OPPIA: A Context-Aware Ubiquitous Learning Platform to Exploit Short-Lived Student Networks for Collaborative Learning

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Abstract: We present the OPPIA platform, a ubiquitous and smart learning environment, that deploys sporadic learning networks (SLNs) among people (students, teachers and experts) who happen to be in a common place or in a remote place but connected to the platform through the Internet. The idea is to establish dynamic learning networks that encourage their members to work together and create a learning environment with proper resources and activities to satisfy their learning needs. This paper describes the design of the platform from the lowest levels of establishing connections among members of the SLNs, up to the highest level of smart learning services.

1 INTRODUCTION

The advance of electronic devices, wireless technologies and communication networks is changing the way in which we interact with our environment. On the one hand, the presence of electronic devices and microelectronic systems embedded in everyday objects in our lives (mobile phones, laptops, cameras, audio and video devices, clothing, vehicles, etc.) generates environments rich in sources of digitized information, accessible anywhere and anytime. On the other hand, the omnipresence of the Internet and the boom of the social networks create new ways of social interaction, breaking the time-space limitations of face-to-face relationships.

This new social and technological context also affects the learning and teaching processes. People have unlimited access to data, information, and resources through their mobile devices, carrying out of the classroom learning and teaching opportunities, and becoming their environment in a extended classroom (Loureiro and Bettencourt, 2014). Moreover, the Internet is allowing to generate learning networks among people located hundreds of kilometers from each other, giving support to different ways of social and collaborative learning (Vassileva, 2008), (Memeti and Cico, 2014).

Different approaches have been proposed in the literature about how to generate environments that encourage people to improve their learning, considering their diferences in prior knowledge, background, and interests; and giving them access to learning contents and collaborative learning networks at the right time, at the right place, and in the right form (Paraskakis, 2005), (Al-Zoube, 2009), (Spector, 2014). For instance, many universities are using Learning Management Systems (LMS) (Coates et al., 2005), (Mahnegar, 2012) and Distributed Learning Environments (DLE) (Alavi, 2004) as a way to give to students and teachers a wide access to different resources to increase the performance of their formal learning processes. On the other hand, Personal Learning Environments (PLE) (Humanante-Ramos et al., 2015), (Dabbagh and Kitsantas, 2012) are being designed to allow people to create their own learning environments to satisfy their interests —most typically, in informal learning scenarios. Similarly, several proposals take into account the learning behaviour of the students and the context to recommend different resources according with their needs and profiles (Mengmeng Li, 2013).

This paper is about applying technologies to enable new forms of learning interactions outside the classroom. Specifically, we are building a plat-

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form called OPPIA ("*OPPortunistic Intelligent Ambient learning*") that aims at facilitating the creation and exploitation of *Sporadic Learning Networks* (SLN), communicating each individual with the people (students, teachers, or experts) that surround him/her or connected through the Internet at a given moment, and considering the information and resources (both institutional and personal) that may be relevant to them, based on their profiles, formal curriculum, expertise, and learning interests. The goal is to provide an ubiquitous and smart learning environment that encourages students to collaborate in their learning process, sharing knowledge and resources to establish dynamic learning networks that are born and die according to their learning needs.

OPPIA harnesses advances in knowledge-based recommender systems and expert systems (i) to establish learning networks among those people that can help overcome the learning needs identified by the platform or triggered by some student, and (ii) to provide tailored made learning services driven by the user's context, by students/teacher/expert profiles, by the institutional learning information (learning objects, general curriculum, teaching scheduling,...), by the personal resources of the students, and by any information about their learning interests. OPPIA allows the connected devices to share resources (e.g. networking capabilities, storage space, computer and processing capabilities, simulation software,...) in order to generate virtual and distributed laboratories, improving the learning opportunities of the SLN members and overcoming specific limitations of their handheld devices.

In addition, our platform uses data mining techniques, personalization capabilities and Semantic Web technologies, in order to efficiently manage the contents available to SLNs and customize virtual learning environments of each of its members. Content and learning activities are offered to each member of the network in the format that best fits their learning style and considering the characteristics of their mobile devices. New contents are generated dynamically, integrating existing institutional and personal resources to satisfy the personal learning needs of the students.

The paper is organized as follows. In Section II, we present the architecture of the OPPIA platform, putting the focus on the functionality of the mechanisms hosted in each level. Next, Section III describes one application scenario of OPPIA to illustrate how our SLNs improve the learning process among students in a university environment. Finally, Section IV concludes the paper and points out some lines of further work.

2 THE OPPIA PLATFORM

The OPPIA platform relies on an fully interactive multi-layer architecture, organized in several layers and services. Conceptually, its architecture has five levels (see Fig. 1) that will be described in the following subsections.

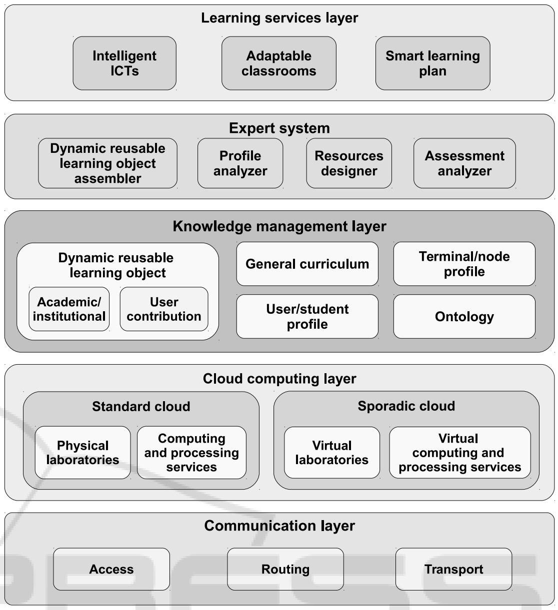

Figure 1: The conceptual layers of the OPPIA platform.

2.1 Communication Layer

This layer is responsible for providing the necessary mechanisms to establish connections proactively and transparently to the users whenever deemed appropriate by the information from higher levels of the architecture. So, the sporadic learning networks rely firstly on ad-hoc networks laid dynamically among the mobile devices of the people (students, teacher or experts) who happen to be close to one another at a given moment. Communications with network members in remote locations, with knowledge bases and learning services (upper layers of our platform) are achived through links to hotspots or 3G/4G connections available to any members of the network. All protocols and mechanisms for establishing links and maintaining the necessary QoS levels are housed in this layer, too.

2.2 Cloud Computing Layer

The second layer aims at enabling efficient sharing of the resources available to each device within an SLN or located in areas close to them and participating in other SLNs. The tandem between mobile devices and cloud computing works perfectly because handheld terminals are constrained by their processing power, battery life and storage capabilities, whereas cloud computing can provide the illusion of unlimited computing resources (Mell and Grance, 2011), (Kim et al., 2011).

The extra resources required by the handheld devices can be provided either by (i) centralized servers in the cloud, depending on connectivity to the Internet, or (ii) cloudlets supported by fixed nodes at the edge of the Internet or by capable mobile terminals connected in the ad-hoc network. With this in mind, we take advantage of the concept of *Sporadic Cloud Computing* (SCC), presented in (OrdoÃśez-Morales et al., 2015), (Ordonez-Morales et al., 2015), in which the user's devices exploit both the resources available in the remaining terminals connected to the ad-hoc network (computing, storing, networking, sensing,...), and those provided from external data centers. In our platform, SCC allows to generate virtual and distributed laboratories conformed with existing resources in the member's devices of the different SLNs, who are physically close to each other. This avoids — as far as possible — dependence on access to the Internet to perform tasks and gives students access to specialized software not suitable for low performance devices. So, our cloud computing layer provides the following services:

- Storing information in spaces in the cloud, linked to source/target devices, creating/consuming users, location, etc.
- Accessing and serving information of high-level user profiles during the formation of ad-hoc networks.
- Synchronizing multiple flows of information coming from the connected devices.
- Managing of the simulation and programming resources available on the users' mobile devices so they can be used in a transparent manner by SLN members (virtual and distributed laboratories).
- Providing access to cloud services on the Internet: databases, semantic repositories, physical laboratories, etc.

2.3 Knowledge Management Layer

Our platform uses information derived from personal or institutional sources to provide users with the best resources (according to their personal learning styles and characteristics of their access devices) and activities (both individual and group) that stimulate their learning and allow them to increase their academic achievement or satisfy their learning needs. The *"Knowledge Management"* layer is the place to put solutions from the areas of data mining, recommender systems and the Semantic Web to automatically select the best profiles to form the learning network, choose the pieces of information for the greatest benefit of the members of the SLN, while personalizing the contents delivered by each device and the activities to be performed by the group. To do this, it is necessary to rely on techniques for modelling the user's preferences, considering different profiles (students, teachers, experts, personal devices...) and contents (institutional and personal). Moreover, in this modelling process, OPPIA takes advantage of the academic information stored in the institutional databases such as general curriculum (containing several academic guidelines based on career, skills, course,...), monitoring teaching activities, and learning outcomes.

In OPPIA, the contents are modeled through *Dynamic Reusable Learning Objects* (DRLOs) (Valderrama et al., 2005), provided by the institution (institutional DRLOs) or from students, teachers or the Internet. In the same way, we need to use recommendation strategies that select the most appropriate contents for each member or group of members of our SLNs. In addition, we need modelling techniques to infer knowledge about the future learning interests of the SLN members by keeping track their academic activities, learner's web surfing habits and preferences, and profiles in traditional social networks (obviously, with the explicit consent from the users). Finally, for the efficient management of the metadata associated with the learning process, information storage, analysis and inferences, we need to use learning ontologies, especially designed for this purpose.

2.4 Expert Systems Layer

To achieve the desired results, both in motivation and performance of the member of a sporadic learning network, OPPIA relays selection and design of contents, educational resources, and learning activities to the "*Expert Systems*" layer. With this aim, the expert system incorporates an assembler able to create DRLOs. The educational institutions (universities, colleges, institutes, schools,...) create official DRLOs — developed in different formats (video, image, text, audio,...) to meet the learning styles of students — that cover the main contents related to the curriculum. In turn, the DRLO repository can be expanded with learning objects from users themselves or obtained from the Internet. Furthermore, OPPIA has the ability to produce new learning objects and educational resources, from DRLOs existing in the repository. For this, the *profile Analyzer*, the *Resource Analyzer* and the *Assessment Analyzer* are used.

2.5 Learning Services Layer

In order to access the different services and learning objects that are provided by our intelligent learning ambient, the services layer incorporates three main elements: a set of intelligent ICTs (mobile apps, desktop and web applications, including functionalities as sporadic chats, forums, renderers of learning objects, etc.), adaptable classrooms (virtual classrooms that are set to the user profiles), and smart learning plans that are dynamically designed for a particular learning session.

3 SAMPLE APPLICATION SCENARIO

In this section, we describe a specific sample scenario where a set of university students collaborate to improve their performance in maths. Events occur in the reading room of the central library of the university. As usual, many students are with their laptops, debugging and understanding class notes, developing their tasks or preparing their exams. John, a first-year student of electronics engineering, is solving some problems of differential calculus. The results of his recent tests showed that he needs a lot of work if he wants to pass the course. Like John, other students from different groups are working on the same subject; however, because they are located in different parts of the reading room and belong to different classes, they ignore the situation, making it impossible for them to work together to improve their academic performance. In this situation, OPPIA can manage the creation of a sporadic learning network among students with similar weaknesses, organizing their work and providing resources in a way that they will be systematically accessing an increasingly more complex knowledge.

To this end, firstly OPPIA accesses the knowledge base to analyze John's profile. Specifically, it seeks to determine what kind of learning resources (video, image, voice, text, ...) John has used more often. Likewise, it checks the results of his latest test of differential calculus, discovering that John's main shortcomings lie in his prior knowledge of analytic geometry, rather than understanding the concepts of calculus (based on feedback from his teacher). With a similar procedure, OPPIA analyzes the profile of the other students present in the library. Through the *Expert Systems* layer, our platform selects students who foresee a better learning outcome and send them an invitation to form the SLN. The message contains the session length and subject matter. With the confirmation of the members, the SLN is formed, proceeding to unfold the virtual workplace.

When John accesses his virtual workspace, he notices that the platform has assigned a work plan divided into three parts: individual activities, group activities and tutorial session. In OPPIA, the "*Learning Services*" layer generates custom work plans for each SLN member, coordinating and synchronizing the group and personal activities. In the case of John, his personal activities include reviewing several videos explaining the theme, the study of multiple slides with a summary of the main concept, several mathematical games and the development of multiple-choice tests. As can be seen, OPPIA has chosen these activities and resources based on John's visual learning style.

Upon completion of individual activities, the SLN members move on to group activities. Students are challenged to solve a series of problems aimed at putting into practice the concepts learned in their individual work. To do this, John and the other SLN members have communication tools (chat, group video conferences, forums) that allow them to interact and address each of the questions that the system will propose to them.

Finally, OPPIA programs a virtual tutoring with one of the professors of the Department of Mathematics, who is connected to the platform at that moment. Because the platform has access to teacher hours, the system sends a request message to schedule a consultation through a virtual classroom with students of the SLN. This virtual class, reinforces the knowledge developed during the working session of the students. After the virtual class, the session is terminated and the learning network is dissolved.

4 CONCLUSIONS

The OPPIA platform aims to provide the necessary mechanisms to exploit the potential of short-lived learning networks to improve the academic performance of students and satisfy their learning needs. Our platform greatly enhances the learning experience of the SLN members through (i) an appropriate selection of those profiles that will provide greater support to the development of the learning tasks, (ii) the sharing of the resources available on students devices that allow to create virtual laboratories that may be used transparently by users of the platform, and (iii) the design of resources and learning activities based on the analysis of the student profiles, academic performance, study schedules, and personal learning interests of the SLN members.

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