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SOPPIA: Social Opportunistic Intelligent Ambient of Learning.

Paúl E. Vintimilla-Tapia, Jack F. Bravo-Torres,
Pablo L. Gallegos-Segovia and Esteban F. Ordóñez-Morales
Grupo de Investigación en Telemática y Telecomunicaciones
Universidad Politécnica Salesiana
Calle Vieja 12-30 y Elia Liut, Cuenca, Ecuador
Email: {pvintimilla, jbravo, pgallegos, eordonez}@ups.edu.ec

Martín López-Nores
and Yolanda Blanco-Fernández
AtlantTIC Research Center, University of Vigo, Spain
Campus Universitario s/n, 36310 Vigo, Spain
Email: {mlnores,yolanda}@det.uvigo.es

***Abstract*—Sporadic learning networks (SLNs) are networks of short duration, conformed for students, teachers and experts. They can be described as dynamic learning networks that facilitate the cooperative work among different users who share preferences. Through exchange of resources and knowledge, they implement a new social educational paradigm. Another important aspect is their creation-death nature, since their duration depends on the users needs. They are created when required and died when no longer used. In this article we present SOPPIA, an educational sporadic network that provides social learning and self-learning services. Social learning occurs through the creation of sporadic work groups, following the nature of SLNs; while self-learning is achieved through individual activities recommendation and the use of personalized virtual machines.**

I. Introduction

Today, Internet is an extant medium in all daily activities [1]. From scientific point of view, it can be understood as a technology that allows communication between computers and mobile devices, but it is much more than that. It is a form of communication, interaction and social organization, in which economic, political and cultural nuclei all over the world are integrated [2]. This gives rise to the creation of network society concept—a trend that implies globalization of the information access. It is based on a networking organization that helps to process, store and transmit content without time, space or volume restrictions [3], [4]. In addition, thanks to its organization, technologies are created to improve the development of people skills in different fields [1], [5].

One of the fields that has been most influenced by network society is education [6]. With unlimited and ubiquitous access to all kinds of information, the educational paradigm changed. Restrictions of a formal and planned education were eliminated to allow an informal and spontaneous education. Each student has no longer dependence on time and place to learn about a topic of interest; he/she can do it anytime via Internet [7], [8]. Futhermore, the large processing capabilities of mobile devices, which implement wireless communications in their schemes, improve significantly the framework within which informal education is developed [9]. Because there are different ways of accessing Internet, education in network society is classified into three types [10]–[12]:

- E-learning or virtual learning: Is a learning-teaching modality that is based on the design, assembly and evaluation of a course or formative plan, developed through a networking organization. It is applicable to individuals who are spatially-dispersed in relation to a teacher. Then, they can access various contents through Internet.
- M-learning or mobile learning: This concept is understood as the application of e-learning in mobile devices (smartphones, laptops, tablets), through which access to content offered by various virtual courses. So, in addition to taking advantage of networking organization, it benefits of wireless technologies that present this class of devices.
- B-learning or mixed learning: Is a learning-teaching model that exploits the characteristics of face-to-face learning combined with virtual learning. However, virtual space is not only a resource of support for face-to-face learning; it is also a tool through which a teacher proposes various activities to be carried out.

Ideas described above allow to understand the teaching scheme that can be applied for a given subject, depending on the resources that are available. However, there is a fundamental concept that is taking on a great deal of importance in education, peer-learning [13]. This concept describes an educational practice in which students interact with their peers to achieve goals raised by a common teacher. It is widely known in the pedagogy world and arises of socialization theories as a stimulus of learning, proposed mainly by Vigostky and Piaget [14]–[16]. Then, combining these theories with all the resources provided by network society, a new educational tool is born, such as social learning networks.

A social network is a type of networking organization that allows communities to be formed based on different affinity classes. Its mainly objective is to provide exchange

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of information between different users that are separated by thousands of kilometers [17], [18]. From the educational point of view, social learning networks support the teaching process, essentially because: (i) they improve teacher-student communication, information flows better between the two parties, thanks to the informal social relation that is formed; (ii) they allow each student to access a sufficient amount of information that facilitates the fulfillment of the objectives proposed by the teacher; (iii) they help to establish relationships with experts in each subject, from which each student can extract information and knowledge; and finally, (iv) they interven in the creation of educational social groups, in which help can be requested to resolve any doubts [18]–[21].

Although the advantages of using social learning networks in educational process are broad, there is a significant problem. Students only access the content available in their social circles. If an expert is outside the scope of these social circles, the students will not be able to contact him/her and will lose a significant educational resource [22]. From this problem arises the idea of SOPPIA (Social OPPortunistic Intelligent Ambient of learning), a sporadic educational social network based on OPPIA platform (OPPortunistic Intelligent Ambient of learning). SOPPIA focuses on the creation of sporadic learning networks, in which students, teachers and experts, from a common theme, share the same virtual space in a given time. In this way, a link is created that facilitates student-teacher/expert interaction and adds a new tool to the educational paradigm. All students access the knowledge and experience of various teachers/experts in a simple way. In addition, students share their doubts with each other to find a common solution, which enriches educational process. Once the learning process ends, the virtual space that was created disappears immediately.

This paper is organized as follows. Section II presents a theoretical support about social networks influence in the education. Section III exposes the concept of sporadic learning networks, and thus, in Section IV describes OPPIA platform. To understand SOPPIA operation, Section V and VI show its architecture and the development of a first implementation. Finally, the conclusions and future work are presented in Section VII.

II. Social networks in the educational process

In society network, social networks are a tool that plays a fundamental role in educational process. This is mainly due to their ability to form communities, where students, teachers and experts are grouped in the same virtual space [23]. However, for social networks to be developed as an educational tool, in which knowledge can be shared, they must fulfill three conditions: boundary condition, heterogeneity condition and responsibility condition [17]. The boundary condition defines the goals and rules about the behaviour allowed for members of a community. On the other hand, the heterogeneity condition expresses that a community should be made up of members with different seniority (new-veterans), who have the capacity to resolve doubts (teachers-experts) and the predisposition to participate (students) in proposed activities. Finally, the responsibility condition establishes the characteristics that allow to describe each member according to the role that plays and the activities in which he/she participated.

When analyzing these conditions, it is observed that they are present in most non-educational social networks because the majority of these have a usage policy that must be accepted by each user before registering as a participant (boundary condition). In addition, they allow the formation of self-organized communities, whose participants have the common goal of exchanging information (a condition of heterogeneity), and through the implementation of a user profile, guarantee the temporary stay of each participant, giving access to their personal information (condition of responsibility) [17]. Thus, any non-educational social network can be seen as a valid learning tool, and according to its use, can be classified into three principal categories [24]–[26]:

- Horizontal social networks: They are aimed at a general public, without focusing on a specific topic. Among the most popular are Facebook, Twitter and Google+.
- Professional social networks: Give sustenance to content related to the work ambit. They allow stablish professional contacts, as well as the search for job opportunities. Among the most prominent is Linkedin, Viadeo and Xing.
- Social content networks: They form links between their participants through the generation and dissemination of content in different formats. Among the main ones are YouTube, Pinterest, Instagram and Slideshare.

Of the before examples, Facebook, Twitter and YouTube are the most widely used globally [26]. Students employ social networks for different purposes, including discussion of classes, out-of-school learning and planning of educational collaborative activities [27]. However, the main reason students turn to its support is the exchange of information and knowledge [28]. In the remainder of this section, a review of these social networks is described.

A. Facebook

Facebook[1] is a social network that is defined as a networking tool. Allows the exchange of information, through communication between its different users [26]. Around the world, a lot of people use Facebook for countless purposes, which are summarized in the creation of content for various areas, among which is education. Futhermore, several organizations, private and public, interact with Facebook either for publicity reasons or dissemination of information [27].

Facebook has 1393 million active users each month, which makes it the most used social network at the moment. Among these users are students, who get in touch with their peers and teachers [27], [29]. The creation of multimedia material, such as photos and videos, and the employ of Facebook Messenger as a tool for chatting, allows students to share what they have learned with those who need it [30].

[1] www.facebook.com

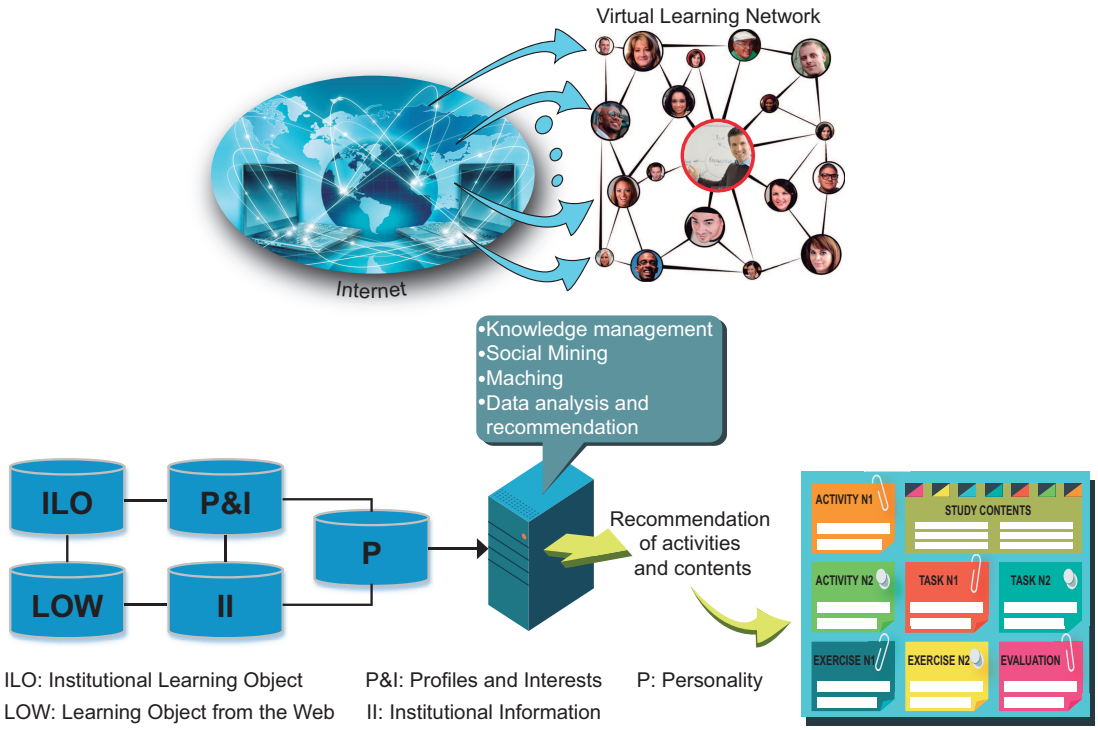

Fig. 1: Sporadic Learning Network: Structure and Operating.

B. *Twitter*

Twitter[2] is a social network that allows communication and interaction between its users through tweets. A tweet is a burst of information, with a maximum length of 140 characters, used to tell a story or to attract the attention of a user to a specific topic [31]. Tweets can be connected to additional information such as links to external pages and multimedia content. Twitter manages a communication scheme in which each user "follows" the content authors; this means that, after "following" an author, all the content that he/she publishes becomes visible to the "follower" [32]. In the educational field, Twitter is a microblogging tool that enhances social interaction, as students are motivated to engage with both their peers and teachers. Then, this social network allows to generate interaction in an online course, either by the exchange of information between students or by the implementation of a virtual teacher [30], [33].

C. *YouTube*

YouTube[3] is a social network that is characterized by allowing interaction among its users through creation and publication of videos. Currently, YouTube has more than one billion subscribers and for each minute, 300 hours of video are uploaded, being the third most visited site worldwide, after Google and Facebook [34]. In addition, YouTube reaches a larger audience than any television network, supporting 76 languages; this reflects the great social acceptance it has [35]. From the educational point of view, YouTube allows the implementation of e-learning videos, which are a powerful learning tool. This type of videos improves the transfer of knowledge between a teacher (author of the video) and countless students (subscribers of the author), since complex procedures on different topics can be explained step by step. With this, the knowledge that each student requires is reinforced and the activities developed in class are complemented [30].

Although non-educational social networks are considered as a valid learning tool, problems such as uncertainty about the connections of each user and isolation that affects his/her reach outside social circles, are the main challenges that must be overcome to get a satisfactory educational process. As a solution, we propose the implementation of sporadic learning networks, which will be described in the next section.

III. SLNs: Sporadic Learning Networks

Sporadic learning networks (SLNs) are social networks that are created for a limited time—hence the name sporadic—which depends on the learning needs of their members [36]. These networks are based on a networking organization, so they are implemented through Internet. However, they need to work in tandem with intelligent systems to incorporate a more robust learning structure, since it is necessary to group different users in the same time-space (according to their affinities and dispositions) to share knowledge and resources. In addition, due to their creation-death nature, according to the disposition of users, they focus on supporting informal educational paradigm.

[2]www.twitter.com
[3]www.youtube.com

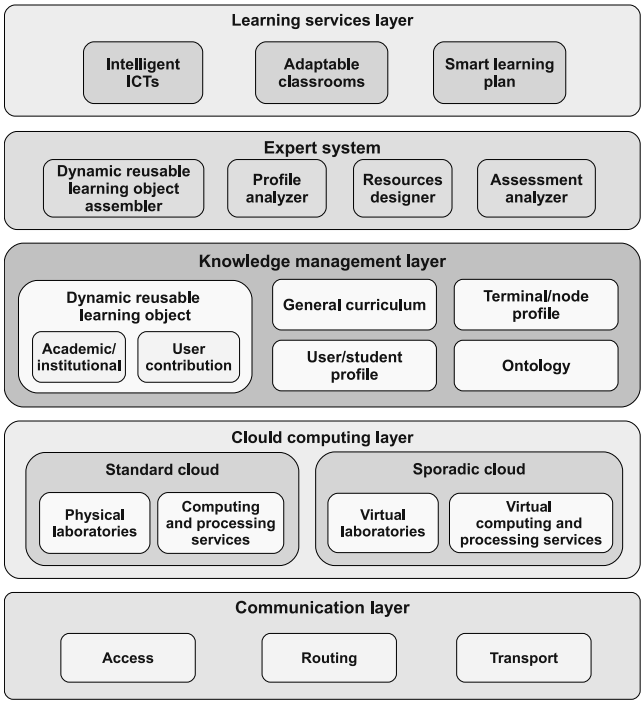

Fig. 2: The conceptual layers of the OPPIA platform.

The main characteristic of SLNs is that they facilitating the creation and operation of short networks, communicating to each user (student, teacher or expert) with their peers. This is achieved by configuring the organization of the network, since it is not taken into account if its members know each other; the only important thing is that they share related topics and have the need to learn at a certain time. Also, to perform a more personalized filtering of their preferences, personal and institutional relevant resources must be accessed, such as educational profile, experience and learning interests. The target is to provide a smart and ubiquitous learning environment that encourages its users to collaborate with each other to achieve diverse goals in their educational processes. With this, the problems of uncertainty and de-socialization present in social learning networks are solved, breaking the paradigm of social sphere.

As can be observed in Fig. 1, SLNs base their structure and operation on relevant information extracted from formal information sources (*Institutional Learning Objects*) and informal sources of information (*Web Learning Objects*). This information is the starting point of the OPPIA platform for structuring of sporadic learning networks, since it allows to group users who have a common problem of studies in the same virtual-temporal space. On the other hand, OPPIA has in mind the profiles, interests and personalities of the users that are going to be grouped, which allows establishing cooperative education. Then, once a selected user agrees to join an SLN, OPPIA offers a range of learning resources and activities—both individual and group—that need to be developed over a given period of time. Three types of SLNs are possible:

- Physical sporadic learning networks: In this type of network, thanks to geo-location, the system can determine a group of individuals close to each other, who may be potential members of a learning network. In this way, users who are selected according to their interests and profiles can configure a network in the same physical environment. The system will support the configuration of the network and the structure of the work to be developed.
- Virtual sporadic learning networks: In the case of a pure virtual network, potential candidates are physically distant from each other but connected to the system via Internet. In this case, the interaction is carried out through intelligent tools and services provided by the platform. As in the previous case, the system will provide activities to be developed and learning resources.
- Hybrid sporadic learning networks: Hybrid networks, on the other hand, are a combination of the two previous ones. These networks make it possible to increase the possibility of interaction between students and to integrate experts or teachers geographically distant from the group and who, through their expertise, can enhance learning.

In the following section, the architecture of OPPIA platform for the deployment of sporadic learning networks is analyzed.

IV. OPPIA PLATFORM

The OPPIA platform relies on an fully interactive multilayer architecture organized in several layers and services. Conceptually, its architecture has five levels (see Fig. 2) that will be described in the following subsections.

A. Communication Layer

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

B. Cloud Computing Layer

The second layer aims to enable efficient sharing of resources available to each device within an SLN. The tandem between mobile devices and cloud computing works perfectly, due to handheld terminals are constrained by their processing, battery life and storage capabilities, whereas cloud computing provides the illusion of ”infinite” computing resources [37], [38].

The extra resources required by the handheld devices can be provided either by (i) centralized servers in the cloud, depending on connectivity to Internet; (ii) cloudlets supported by fixed nodes at Internet edge; or, (iii) mobile terminals

connected in the ad-hoc network. With this in mind, OPPIA takes advantage of the concept of Sporadic Cloud Computing (SCC), in which the devices of the user exploit both the resources available in the rest of terminals connected to the ad-hoc network, and those provided from external data centers. In this platform, SCC allows to generate virtual and distributed laboratories, conformed with existing resources in the devices of the different members of each SLN, who are physically close to each other. This avoids—as far as possible—dependence on access to Internet to perform tasks and gives students access to specialized software not suitable for low performance devices. Hereby, cloud computing layer provide 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 user profiles of high-level 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 user mobile devices, which will be used in a transparent manner (virtual and distributed laboratories).
- Providing access to cloud services on Internet such as databases, semantic repositories, physical laboratories, etc.

C. Knowledge Management Layer

OPPIA platform uses information derived from personal or institutional sources to provide users 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. By this way, the academic achievement of each student is enhaced, satisfying their needs. The ”Knowledge Management” layer is the place to develop solutions from areas such as data mining, recommender systems and Web semantic, to automatically select best profiles to form a learning network. To do this, it is necessary to rely on techniques for modelling user preferences, considering different profiles (students, teachers and experts) and contents (institutional and personal). Moreover, in this modelling process, OPPIA takes advantage of the academic information stored in the institutional bases such as general curriculum, teaching activities and learning outcomes.

In OPPIA, contents are modeled through *Dynamic Reusable Learning Objects* (DRLOs) [39], provided by the institution (institutional DRLOs), students, teachers or Internet. In the same way, the platform needa to use recommendation strategies that select the most appropriate contents for each member or group. In addition, it requires modelling techniques to infer knowledge about future learning interests of the members, by keeping track their academic activities, Web surfing habits and preferences, and profiles in social networks (obviously, with the explicit consent from the users). Finally, to efficient management of metadata associated with the learning process, information storage, analysis and inferences, it is necesary to use learning ontologies, especially designed for this purpose.

D. Expert Systems Layer

To achieve the desired results, both in motivation and performance of users, OPPIA relays selection and design of contents, educational resources and learning activities, to the ”Expert Systems” layer. With this aim, the platform incorporates an assembler able to create DRLOs.

Educational institutions create official DRLOs—developed in different formats (video, image, text and audio) to meet the learning styles of students—that cover the main contents related to the curriculum. In turn, DRLO repository can be expanded with learning objects from users themselves or 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, Resource Analyzer and Assessment Analyzer are used.

E. Learning Services Layer

In order to access different services and learning objects that are provided by the intelligent learning ambient, ”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.

From OPPIA, born SOPPIA, a sporadic social network of learning that allows interaction between students, teachers and experts. Following section details the architecture of SOPPIA.

V. SOPPIA Architecture

SOPPIA is a modular system, which is lodged in a hybrid cloud. However, information processing is distributed between a public cloud and a private cloud. This architecture can be seen in Fig. 3.

A. Public Cloud

The public cloud structure is made up of an UTM (Unified Threat Management) offering perimeter and IPS/IDS assurance services. Additionally, it is a site-to-site and site-to-client VPN server. The site-to-site VPN interconnects the private cloud with the public cloud, ensuring the transmission of information from end to end; while the site-to-client VPN allows customers to access SOPPIA services, ensuring confidentiality and integrity of the information. The public cloud is made up of four layers that will be described in the follow subsections.

1) Web services layer: Its purpose is to validate access through an API connection, by means of the AAA service (Access, Authorization and Audit) and the interaction with the system. In this layer a load balancer based on Round-Robin is added which, besides of distributing the load, offers high availability in Web services.

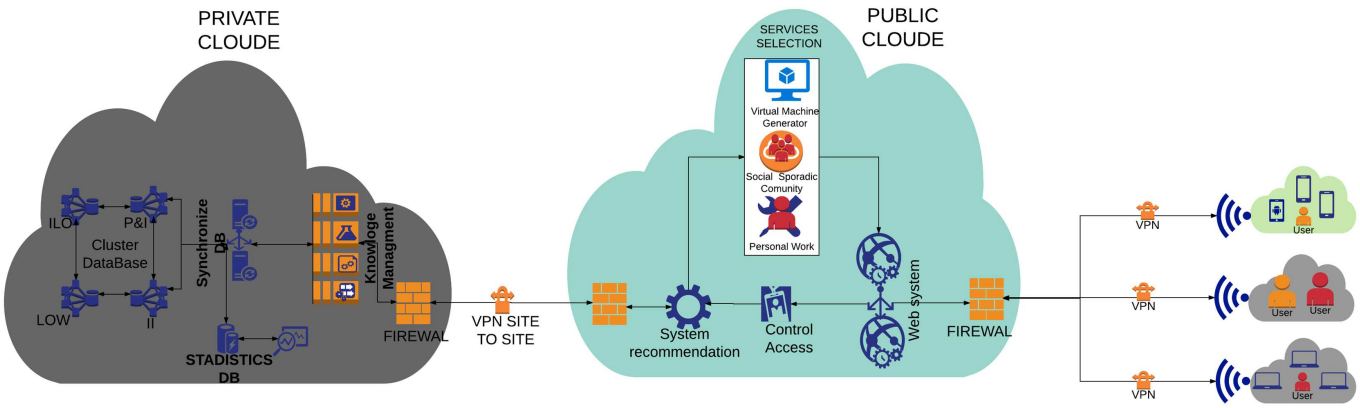

Fig. 3: Architecture of SOPPIA, it manages a private and a public cloud.

2) Access control layer: Allows validation, creation and management of users, and auditing functions. The software selected to perform these functions is Microsoft Active Directory.

3) Recommendation layer: This layer handles critical processes, in which algorithms are executed to generate a series of options that will be recommended to final user. It is used the user-nearest neighbor recommendation algorithm, since it allows making recommendations according preferences.

4) Services layer: The services offered by this layer are lodged in different instances of the cloud, because their nature is different and heterogeneous. Three different types of services are handled:

- Virtual machine generator (VMG): This service is based on the IaaS (Infrastructure as a Service) model and allows each user to access a virtual machine (hosted in the cloud) that presents characteristics, both hardware and software, according to educational needs.
- Social sporadic community (SSC): This is a service that runs on a different instance of the public cloud, since it requires scalability and high availability. Its main function is to generate temporary virtual spaces, in which sporadic learning networks are formed among users with common affinities.
- Personal work (PW): Like SSC, it is a service running on a different instance of the public cloud, due to its scalability and high availability requirements. This service is responsible for presenting individual learning tasks to each user with the purpose of reinforcing knowledge.

B. Private cloud

The private cloud is in charge of managing databases that provide information about users. It communicates with the public cloud through a connection tunnel, by means of which the identity parameters of each user are sent. These parameters go to the knowledge management instances (Knowledge management) to work with the different databases. The private cloud is structured by two layers: knowledge management and database synchronization.

1) Knowledge management layer: Its purpose is to implement algorithms of classification, data mining and machine learning, which allow to work with information provided by the databases. This layer is in charge of providing user information that requires the public cloud.

2) Database synchronization layer: Its main function is to make a middleware of connection between databases of institutional learning objects, databases of Web learning objects, databases of institutional information and databases of interests profiles of each user. It is required to implement an interpreter, since it is worked with heterogeneous databases, which are grouped into one cluster divided into four different instances interconnected by virtual networks. In this way, high performance and availability clusters are created to enable better platform performance; a client-server system minimizes resource consumption. Additionally, in this layer exists a relational database develop in MySQL, which registers both statistics of activities performed by users and the monitoring of the another databases.

This architecture allows the optimal functioning of SOPPIA, which will be explained in the following section, taking as an example its first implementation.

VI. SOPPIA Implementation

SOPPIA begins its operation with the predisposition of students to initiate an informal educational process. Then, when a student is online, SOPPIA accesses information resources and, through a recommendation system, provides an educational service. At this point, there may be two different cases:

1) Case 1: There are online two or more users who have similar preferences and wish to join an SLN to start a social learning. In this case, an SLN is created on a given topic and a role is assigned to each user (SOPPIA reviews the performance of its users, basing on their institutional curriculum and experience). It is identified

who has problems or is studying something related with the given topic, to assign him/her the student role; otherwise, the teacher role is assignated. In addition, a teacher can become an expert when he/she attains a level of experience that is measured by his/her history of participation in the activities proposed by SOPPIA. Once the SLN is created, all members socialize among themselves, sharing resources and knowledge. Finally, the SLN is destroyed when all the users abandon it or it is only one. In Fig. 4 it is possible to visualize the invitation to a user to be part of an SLN.

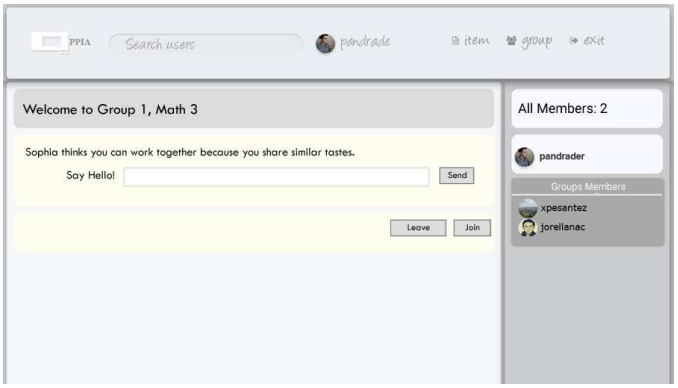

Fig. 4: Invitation to an user to be part of a SLN.

2) Case 2: There are two or more users who have similar tastes but do not want to join an SLN; there are not more than two users who have similar tastes; or, there is an SLN that has only one user. In these cases, SOPPIA proposes a series of activities that must be completed individually. The objective of this service is to promote self-learning and reinforce obtained knowledge in classroom. Among the activities that SOPPIA recommends are learning guides, video tutorials, readings, games, self-assessments and the use of virtual machines. With the implementation of virtual machines, each user is provided with external hardware and software resources, through which he/she can perform simulations or implement algorithms, without any limitation. Once a user has completed an activity, their level of experience increases (to become an expert) and a new activity is recommended. In Fig. 5, SOPPIA recommends to a user the development of a learning guide.

VII. Conclusions and Future Work

Sporadic learning networks are born as an alternative that seeks to solve the disadvantages presented by social networks as educational tools. Thanks to communications technology and the organization of network society, resources and knowledge are shared among several users over a period of time. In addition, the benefits offered by education theories in social environments are taken advantage, avoiding any process of de-socialization as a consequence of the limitations of social spheres. SOPPIA exploits the advantages offered by short-term networks to improve the educational performance of its

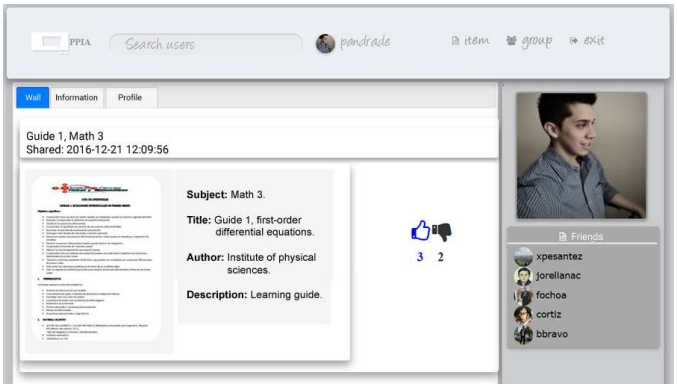

Fig. 5: Recommendation of an learning activity to an user.

users, meeting different needs. In this article, we present a first implementation of SOPPIA, based on the institutional and personal resources of each user to form an SLN or present different learning activities.

As future work, we plan to continue taking advantage of the benefits of cloud computing to share resources through the use of virtual machines. Besides, we are implementing a serious game within OPPIA, which purpose is to be used as a new educational tool.

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