# A Proposal of an Architecture for Educational Environments

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**Abstract.** Current technology allows educational environments to offer teachers and students the functionality and the information required at any time, whichever place and circumstance. Concretely, these environments mix three remarkable features: ubiquity, context-awareness and collaboration. In this way, the system to be deployed can avoid oversights when performing tasks. In addition, students can be motivated through technologies that they usually use in their daily life. In this paper, we present the definition of a system architecture, which is the first step to obtain the proposed environment. The architecture presents both a software architecture and a hardware architecture. The software architecture shows the layers in which the system distributes functionality and information.The hardware architecture shows the hardware components to be used, such as smartphones, server, communication elements, etc.

## 1 Introduction

Computer users do not use systems in order to know their functionality but to perform their tasks. Users need systems with a simple and easy way of work; they automatically give increasingly more importance to systems that provide help to complete tasks. To this respect, the present technology allows to offer environments with systems where users can automatically obtain information and functionality based on their state (i.e. location, current task, etc.). In this way, we propose a collaborative ubiquitous and context-aware system which will allow users the possibility to access the necessary information and functionality at any place and any time.

Daily needs make educational tasks management essential for the proper work in the educational centre. Teachers and students can be affected negatively without a correct management of their tasks. In this sense, a collaborative, ubiquitous and context-aware system will help them with the adequate protocols' tracking which users have to complete in any situation and task. The system will allow users to perform their tasks collaboratively [7, 10]. Collaboration will unify efforts and will improve the coordination between students and teachers. Ubiquity [4] will allow to access to information and functionality offered by the system at any place and any circumstance. Context-awareness [2] will provide the system with the capacity of adapting its functionality and content based on the user´s context. They will not be required to

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have exhaustive knowledge of the operation of the system; it will help and guide them every time by offering the functionality and information that users need according to their location and current task. For example, if a student cannot find the book he needs or he has doubts about his current homework, the system will indicate him the teachers or classmates who can help and the way to contact them.

Considering how the proposed system can help in educational environments for everyday operation, these have been selected as the adequate environment for this system application for several benefits and reasons. (1) First, teachers have to manage the evolution of their classes and students. They need a high level of collaboration with students and workmates in order to complete the educational process. (2) Then, ubiquitous systems facilitate educational environments management. Students and teachers will be able to access any information or functionality they need at any time and any place. In their devices, users will always have the adequate functionality for their current tasks or location. (3) Besides, users will be able to know what is happening in the system every moment, what other users are doing, and the resources state. Awareness [3, 6] means knowing what is going on, which is essential in a collaborative environment. Teachers can know how each student evolves. In addition, the students are able to know who can complete tasks with him or who can help. (4) Moreover, the system will reduce human errors and oversights related to task, timetable, tutorials, etc. For example, it will remember important tasks and the steps to be followed. The purpose will be always to improve the operation of such environments. The system is able to motivate students in their studies through new technologies, which can be a friendly and well-known way of working.

In order to be able to develop the proposed system, a previous definition of architecture is essential, which will be based on its development. This paper describes an architecture proposal carried out by the authors. Two parts compose the architecture: the hardware architecture, which describes the hardware distribution; and the software architecture, which shows the layer distribution of the components' system where each layer has its own information and functionality.

The document is organized as follows: the next section presents some related works with close architectures to the proposed one. The third section explains the architecture proposal for educational environments. Finally, the last section presents conclusions and future works.

## 2 Related Works

The authors have studied some several architectures proposed during the last years and have selected proposals which are described together with possible improvements. The selection criteria was if they provided an important diversity source and if they implied remarkable terms, conditions which contributed to formalize the proposal presented in this paper.

One of the most interesting proposals [9] gives automatic feedback through the gathering of health vital signals. The architecture is focused on an ubiquitous environment and is composed of two layers: the *smart objects layer* and the *user layer*. The user layer is considered as a simple tag (e.g. RFID) that allows the initial interaction with the system. Therefore, the smart objects layer is responsible for the main

part of the architecture. This layer is based on three components which offer services to smart objects and localize devices. (1) *Devices interface*: it presents information to the devices. (2) *Application core*: it is responsible for running every function that the user application may contain. (3) *Tracking component*: it detects and identifies users. This work can be improved adding a new layer (parallel to user one) to manage sensor data. Proposed improvement will speed up the management of environment data, which usually has an important volume. Sensor layer can obtain and organize data from the environment and it can examine the information filtering errors. Additionally, the main objective of the architecture can be increased using collected data to obtain extra useful information for the users: localization of other users and resources, state of resources, availability of needed users, etc.

Another architecture [5] based on ubiquitous and context-aware systems is distributed in three layers: application, context-aware and detection/monitoring. As a wireless Bluetooth network performs communication in mobile nodes, improving that communication using Wi-Fi could be interesting. A new network will mean less connectivity problems in long distances.

An outstanding proposal [1] consists in an architecture (applied to context-aware environments) based on client-server relationship and on LOCA (Location-based Context Aware) framework, which is described in the same article as the architecture. Three components make up the framework and the architecture: *request service, server service* and *agent service.*The architecture operation is based on the interaction between the different components where the agent service is the main element. That element receives a request from the request service and searches for the nearest server service able to offer a correct response. An improvement of this architecture would be the incorporation of collaborative capacities between users and between request services.

NARF [8] is an architecture based on ubiquitous environments with a different structure from previous related works. Two main blocks define the architecture: the *Runtime System* and the *Development Tools*. Context recognition guides the architecture functionality in a real system allowing applications (external to the architecture) to obtain context features and to be informed about context changes. In order to facilitate updating methods, the development tools are able to reuse the recognition logic previously used. These tools will help to accelerate the resolution process of certain situations if they could be added to the runtime system.

Finally, the last remarkable related work [11] describes an architecture oriented to ubiquitous and context-aware environments. As the previous one, this architecture is structured in a different way from most of the studied related works. The architecture is composed of the following elements: web application, BPEL (Business Process Execution Language) processing service, reasoning engine, user detection service and additional utilities as web services. The Web application allows users to interact with the system and the reasoning engine contains the logic of the application, therefore, it is responsible for the architecture behaviour. The detection service is a multimedia service used to detect images with people faces.People are very important in the architecture so an improvement would be to incorporate the possibility to collaborate. In this sense, the architecture will have a new dimension and then, a new functionality that would make it applicable to more environments and fields.

The related works show that there is great interest to find an adequate architecture for ubiquitous and context-aware environments. Multiple possibilities exist to select

technologies in order to obtain the correct architecture, for example web services, which are an important element in environments where mobility means more than just a simple feature. Regarding all the concepts, ideas and technologies used in the related works, the authors have developed an architecture proposal focused on context-aware, ubiquitous and collaborative environments. Concerning suggested improvements to each related work solving found gaps, proposed architecture includes features in order to consider them. This proposal is explained next.

## 3 Architecture Proposal

The general aim of this work is to propose a context-aware, collaborative and ubiquitous system applied to a real educational environment. In this section, we present the architecture we have defined to support this kind of systems. More specifically, we have defined two base architectures: the hardware architecture and the software architecture. The former focuses on the way the different elements used for the implementation of the system are distributed in the educational environment. The latter defines how the different elements needed to handle the system are organized according to a set of layers defined on the basis of its functionality.



### 3.1 Hardware Architecture

The hardware architecture defines the hardware elements that make up the proposed system and their interconnections (see Figure 1). Thanks to the technological advances in the last years, the possibilities of hardware selection in the proposed system are very wide. This architecture is divided into different blocks to offer a distribution as clear as possible, where each block contains a concrete functionality that distinguishes from the rest of them. The functionality will depend basically on the capabilities of the elements of each block. The blocks composing the hardware architecture are described next:

- *Server*. Its function is to analyze the information of the users´ environment stored in the database. The outcome of the analysis will allow to offer the students and teachers the functionality and information they need at any moment. It is important to note that the information or functionality could be required by the user or by the software application that s/he is using in his mobile device. In the first case, a student or teacher may require certain information or functionality by means of the different options the software application offers. Nevertheless, the second case can be when the software application offers certain information or functionality to the user in an automatic way, thus making the system context-aware. This feature implies that the system may offer the proper functionality and information according to the user context, with no previous explicit action by the user. As the system is ubiquitous and allows the access to the information at any place and circumstances thanks to the technology available throughout the environment, the software application will be able to request the needed information and functionality to the server by itself.

The server will analyze, for both requests, all the appropriate information coming from the environment where the user is located at that moment, together with the significant information from the user involved. The information regarding the user´s environment is wide and diverse: user location, other users´ location that may be useful, resources needed, state of the different resources needed, resources location, functionalities offered by the system which may help the user to perform his task, complete information on the task to be performed (steps to follow, restrictions) and so on.

A key point of any system of this nature is efficiency. The system requires a high level of efficiency, besides offering the required functionality. For this reason, the information analyzed by the server in each case must be accurately defined. This definition consists on several fields and parameters that refer to the information of the educational environment. This is important because this way the server will localize the information in a rapid and concise way, based on the content and type of parameters and the searches in the database, which is the main source of information, are improved. All this process of reducing data processing is very important because the server will not only receive requests from a single user but from any of the active users in the system and at any time instant. Therefore, a user must receive the needed information and the adequate functionality in the shortest possible time in such a way that it is useful and can be used according to his current state and not to a past state. Otherwise, it will useless or even more, totally inconvenient or disturbing for the performance of the tasks.

- *Database*. Basically it contains the information regarding the current state of the environment where the system is deployed. Its structure must allow simple and rapid content searches. It must relate, by means of the proper fields, each user with the tasks s/he is involved and in turn, the tasks with the context information and the required functionality in each case. Additionally, the database must offer stored procedures and functions that facilitate access and management with the aim to provide a data system as accessible as possible. We have to consider that the information stored is private in many cases. The data stored in the database is not only regarding users' tasks but also regarding their address, contact persons, marks, etc. This way, the database must include an access and security system as reliable as possible.
- *Mobile Devices*. They offer all the users of the system the mobility they need throughout the educational environment. They are essential for the system to be considered as ubiquitous. They allow users to have access to the system and enable the system to offer users the information and functionality they need in any place and at any time. The mobile devices included in this component may be a PDA, an Smartphone, an IPhone, an IPad and Laptops. These devices have to allow connectivity via Bluetooth, Wi-Fi and RFID in order to be able to use any functionality.
- *Static Devices*. Due to the fact that not all the users require mobility in their actions (for instance, teachers who are preparing an exam in their office) considering static devices in the architecture is a necessity. The most common static device is the Personal Computer. Nevertheless, we also consider wall screens, last generation televisions placed throughout the environment. The aim of these screens is to offer the users certain important information in certain areas, with important data for the performance of their tasks: exam marks, information about the following class, in-

formation regarding the state of other pending tasks, timetables, maps showing the user's current situation in the educational environment and the path or route to follow, if necessary.The most suitable places to place this type of devices are the users´ common areas and those areas where it is difficult to establish wireless connectivity, as for instance a lift, corridors, dining hall, etc.

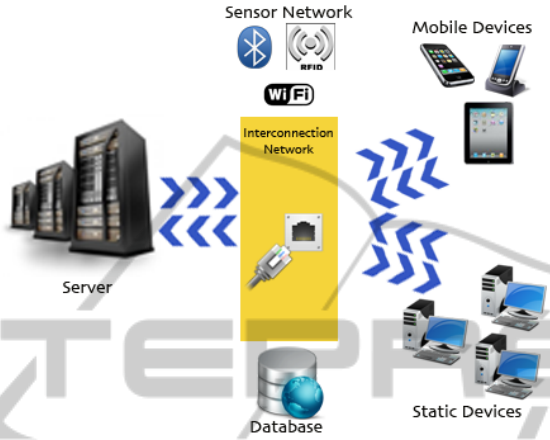




**Fig. 1.** Hardware architecture for a collaborative, ubiquitous and context-aware system.

- *The Sensors Network*. It is a set of sensors distributed throughout the environment which enables to obtain information on the state of the environment itself at any time, which is essential for any context aware system: users in the system and their location, resources location, etc. This information is stored in the database and will be analyzed by the server with the aim of offering the adequate information and functionality to system users. The sensors network is made up of two types of sensors: (1) *static sensors* that are located in specific areas and control and collect information on events in that area; (2) *dynamic sensors* which are moving in the environment. Mobile devices are closely linked to them, as they may become sensors in specific moments. All mobile devices incorporated in the system use Bluetooth and Wi-Fi technology; therefore, the client application uses them to capture the information on the environment. Concerning RFID technology, a sensor can be a PDA with a RFID reader. Beside the RFID sensor, it requires RDIF cards (with RFID tabs) which allow to obtain information on the user or element to which they belong just by simply reading their tab.
- *Interconnection Network*. This is a necessary component so that all devices can be interconnected. It allows users to get the information offered by the system and also the possibility to communicate among them. The component is made up of a local network with the participation of all the physical elements of the system, from a PDA to the server itself. The local network is a cable network (for static devices) together with a WLAN network (for mobile devices).

### 3.2 Software Architecture

The software architecture allows to visualize the system structure by means of a group

of layers which are interconnected (see Figure 2). These layers show the way in which the information and the functionality offered by the system proposed is distributed in different levels, each offering specific treatment of the information. This structure is based on four concepts, which represent the functionality of each layer: (1) *interaction*, concerning the way the system is used by users and how the information on the environment is obtained by the system; (2) *management* of the information on the environment and the users´ requests; (3) *ubiquitous context aware collaborative application* that generates responses to users´ requests. It involves the study and analysis of the information on the environment aimed at offering users the necessary functionality and information; (4) *information* that is the representation of the current state of the environment in the system as a database.

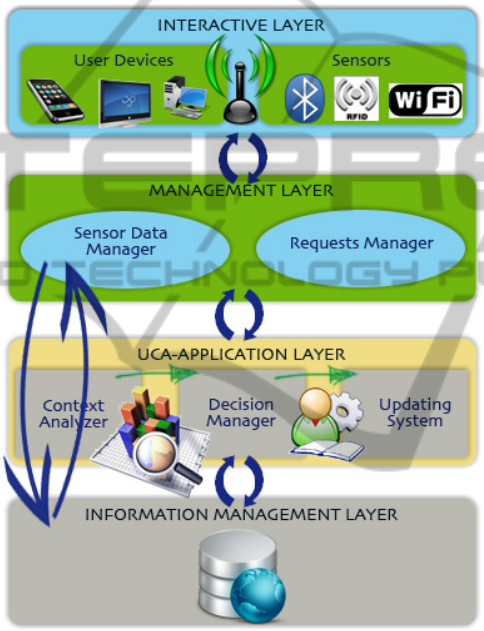


**Fig. 2.** Software architecture for a collaborative, ubiquitous and context-aware system.

Taking into account the previous basic concepts, the layers which make up the software architecture are next described:

– *Interactive Layer*. It represents the interaction of the educational center´s user with the system, as well as the interaction of the system with the users. Thus, interaction is bidirectional pursuing to offer an ubiquitous and context aware system. Obviously, users must be able to interact with the system through a client application offering the functionality and information required. But, since the system must be ubiquitous and context aware, the system plays an important role in the interactive layer. It must be capable of interacting on its own with the users and with the environment in general to be able to obtain relevant information (through the application and the sensors present in the environment). The information obtained will be the state of the environment, which, after being analyzed, will allow to offer users the information and functionality required at each specific moment. This is the es-

sence of any context-aware environment: the system is able to automatically provide what is needed, depending on the user´ needs and their environment.

- *Management Layer.* This element receives the users´ requests (*requests manager*). They are classified depending on the user and the parameters of the request. Those parameters mainly represent the objective of the request: functionality or information request, task start or end verification, timetable, etc. Once the request has been classified, it is sent to the management layer. This pre-processing facilitates the search for the information related in the next layer. Consequently, the achievement of request solution is improved and more rapid.
  Another task of the management layer is receiving and transforming the incoming information from the sensors through the interactive layer (*sensors information manager*). This transformation is necessary before accomplishing data analysis and study. It involves eliminating useless or repeated information and gives it the appropriate format to be inserted in the database. The format will be in relation to the set of parameters which characterize each register in the database. These parameters make the search for information more dynamic, especially when working with large amounts of data.
- *CUCA (Collaborative Ubiquitous and Context Aware) Application Layer.* Its objective is to analyze requests and their environment to offer the functionality and information each user may require at each specific moment. The process is as follows: (1) the layer receives a request from an user or from the application automatically; (2) the system analyzes the state of the context in relation to the request; (3) based on the analysis performed, the system makes a decision, which will be the functionality to be run or the information to be displayed; (4) finally, if the decision implies a change in the system, it is reflected in the database. Its implementation will be distributed between the server and a set of intelligent agents. The agents –distributed throughout the environment devices- allow the possibility to offer some functionality on the part of the system with no need to access the server. So that its functionality can be implemented, the CUCA application layer contains three elements: *context reader, decision manager* and *updating system*. The context reader is the tool responsible for reading the information which is relevant for the current environment context, based on the parameters received as input, sent by the decision manager. The input enables selecting the information required by the manager from the database to be able to make a decision on the request under consideration at that moment. The decision manager is the component that receives requests from the *requests manager* on specific information or functionality of the system from the users or from the applications they are using. In order to respond to the request, the information on the current context which will help to decide on the request is in turn requested to the *context reader*. When the information requested is received, the component studies the current context and collects the information to be displayed and/or the functionality to be used by the user. Finally, the updating system applies changes in the database. If the decision implies a change in the system, the fields associated in the database will have to be modified and should, subsequently, present an updated state to be able to take decisions in accordance with the state of the system.
- *Information Management Layer.* This layer is made up of a database which stores the system information (concerning users, timetables, resources, tasks and loca-

tions) and the tools required to access that information (whether writing or reading tools).

## 4 Conclusions and Future Work

Nowadays, current technology eases to create environments where users can collaborate and access to needed information and functionality based on their context. In this way, it is possible to mix collaboration, ubiquity and context-awareness in the same system in order to improve the management of educational environments. This improvement allows students and teachers to perform their tasks avoiding oversights and, more specifically, to perform adequately the educational process. These kind of environments motivate students in their daily work because they can use their smartphones, mobile devices, PDAs and laptops; something that can establish a friendly way of study.

In this paper we have presented an architecture proposal as previous necessary and complementary step to the development of a collaborative, context-aware and ubiquitous system in an educational environment. Concretely, two parts composed the proposal: hardware architecture and software architecture.The first one shows the distribution of the hardware devices as blocks offering different functionality: *server, database, mobile devices, fixed devices, the sensor network and the interconnection network*. Then, the software architecture describes the layers in which the information and the functionality offered by the system proposed, is distributed in different levels. The layers are as follows: (1) *the interactive layer* that manage the interaction between the system and users, which is bidirectional; (2) *the management layer* which classifies each received request in order to facilitate the search of the answers; (3) *CUCA application layer* that is responsible of analyzing each request and take decisions; and finally, (4) *the data management layer* which works directly on the database.

We are currently working on the design of a system in a real case study considering the aforementioned architectures and concepts regarding awareness. The deployment will consider user tests and evaluations based on the knowledge and the use of the system by the students and the teachers. New technological proposals to be included will be studied in order to improve the management and the use of the system, as well as the user experience.

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