

# Attendance monitoring as a context-aware service

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*Abstract:* We propose an approach to attendance monitoring using mobile devices and the mobile device management infrastructure. Attendance monitoring is regarded as a mobile context-aware service that integrates with other services and information systems of the university. As a result, attendance tracking can be faster and more precise, using the best method that is available in the classroom where the educational event takes place.

*Key-Words:* Attendance monitoring, educational institutes, mobile device management, context-aware services.

## 1 Introduction

Attendance monitoring is an important aspect of the educational process. Research suggests that a statistically significant correlation exists between the class attendance and the academic progress [1, 2]. The analysis of classroom attendance data provides instructors an insight into potential issues with course progress. At the same time, students are encouraged not to miss their classes if lecture attendance counts towards grading. Continuous monitoring of attendance may be obligatory for international students in relation to the country visa policy [3, 4].

Attendance checking is often performed in a non-automated manner. For example, in St. Petersburg State Polytechnic University there are three common ways to check attendance. In small groups, the instructor records if a student is present when she sees this student. In larger groups, or when the instructor does not know students well enough, the instructor calls the roll. If calling over would take too long time, the instructor may choose to make students to write their names on a sheet of paper. Sometimes additional verification is performed to detect missing students who have been checked in by their classmates.

The attendance data is usually processed by departments and by the university administration. The data may be collected using attendance reporting software or paper registers [3, 4]. Sometimes the attendance check process itself is automated [5].

In this paper, we survey existing approaches to the

attendance check automation and propose a new way to integrate different methods of attendance tracking. We regard attendance monitoring as a context-aware service that uses class time and location to find the best available method of automated attendance tracking in order to make attendance check less disturbing for both instructors and students.

## 2 Related Work

Attendance check can be automated. The necessary equipment may be installed in classrooms, or instructors and students can use their own mobile devices. The problem of attendance check automation has been researched by many authors. Let us review main approaches that have been proposed so far.

The events of entrance and exit may be tracked using RFID sensors or other NFC devices [6, 7]. This method is commonly implemented in access control systems, so existing access management infrastructure can be used. The main drawback of the method is coming from the fact that students are identified by their access cards. If a student misses the class but has given her access card to a friend, she will be accounted as present. On the other hand, the need to put access cards close to the reader slows down entrance into the classroom, so the crowd at entry is more likely to form. Some students in the crowd may pass without being tracked, which leads to false negatives during attendance checking.

Students can be identified based on their biometric data [8, 9, 10, 11]. Methods of this family are very accurate, and their usage makes cheating difficult. To implement biometric identity verification, special equipment and a database containing biometric data of all students are needed.

As a less obtrusive method of biometric authentication, face recognition can be employed [12, 13]. Authors of [13] propose to use face-based authentication at entry. In the paper [12], the video of the class is recorded during the lecture. This approach is attractive because it does not distract students, and may be combined with ordinary lecture recording. On the other side, common face recognition techniques have somewhat inaccurate (e.g., precision is 80% in [12]). There are commercial access control systems based on face recognition, but the number of users is limited. E.g., devices by ZK Technology [14] allow up to 500 different faces. As large institutions have several thousands of students, face-based attendance tracking may be hard to implement.

Students can also be identified using their mobile devices, such as smartphones [8, 15, 16]. A mobile device may be used as an authentication token or as a computer that communicates with attendance management system. As an authentication token, the device provides a unique key using Bluetooth, NFC or other available media. When a mobile device is used as a computer, its camera, microphone, and other peripherals can be involved. For example, the paper [16] describes a method of attendance checking using QR codes. A random QR code is displayed to students using a projector. A student uses her mobile device to recognize QR code and to send a message to the instructor's device. This message contains the data obtained from QR code and the identifier of the student. As the QR code is randomly generated, it is more difficult, although possible, to check in a missing student.

### **3 Attendance monitoring as a mobile context-aware service**

Each method of automated attendance monitoring needs a specific set of equipment to be installed in the classroom. RFID-based and biometric methods require a set of sensors. They may be easier to implement if the classroom already has an access management system using the same method of authentication. Attendance checking based on face recognition may be performed without preinstalled hardware, as it may be implemented using a portable web camera or a smartphone. However, for continuous recording of the audience during the lecture a stationary camera is more convenient. The mobile device based methods

are most versatile as they can be used even in completely unequipped rooms. For example, when attendance is checked using QR codes, one can print the code on a paper sheet in advance, and set up an ad-hoc Wi-Fi infrastructure to receive attendance data. However, automated attendance tracking may be easier if additional devices are available.

Although every classroom has a different set of authentication facilities, sticking to only one universal method that works everywhere, such as QR-code recognition, is not always appropriate. For example, if every student must use an RFID-based access control system to get into the classroom, there may be no need to check attendance again if the necessary data can be obtained from the access control system. Automated attendance monitoring software should be able to interact with all available authentication equipment to collect attendance data. It should also help instructor to select the best available method of attendance checking.

As the survey [17] shows, more than 95% of university students in Russia use smartphones, tablet computers, or other mobile devices that can run user-installed software. Therefore, a mobile device can be viewed as the main medium of electronic communication between the student and the instructor during the lecture.

In particular, we propose to use mobile devices as the default authentication tool for attendance management. Unlike prior research, we regard attendance monitoring not as a stand-alone activity but as a service integrated with other mobile and information services of the university.

To achieve this, it is necessary to identify the mobile devices that are used by students and instructors, and to connect them to the university network resources with appropriate permissions. This problem can be solved using the mobile device management (MDM) infrastructure [17, 18].

When a service is implemented using MDM infrastructure, it can obtain context information about the mobile devices that use it, like the time of the request, the location of the device, and the user identity. This reduces the amount of data that should be explicitly provided to the service, and makes the attendance monitoring more precise.

That said, we propose to implement attendance monitoring as an MDM-based context-aware service.

The paper [18] describes a set of mobile services that may be implemented using the MDM service of an educational institution. These services, among other things, provide information on schedule and classroom equipment, class membership, and mobile device location. The data is obtained from the institution information systems, and from the MDM

server that updates location information in real time by communicating with mobile devices. Services are provided to the applications running on registered mobile devices, and to other services and information systems of the institution.

Mobile services offer new options that simplify attendance monitoring.

- A common authentication service. A mobile device that has been registered in the MDM system becomes an authentication token for all services using MDM-based authentication. If a student replaces her smartphone, she needs only register her new device in the MDM system. Existing attendance records will not change.
- A centralized user database. The MDM system provides information on the user that owns a registered mobile device. If permitted by corporate rules, instructors may obtain the necessary data such as name, photographic image and curriculum of any student who has checked in.
- Automatic update of central attendance database. The results of attendance check may be automatically sent to the central server without diverting the instructor. Attendance history may be updated many times during the lecture, allowing recording not only the absence of a student but the late attendance too.

The context of the attendance monitoring service includes the location where attendance checking takes place, and the time when it occurs. The use of context enables automatic search of information that is relevant to the specific lecture, and the following features become available.

- Access to the information on schedule. The list of students who should be attending the lecture becomes automatically available based on the schedule and the information on last-minute changes.
- Access to location data of specific mobile devices. Location data of students mobile devices may be used in attendance checking to discover cheating attempts. Knowing each other location also helps the instructor and the students to coordinate in case of unpredictable delays.
- Automatic selection of the best available method of attendance checking. If the attendance management service knows in which classroom the lecture takes place, it may automatically suggest the way the attendance should be tracked.

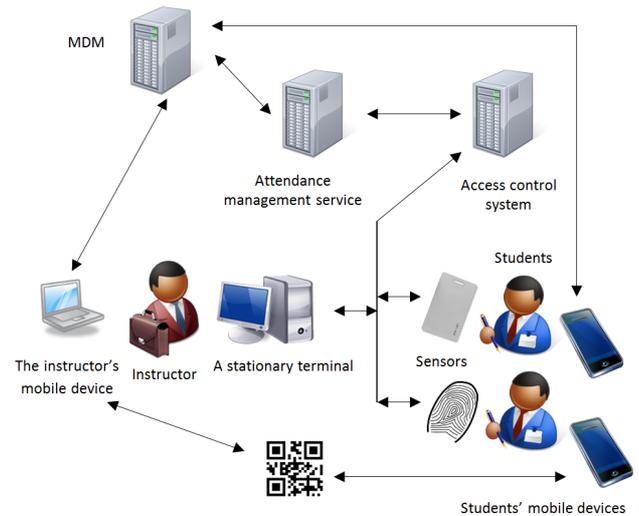


Figure 1: Architecture of the attendance monitoring system

- The integration of the institutional services is a necessary condition for enabling these features. In particular, access control systems should provide authentication data to the authorized services, and attendance management service should have access to schedule and classroom equipment databases.

Our main goal is to make attendance check transparent and as less distracting as possible for both the instructor and the students. To track the attendance, the service obtains the necessary information about schedule and students, takes into account the location of each students mobile device, and communicates with available authentication equipment in the classroom. The instructor may also manually correct the results of attendance checking to check in the students whose presence has been identified incorrectly.

## 4 Attendance monitoring use case

The proposed system architecture is shown in Fig. 1. Main components of this architecture are the mobile device management system of the institution, the attendance management service, a set of access control and authentication systems installed in classrooms, and instructors and students mobile devices.

During the lecture, the instructor starts the attendance management application on a mobile device, or on a classroom terminal. The application connects to the attendance management service and provides the context. If the software is running on a mobile device, the context is obtained using the MDM system. In case of the stationary terminal, the location context

is known to the attendance management service as it is determined by the physical location of the terminal.

Based on the context, the attendance management system responds with a list of students who should be present in the classroom. The system also discovers the authentication equipment that is installed in the classroom. The list of available methods of attendance checking is formed and displayed on instructors device. If an access control system is listed, the attendance management system tries to obtain attendance data from it. If successful, the attendance data is displayed to the instructor.

If no attendance data is available, the instructor should initiate an attendance check using one of available methods. For example, let us suppose that the method based on QR code recognition is selected. The instructor shows the QR code to the students. If instructors mobile device is connected to the projector, the QR code may be generated automatically. Otherwise, the instructor should supply the correct code to the attendance management application, e.g., by scanning the QR code. To check in, every student should run the attendance management application on a mobile device and scan the QR code image. The recognized code is passed to the attendance management service. Using this code and the location of the device, that is obtained from the MDM system, attendance management service check the student in and marks her as present in the instructors interface. The instructor can also check in the students who have not been authenticated automatically. If the instructor decides to use other methods of attendance tracking, the attendance management service carries the communication with necessary authentication equipment. This process may be repeated multiple times, and the system can notify the instructor if an obligatory attendance check is missing.

## 5 Discussion and implementation

The proposed approach to attendance management automation has some advantages.

- The attendance tracking is performed using the best available authentication methods. In particular, the attendance data can be obtained from the access control system, gathered using students mobile devices, or manually added by the instructor.
- The instructor has actual information about the students attending the lecture.
- The attendance management may be integrated with other services, such as polls and quizzes.

To implement of the proposed architecture, it is necessary to analyze the existing infrastructure of the educational institution, and to ensure that all components communicate using the common protocol. However, the attendance management service does not depend on any specific components except the MDM server. It is possible to deploy the attendance management system together with the MDM system. Additional features may be added to it later, as far as new services are integrated with the common MDM-based infrastructure.

## 6 Conclusion

In this paper, a set of known approaches to automated attendance tracking has been reviewed. Each of these methods requires a specific set of equipment. The most general method is based on students mobile devices. This method may be used even in an un-equipped classroom. At the same time, other methods can be more convenient in specific circumstances.

We propose a novel approach to implementation of attendance monitoring based on mobile devices. The attendance monitoring service is regarded as a context-aware service that is implemented using a mobile device management system. This service is integrated with other university services and information systems. The usage of contest and the integration of attendance monitoring and other services allows for selecting the best available method of attendance tracking, making attendance check less disturbing to both students and instructors.

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