Architecture of a Platform for Building Context-Aware Educational Mobile Services

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Abstract: In this paper we present an architecture of the software platform directed to building of context-aware educational mobile services. The platform is implemented around a mobile device management system as its core. The MDM system provides basic functionality to the services. It also serves a source of context in which interaction between mobile clients and services takes place. As an example of a platform-based service, the architecture of an automated attendance management application is described.

Key–Words: Mobile education, mobile service, mobile device management, software platform architecture.

1 Introduction

Modern mobile devices are more than just communication media: they are feature-rich terminals giving access to a wide class of services. Wireless networking and a wide selection of mobile software available at stores allows users to play games, to read books and news, to search in databases, to create and share documents, to help and to ask for assistance, and to collaborate in multiple ways. Rich capabilities of mobile devices also find their use in education, especially in distance learning. Free applications are available, which provide access to massive open online courses (e.g., Coursera, Udacity, edX), and to learning platforms, such as Apple iTunes U. Traditional universities are also heading in the wider adoption of mobile services and applications as a part of e-learning educational technology. Mobile intranet services are also used to provide better day-to-day activity experience for students and staff.

To implement mobile educational services, an institution should solve a number of problems, such as reliable user authentication and authorization, dealing with multiple mobile platforms, and deployment of software. As these problems are common to all mobile services that the institution provides to users, it is inefficient and error-prone to solve them again for each service. A common platform is needed, upon which educational services may be built. One widespread solution that handles main aspects of mobile device usage in organization is to deploy a mobile device management (MDM) system. The MDM system registers mobile devices, which belong to the company employees, and communicates with them. Common functions supported by MDM services available in the market include device authentication, installation of software and operating system updates, and managing device settings to enforce corporate policy.

We propose to use a MDM system as a core component of the software platform for building educational mobile services. The MDM server takes upon itself all common tasks related to mobile devices, such as user authentication, software deployment, and messaging, and manages common context of user interaction with the platform.

This architecture makes easier to develop context-aware services. According to [1], "a system is context-aware if it uses context to provide relevant information and/or services to the user, where relevancy depends on the users task". In respect to mobile devices, context includes user identity, device location, its state (such as the set of installed applications, battery charge level, and notification settings), shared application data (which may include, for example, calendar entries, contacts, or status messages) and contextual information on nearby devices and their users. This information may be hard to obtain for a service, but it is available for a MDM server that authenticates all users and interacts with their mobile devices.

In the rest of the paper, we discuss the issues associated with implementation and usage of educational mobile services, and describe in more details the architecture of the MDM-based service platform. As a more detailed example, we describe the architecture and implementation of a context-aware attendance monitoring service.

2 Mobile services for education

Modern educational technology may benefit from adaptation of internet, intranet, and mobile services of several types of internet and mobile services. Such services may address, among others, the areas of distance learning, classroom interaction support, academic progress monitoring and analysis, and of supporting daily activities of students and instructors.

As the survey by Pereira and Rodrigues [4] shows, many of these services are actually implemented using mobile devices, and put into practice worldwide, especially in developing countries that need to make education more accessible. Most popular are services providing access to learning and reference materials, and online quizzes. Yet another interesting area in mobile education is represented by educational games. Although traditional computer games, either available in entertainment stores or specially developed with educational purpose, are often used in learning [4], mobile devices bring novel features that may be effectively used, like the possibility to learn by playing in real environments [2].

Based on a survey conducted in Peter the Great St. Petersburg Polytechnic University [5], we identified the set of educational services that instructors and students have been most interested in [6].

- Access to the timetable and timetable alterations, and events and calendar management.
- Access to information about administrative procedures, business-process guides.
- Interactive teaching tools.
- Support of surveys, tests, and examinations.
- Group work support, distribution of tasks.
- Support of certification and graduation processes.
- Attendance monitoring.
- Student performance monitoring.

These services share common data and should implement a common set of basic functions. Their development is largely simplified if the services are built on the common platform that provides the common functionality. Our goal is therefore to design a service platform for building context-oriented mobile services.

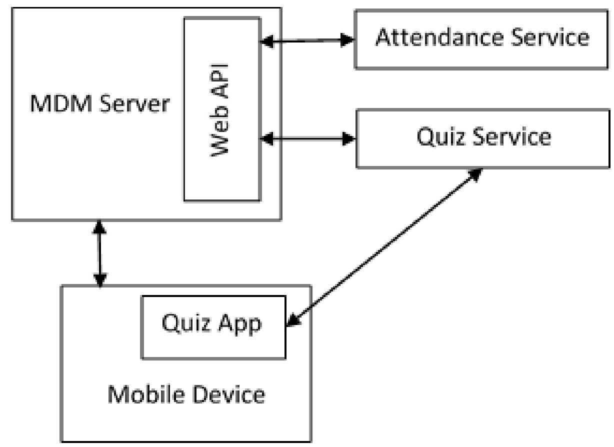

Figure 1: Platform architecture

3 The architecture of the MDM-based service platform

We propose the following architecture of a platform that enables the implementation of context-aware mobile services. Although our primary goal is the implementation of educational services, this architecture can be used in other environments as well. The only requirement is that users should register their devices in the MDM system in order to use all platform features.

The platform consists of three main groups of components.

- The mobile device management system, which acts as a core of the entire platform.
- The services that are implemented in the platform.
- Mobile devices and stationary computers used to access the services.

Services interacts with the platform core using the MDM server Web API. To be able to use this API, a service should obtain an identification token. The token is generated when the administrator register the service in the MDM database. To make a request to the server, the service calls Web API and provides the token.

Interaction between these components is depicted in Fig. 1. In this example, there are two services: an attendance monitoring service, and a service to perform quizzes. A user interacts with the quiz service using an application running on her mobile device. To authenticate the user and to get context data that may be used to set up individual quizzes, the service connects to the MDM server and makes a request using the server Web API. The MDM server responds using the information taken from its databases and obtained by communicating with the mobile device.

The MDM server provides the following basic services.

- Users and groups management.
- Authentication and athorization.
- Messaging.
- Document distribution.
- Event management and user registration.

The users and groups management service provides information about registered users and user groups. A user group is a set of users defined by some common property defined by the administrator and may correspond to faculty members, students of the same class, or the participants of the same project. By request, the server returns membership information for a given user or group. MDM server implements an administrative interface for user and group management.

The MDM server perform user authentication using the data obtained by communication with a registered mobile device, and also provides the common authentication cababilities such as login and password check. The interaction with mobile devices allows the server to use device-based authentication (PIN-code, fingerprint check) when available. Authorization relies on the permissions set by the administrator, who define group rules (and individual user rules, if needed) for all registered services.

Messaging service provides delivery of messages from services to mobile devices, and the communication of messages sent by users. Likewise, document distribution service provides document storage, sharing, and delivery to devices. The MDM server notifies the users' mobile devices that a message or a document is available using standard push notification service of the mobile platform.

The event management service allows the administrator, or to any authorized user, to schedule public events, e.g., meetings, talks, or conferences. After the event is scheduled, any user can register herself (and possibly others, if the user has necessary rights) as a participant.

It may seem unnecessary to put such high-level facility into the platform core. Although this facility could certainly be implemented as a regular service, we have found it convenient to include event management functionality in the MDM server API. One reason behind this decision is that the information about user-scheduled events and their participants is used by multiple educational services, including timetable and calendar services, attendance monitoring, and student performance monitoring. Moreover, with event schedule being available, users can transparently use the facilities of other services, e.g., to assign a quiz, or to share a set of documents with event participants. Furthermore, the information about scheduled events is logically a part of the context of user interaction with the MDM server and platform-based services.

4 An example service: context-aware attendance monitoring

As an example, let us discuss the architecture and the functionality of one specific service, automated attendance monitoring. Here we only describe the overall architecture of our solution and its interaction with the service platform. A more detailed discussion is available elsewhere [7].

The goal of the automated attendance monitoring is to determine who is attending a specific event while minimizing required human effort. The most widespread use of attendance monitoring in education is the monitoring of class attendance by students. In this case it would be desirable to the monitoring system to provide some cheating prevention facilities.

Our system is implemented using mobile devices and an attendance monitoring mobile service. It can also be integrated with an existing access control systems if they are available. The architecture of the service is represented in Fig. 2 (taken from [7]).

To check whether a student is present in the classroom, an automated system must solve two problems. First, a student should be authenticated. Second, the system should make sure that the authenticated student is located in the classroom. Our implementation of the automated attendance management service uses mobile devices to solve both authentication and localization problems. To be able to register their presence, each student should install a mobile application. This application may also be automatically installed using the MDM software distribution facility.

The authorization problem is handled by the MDM server. The student's mobile application connects to the attendance monitoring service, which calls the authentication service using MDM server Web API.

Reliable localization of the device is more difficult. Modern mobile devices can provide information about the device location. This information is

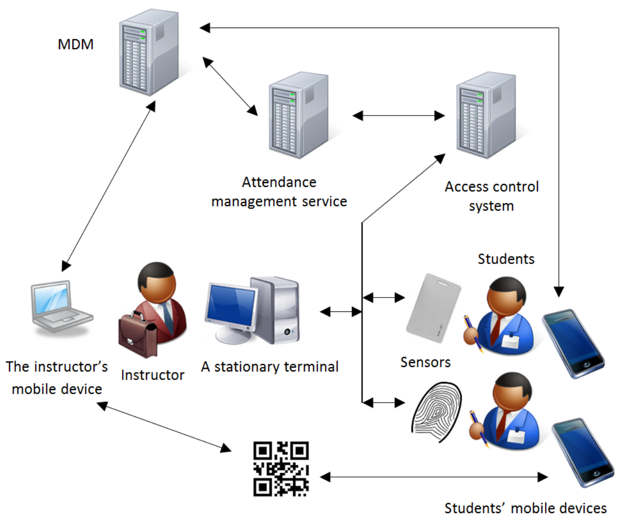

Figure 2: Attendance monitoring service

based on the data obtained from GPS or GLONASS receivers, and from levels of signals in available wireless networks. Our MDM server can get the device location data and provide it to the authorized mobile services. Unfortunately, for indoor environment the coordinates obtained this way have insufficient precision. Better precision may be achieved by combination of multiple localization methods ([8]) and a specific placement of sensors ([3]). When no such techniques are used, the MDM server cannot reliably distinguish between devices located in two adjacent rooms. Yet another problem is that device location data usually contains only planar coordinates, so it is hard to tell at which level of a multistory building the device is located.

As the device usually cannot provide sufficiently precise location data, additional information is needed to check if the device is located in the right classroom. We implement three methods of obtaining this additional information.

1. Localization based on the unique data that are available only in the classroom in question. We use temporary QR codes that should be recognized by the attendees mobile device.

2. Localization based on the proximity between devices. In this case, we also use temporary QR codes. This time the students device generates a QR code on the screen, and the instructors device should recognize it.

3. Localization based on the common media such as common Wi-Fi access point, to which all students should connect their devices.

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 uses 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.

The attendance monitoring service uses context to obtain necessary information. The data on event schedule and mobile device location is obtained from the MDM server, as a part of mobile device interaction context. Information on classroom equipment and class membership may be got from university information systems if they are available. This background data forms the full context in which attendance checks occur, 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.

- 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.

5 Conclusion

This paper is devoted to the architecture of a software platform for building context-aware educational mobile services. This platform is based on the mobile device management system. The MDM server plays two roles. First, it interacts with mobile devices, and forms the context of user interaction with mobile services. Second, the MDM server implements a set of basic features commonly needed by educational services, including user authentication, messaging, and document sharing.

As an example, we describe the implementation of an automated attendance monitoring based the platform. 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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References:

[1] A. K. Dey and G. D. Abowd, Towards a Better Understanding of Context and Context-Awareness, *HUC'99: Proceedings of the 1st international symposium on Handheld and Ubiquitous Computing*, 1999, pp. 304–307.

[2] J. Huizenga, W. Admiraal, S. Akkerman, and G. T. Dam, Mobile game-based learning in secondary education: engagement, motivation and learning in a mobile city game, *Journal of Computer Assisted Learning*, 25(4), 2009, pp. 332–344.

[3] M. Marks, E. Niewiadomska-Szynkiewicz, J. Kołodziej, 2014. High performance wireless sensor network localisation system, *Int. J. Ad Hoc and Ubiquitous Computing*, vol. 17, issue 2/3, pp. 122–133

[4] O. R. E. Pereira and J. J. P. C. Rodrigues, Survey and analysis of current mobile learning applications and technologies, *ACM Computing Surveys (CSUR)*, 46(2), 2013.

[5] A. Samochadin, D. Raychuk, N. Voinov, D. Ivanchenko, and I. Khmelkov, MDM based Mobile Services in Universities, *International Journal of Information Technology & Computer Science (IJITCS)*, vol. 13, no. 2, 2014, pp. 35-41.

[6] A. Samochadin, D. Raychuk, S. Nosnitsyn, and I. Khmelkov, A comprehensive set of mobile services supporting education process, *Procedia — Social and Behavioral Sciences*, vol. 182, 2015, pp. 613–618.

[7] A. Samochadin, D. Timofeev, D. Raychuk, I. Khmelkov, Attendance monitoring as a context-aware service, *Proc. of 10th International Conference on Educational Technologies (EDUTE'14)*, 2014, pp. 44–48

[8] S-C. Yeh, W-H. Hsu, 2013. Locating schemes based on adaptive weighting strategy in heterogeneous wireless networks, *Int. J. Ad Hoc and Ubiquitous Computing*, vol. 14, issue. 2, pp. 99–108