Online Presence in Adaptive Learning on the Social Semantic Web

Jelena Jovanović[1], Dragan Gašević[2], Milan Stanković[3], Zoran Jeremić[1], Melody Siadaty[4,2]

[1]*University of Belgrade, Belgrade, Serbia*
[2]*Athabasca University, Athabasca, Canada*
[3]*Université Paris-Sud XI Orsay, Paris, France*
[4]*Simon Fraser University, Canada*
jeljov@gmail.com, dgasevic@acm.org, milan.stankovic@gmail.com, jeremycod@yahoo.com, melody_siadaty@sfu.ca

Abstract

In adaptive learning environments, this exchange of online presence data cannot be considered isolated from the overall learning context. However, there is yet no systematic solution to exchanging and integrating online presence data from diverse instant messaging and social networking applications. To address this issue, we propose an ontology-based approach to sharing online presence data in adaptive learning environments through the use of the Online Presence Ontology. This ontology is integrated into the Learning Object Context Ontology framework, which allows for capturing and unambiguous representation of all relevant data about students online presence, their mutual interactions, as well as their interactions with learning resources. On top of this ontology framework, we have developed innovative, context-aware learning services presented in this paper. The use of these services is demonstrated in a learning environment for studying software patterns.

1. Introduction

The wide and ever increasing acceptance of instant messaging (IM) tools and social networking services lead to a proliferation of social activities among Web users. Favoring direct and frequent communication among their users, the great majority of those tools/services allow (and even foster) users to post descriptions of their temporary state: custom messages, availability/willingness to chat and often visual representations known as avatars. We use the term Online Presence to refer to these temporary descriptions of users' presence in the online world [1].

The notion of online presence is especially important in collaborative learning environments which are becoming more widespread with the rising acceptance of modern pedagogical theories which argue for students' active involvement in the learning process and construction of knowledge through social interactions. By giving students insights into their classmates' activities (both online and offline), emotional state, likes and dislikes (often reflected in their status messages), students' online presence data can provides those missing nonverbal clues typical for face-to-face interaction (e.g., body language, facial expressions, gestures) and thus increase students' awareness of each other. However, students' online statuses on IM and discussion forum tools of learning environments cannot fully serve this purpose; more important tend to be the data students post on global social networking sites and IM services, that is, typical socializing online networks like Facebook, MySpace, Twitter, and MSN, where students tend to be more earnest about their activities, feelings, opinions, etc.

A significant number of studies have explored the notion of social (online) presence – the perception of interpersonal connections with virtual others – as a factor that significantly influences the success of online learning. Those studies have shown that social presence is an important factor in improving instructional effectiveness [2]; it promotes collaborative learning [3], and is significantly related to overall learner satisfaction with the courses, students' perceived learning, and their satisfaction with the instructor [4]. In contrast, the lack of social

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presence can lead to more frustration and less affective learning [5]. Furthermore, by being aware of a student's online presence, an e-learning system is better able to adapt the student's interactions with his/her social environment (i.e. other students and teachers). In addition, online presence data allows for more subtle personalization to take place and higher quality recommendation (e.g., not recommending collaboration with a peer who is currently busy and does not want to be disturbed). This data might also reveal students' current real world location, thus enabling the e-learning system to recommend peers who are nearby and could be contacted for an ad-hoc F2F meeting.

Our literature review indicated that the previous work on social (online) presence in education considered exclusively discussion forums and/or IM tools as means for establishing social presence in e-learning environments. However, in the time of work and information overload, and consequentially a changed attention paradigm – reduced to shorter time periods, online status updates is becoming the prevailing communication form of today's students. Therefore, we focus on the role of students' online statuses and custom messages posted on diverse Web tools and services as means for establishing their presence in the online world. However, there is still no systematic solution to exchanging and integrating online presence data from different IM tools and social networking applications. Different formats used for representing semantically identical data, prevents seamless transfer of that data among services. In order to address this issue, in our previous work, we have developed the Online Presence Ontology (OPO) [1] for modeling the semantics of the relevant features of a user's appearance in the online world, with the final aim of enabling interoperability among services that collect and use online presence data. In this paper, we employ this ontology in educational settings and integrate it with our LOCO (Learning Object Context Ontologies) ontological framework [6] for modeling learning context in e-learning environments. The LOCO framework extended with OPO allows for capturing and unambiguous representation of all relevant data about students online presence, their mutual interactions, as well as their interactions with learning resources. As we present in this paper, this ontological framework provides a solid foundation for the development of innovative, context-aware learning services aimed at better supporting students' interactions throughout the learning process.

2. Ontologies for Online Presence and Learning Context

To address the problem of online presence in adaptive learning environments, we use a comprehensive ontological framework, named LOCO (Learning Object Context Ontologies), which is aimed at formally representing all particularities of the given learning situation (i.e. learning context): the learning activity, the learning content that was used or produced, the student(s) involved, and diverse kinds of interactions that occur during a learning process (e.g., students mutual interactions and their interactions with learning content) [6]. Accordingly, the framework integrates a number of learning-related ontologies, such as learning context ontology, a user model ontology, and domain ontologies. These ontologies allow one to preserve the semantics of any given learning context in machine interpretable format thus enabling the development of context-aware learning services.

2.1. Online Presence Ontology

Aiming to enable the integration and exchange of Online Presence related data, we have developed the Online Presence Ontology (OPO) [1]. By using ontology formalisms for representing the semantics of different kinds of presence related data, OPO enables the transfer of this data from one service to another without the loss of semantics. The ontology design emerged from an extensive analysis of the major sources of online presence data, namely, IM platforms, social networks, and other social applications. In addition, being aware of the dynamic nature of social applications, and their ever increasing functionalities, we made the ontology highly flexible and extensible so that it can evolve with the future changes in the way people present themselves online. Like the LOCO ontologies, OPO was also developed with Linked Data principles and best practices[1] in mind, and whenever possible it reuses concepts and relationships from well-known vocabularies such as the Dublin Core vocabulary, FOAF (Friend-Of-A-Friend, http://xmlns.com/foaf/0.1), and SIOC (Semantically Interlinked Online Communities, http://sioc-project.org).

OnlinePresence (Figure 1), the core class in OPO, is a placeholder for all the aspects of a user's presence in the online world. To allow for extending the ontology with possible new aspects of online presence, we introduced the *OnlinePresenceComponent* class to

[1] http://www4.wiwiss.fu-berlin.de/bizer/pub/LinkedDataTutorial/

represent one particular aspect of online presence. The current state of practice in the area of online social interactions indicated a need for three kinds of *OnlinePresenceComponents*:*OnlineStatus*, *Notifiability* and *Findability*. *OnlineStatus* represents a user's attitude towards the possibility of interaction with other people (it is used by IM platforms to indicate a user's 'availability for chat'), whereas *Notifiability* models his/her willingness to be notified by an application (e.g., a chat platform) when a request for interaction arrives. *Findability* is meant for describing the possibility of other users to access a person's contact details and online presence data. Further details of the ontology as well as numerous examples of OPO statements can be found on the project website (http://www.milanstankovic.org/opo).

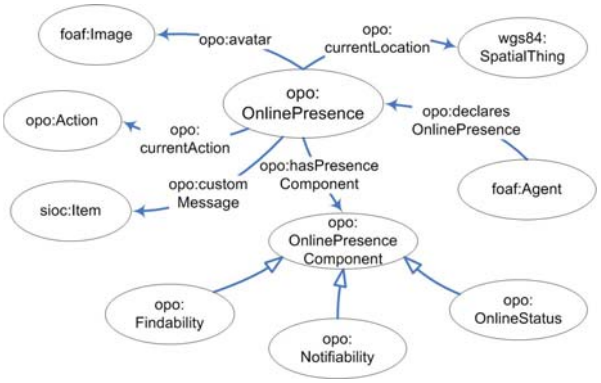

Figure 1. Online Presence Ontology – the basic

2.2. The extended LOCO framework

Extending the LOCO framework to enable formal representation of the online presence declared by a user of an e-learning environment was straightforward. Specifically, the connection was established between the User Model ontology of the LOCO framework and OPO. OPO uses the *foaf:Agent* class to represent a person who declares his/her online presence, whereas the LOCO's User Model formally represents a user of an e-learning environment through its *um:User* class which is defined as a subclass of the *foaf:Agent*. Accordingly, the presence-related properties that OPO defines for *foaf:Agent* (*opo:declaresOnlinePresence* and its inverse *opo:declaredBy*) are inherited by the *um:User* class, thus allowing us to capture data about users online presence not only in the given learning environment, but also on the Social Web in general.

We have also established a connection between the concept of activity (*lc:Activity*) defined in LOCO and the same concept defined in OPO (*opo:Action*) (Figure 2). In particular, we have introduced the *opo-activities:LearningActivity* class as a subclass of the *opo:Action* class and, in order to make the connection highly flexible, related this class to *lc:Activity* through the newly introduced *opo:correspondsTo* property.

3. Ontology-enabled Online Presence in DETPHS

In this section, we illustrate how the proposed ontology framework for modeling online presence in learning context, is leveraged in DEPTHS, a comprehensive learning environment for collaborative project-based learning of software design patterns [8]. DEPTHS integrates several existing educational systems and tools by using the LOCO ontologies as the common data model. The learning process in DEPTHS is further facilitated and augmented by several context-aware educational services.

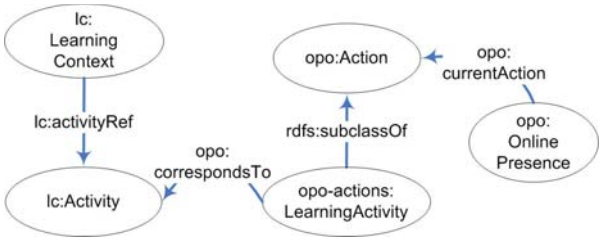

Figure 2. The integration of the Learning Context ontology and OPO: relating activities defined in LOCO and OPO

A typical scenario for learning software design patterns with DEPTHS assumes a project-based learning approach with collaborative learning support. In particular, a teacher defines a specific software design problem that has to be solved in a workshop-like manner by performing several predefined tasks, such as brainstorming, creating and submitting solutions, evaluating solutions etc. In order to get information required for performing this task, students search public online repositories that provide resources on software design patterns, as well as related course content that is internally available. DEPTHS makes this search more effective by providing semantically-enabled context-aware learning services (based on LOCO) for finding related external and internally produced resources. After the cognitive process of creating a solution to the software problem, students are supposed to graphically represent it (i.e., create a software model) using the software modeling tool integrated in DEPTHS.

Collaborative learning in DEPTHS is enhanced (among other things) by the semantically-enabled peers finding service that, based on the student's

current learning context, suggests other students, teachers or experts as possible collaborators. This service allows for collaboration within the DEPTHS environment regardless the tool the participants currently use, as it uses the LOCO ontologies to exchange data between the tools integrated into DEPTHS. However, this service was not able to reach peers who are currently online, but do not use DEPTHS. The following subsections present 4 scenarios that illustrate how we intend to improve this service by making use of online presence in different learning contexts of DEPTHS.

3.1. Scenario 1: who is online?

Tom, a student who uses DEPTHS, is experiencing problems with his assignment; he knows that his friends Mark and Alex have already done that assignment and would like to ask them for help; unfortunately, they are not online, at least according to their online statuses in the Learning Management System they all use. But, in fact, Mark and Alex are online – their active online statuses on Facebook and MSN state that. In addition, Alex is also free, available for chat. If only Tom knew that.

In the presented scenario, it is obvious that Tom would very much appreciate awareness of his peers' online presence regardless of the online tools they are currently using. It would allow him to easily spot when they are present and available, and contact them without leaving his present learning context. This scenario is supported by the mediator service which we propose in order to allow for the exchange of users' online presence data among various online communication tools. The data exchange is based on the OPO ontology, so that the semantics of the users' online presence are preserved during the exchange. The mediator service enables diverse communication tools to both publish users' online presence data and to subscribe to changes of the users online presence data on other tools. The service employs appropriate mechanisms (based on rules and policies) for securing the privacy of the exchanged data and selectively allow access to that data. The development of this service is challenged by maintaining privacy constraints in data exchange, as well as giving users the control over which service or online actor can be granted access to their private online presence data.

3.2. Scenario 2: who to contact?

Let us now consider a scenario where Tom is experiencing a problem with his assignment but does not know whom to ask for help, so he decided to rely on the system's recommendation. Having analyzed Tom's current learning context, the system recognizes that Sheila, Alex and Mark have already mastered the topic in question and would be able to help. However, Mark's 'work overload' custom message indicates that he should not be considered. Likewise, Sheila's custom status 'available only for friends' indicates that she is available only for her friends, and Tom is not one of them. Luckily, Alex is currently available; so the system recommends Tom to contact Alex. If the system had not have access to the students' online presence data, it would have made incorrect recommendation by suggesting Tom to contact any of the three knowledgeable peers.

DEPTHS include context-aware service for peers, teachers and experts discovery [8]. Based on the student's current learning context (captured and stored as RDF triples compliant with the LOCO's learning context ontology), this service suggests other students or experts as possible collaborators. Collaborators are selected and sorted using an algorithm which primarily considers their knowledge (maintained in their student profiles based on the LOCO's User Model ontology) of the current topic (defined in terms of the LOCO's domain ontology). However, the list of potential collaborators has to be narrowed to those who are able to provide help at the given moment. To do that, DEPTHS makes use of the students online presence data maintained in accordance with the OPO ontology. A query over the repository with OPO-based online presence data can provide the identifiers (URIs) of Tom's peer students who are currently online, active and visible, can be freely contacted and are available for contact with other students. By matching the results of such a query with the previously generated list of knowledgeable peers, the system is able to provide Tom with a highly valuable recommendation.

3.3. Scenario 3: how to contact?

Not only that online presence data could significantly help in choosing the available peers to contact, but it could also be used to suggest the most appropriate way to contact a peer based on his/her nature of presence. Let us consider a scenario where a user, Marc Anthony, wants to contact Jennifer to ask for help with his design patterns assignment. At the time, Jennifer is engaged in a cognitively demanding activity, so in her online status she has prohibited any notifications from popping up. Being able to comprehend the formal semantics of Jennifer's OPO-based online status, in particular, the Notifiability

component, the DEPTHS system will recognize that Marc Anthony's attempt to chat with Jennifer will result in no notification being passed to her. In this case, the system suggests another communication channel (e.g., e-mail) by emphasizing and disabling appropriate user interface components.

3.4. Scenario 4: who is nearby?

Nowadays, it has become a common practice for Twitter users to access their accounts from their mobile phones and update their statuses on the move. When accessed from a mobile device (equipped with GPS), Twitter is able to keep track of the user's location, so the location data becomes a part of the user's online presence. The location data can be used for ad-hoc detection of fellow students that are nearby and organization of F2F meetings and assignment-based study groups. This possibility can be especially relevant for blended learning.

The *opo:currentLocation* property of the *opo:OnlinePresence* class allows for capturing students current location (e.g., by using (lat/long) coordinates). By doing a simple computation over geo coordinates, the system can determine physical distances among students and identify students who are nearby each other. In the context of DEPTHS, its semantically-enabled peer discovery service might identify Sheila as the most relevant person for the current problem that Tom is trying to solve. Accessing her OPO-based online presence data, the system learns that she is 'away' (from her online status), but also that she is in the same building as Tom (from her current location data). Therefore, the system offers Tom an option to contact her via SMS for an ad-hoc F2F meeting.

4. First Prototype

In order to test the feasibility and effectiveness of augmenting learning context with students online presence data, our first step was to extend the DEPTHS environment with support for tracking, integrating and leveraging students Twitter posts (also called twits). To allow for capturing and integrating students' twits, we have extended the DEPTHS *Data Mapping Module* which transforms user tracking data of different systems and tools integrated into DEPTHS, into LOCO-compliant learning context data and stores the resulting (RDF)data into DEPTHS' semantic *Repository of Interaction Data*. This extension allows for transforming students' Twitter messages into OPO-compliant online presence data and storing them in the aforementioned repository. The transformation is implemented using XSLT transformation language over the publicly available data about students' posts on Twitter. Specifically, these data are available for every Twitter user via the following URL: http://www.twitter.com/users/show/{username}.xml. If a student's post is a reply to some other, previously published post, that data is also available, allowing us to relate students' posts and get more insights into their interaction. For determining the student's location when submitting a post, GeoNames Java API (http://www.geonames.org/source-code/) is used. Figure 3 gives an example twit represented in OPO.

```
@prefix rdf: <http://www.w3.org/1999/02/22-rdfsyntax-ns#>
@prefix opo:
<http://ggg.milanstankovic.org/ontologies/OnlinePresence.owl#>
@prefix foaf: <http://xmlns.com/foaf/0.1/>
@prefix sioc: <http://rdfs.org/sioc/ns#>

_:bnode rdf:type opo:OnlinePresence ,
    opo:declaredBy [
        rdf:type foaf:Agent ;
        foaf:nick "joe" ;
        foaf:homepage <http://joesmith.net>
    ] .
    opo:avatar <http://s3.amazonaws.com/twitter_production/
                profile_images/98761234/my_picture.jpg>;
    opo:currentLocation <http://sws.geonames.org/3014737> ;
    opo:startTime "2009-04-10T15:45:26" ;
    opo:customMessage [
        rdf:type opo:StatusMessage ;
        sioc:content "@tom I would suggest Strategy pattern" ;
        sioc:reply_of <http://twitter.com/tom/statuses/1493196401>
    ].
```

Figure 3. An example of OPO-based representation of online presence published from Twitter

In this first prototype, we are leveraging the semantically represented and integrated data about students' twits for improving DEPTHS' context-aware service for experts, teachers and peers discovery. Based on the current learning context, this service suggests potential collaborators using an algorithm which considers: 1) their participation in learning activities; 2) their knowledge level estimated by the teacher and other peers' evaluations, including projects evaluations and ideas ratings; 3) their social connections with the peer asking for help. By making this service aware of the students' interactions on Twitter, we are able to better determine each of the mentioned criteria for collaborators selection. For example, we are better able to determine social connections among students as well as to evaluate the level of their engagement in the problem solving tasks (e.g., how often they twit answers to other students questions, suggest ideas for solving the given problem,

etc.). In addition, the location data allow for suggesting F2F meetings with peers who are nearby (as explained in Section 3.4).

We are currently working on the integration of students statuses on Facebook and intend to use that data as well for the improvement of our context-aware recommendation services.

5. Discussion and Conclusions

To our knowledge, there are neither systems nor approaches that take advantage of online presence data to enhance learning experience and provide an environment more adapted to user's presence and the presence of his peers. In the presented research work, through the integration of the OPO ontology with the user model aspects of the LOCO framework, we enabled for a systematic exchange of online presence data in e-learning environments. From the educational perspective, the major benefit of the proposed integration is the increased student-student and student-teacher interactivity stemming from the provision of the advanced peer, expert, and teacher finding services. Unlike other reported approaches to context-aware discovery and recommendation of collaboration partners and experts (e.g., the work described in [7]), our approach, demonstrated in the DEPTHS learning environment, allows for the integration of users' online presence data from diverse sources (i.e., systems and tools) and the compilation of recommendations based on this ubiquitous online presence awareness. Thanks to the shared understanding of the online presence, learning systems can adapt their feedback as per factors such as who is online, who to contact, who is nearby, and how to contact. This means that learners' expressions of online presence are respected, while their peers are trying to communicate with them in different learning contexts. We believe that the proposed solution can be used as a reference model for the integration of various communication services in e-learning environments.

Our initial evaluation of the DEPTHS learning environment (before the support for online presence was added) has shown that its context-aware educational services are very helpful and that active and collaborative learning approach DEPTHS rely upon (brainstorming, modeling and evaluating each other works) considerably contributes to the effectiveness of the learning process [8]. In particular, the peers' recommendation service has been perceived by the majority of the students (84.61%) as very useful for learning process. According to our anecdotal experience, the integration of online presence support in the peer recommendation service has further increased its perceived usability among students. To be able to firmly state this, after making the integration with Facebook fully operational, we are going to repeat the evaluation study and put more emphasis on the service for recommendation of peers in order to determine the actual benefit of having access to students' online presence data. We will also investigate what combination of communication and social networking services provides the best results for different learning contexts in DEPTHS. In addition, we will use quantitative methods to evaluate the recommendation accuracy of the recommendation services.

Since the majority of the online presence data the suggested approach relies upon are often considered as private data, we plan to further investigate various mechanisms for privacy preservation and control over the online presence data. We are considering using an approach similar to the one suggested in [9] for giving users the control over which service or online actor can be granted access to their private OPO data.

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