to support additional information and to response quickly in case of malfunction. The suggestion is to use virtualized servers in bare-metal hypervisors, such as Proxmox (Figure 9).

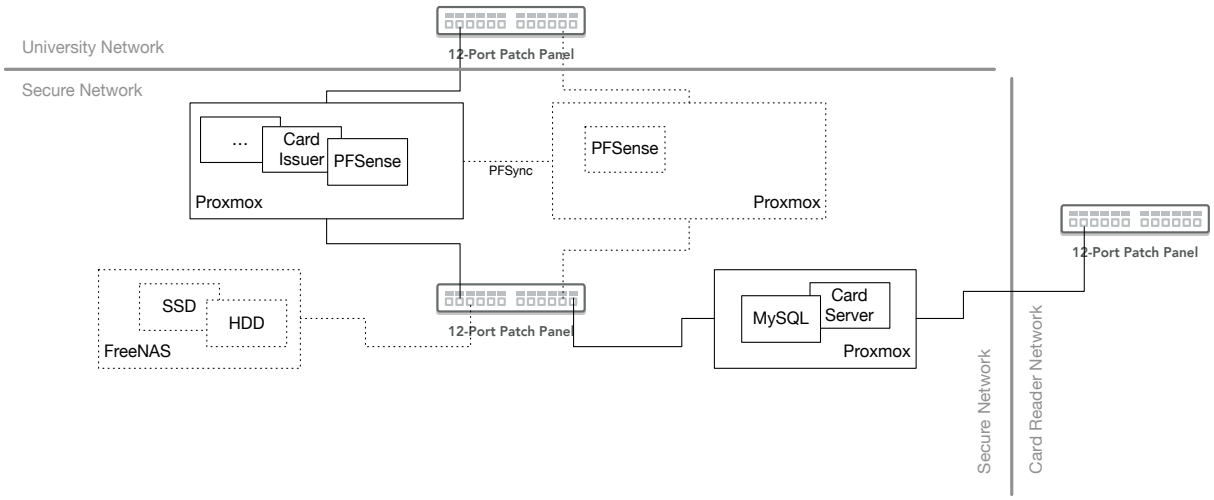

Figure 9. Server infrastructure.

All the network accesses are managed with pfSense, an open-source firewall/router software distribution based on FreeBSD. It also provides VPN access, to allow external access to authorized parties to the protected network. It should be installed in a virtual machine and, in the beginning, in a single instance. Due to its importance, in the near future, it should be provided better hardware resources and fault-tolerance through the duplication of physical hosts and synchronization with pfSync.

The card server is installed, as discussed before, with access to two networks: protected and card reader network. If possible, it can be installed in a different physical host, although, for proof of concept, can be install in the same host as the pfSense firewall.

4 CONCLUSIONS

Universities are required to provide adequate learning environment to students, to maximize their possibilities for learning and academic development. The administrative system requires that

professors and staff to spend a lot of effort and time to gather, analyse and discuss many information related to the daily operation of the organization.

Students motivation depend on the continuous flow of learning, requiring following classes with minimum interruption and as often as possible. An attendance control system can motivate students to keep going to class and, at the same time, help universities to keep valuable information about how the classes are going and how the resources are being used.

An automated system, able to read RFID tags and QRCodes presented by students was presented, with the hardware and software structure. These elements provide the foundation for an attendance control system to be used by students', teachers and administrative services.

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