Activities and Trends Analytics in a Widget based PLE using Semantic Technologies

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Abstract: We report about work in progress on tracking the activities and trends of users from logs in a widget based Personal Learning Environment (PLE) using semantic technologies and standards for retrieval. As input for the observations, we are using the data from our self developed PLE with around 4000 active users. Last two years we logged their activities and modeled them with RDF (Resource Description Framework)* as base for improvement analysis of existing system. The main objective of this work is to outline how learning environments like PLE can benefit from Semantic Web and its contribution for such efforts like analytics, profiling, recommendations and usability.

1 INTRODUCTION

Emergence of the Web 2.0 (O'Reilly, 2005) introduced participation of users as part of the web. The transformation of internet from consuming into interaction medium goes hand in hand with the advances of the web technologies. These changes also influences how we think, inform ourselves, organize our everyday activities but also how we learn. Several research studies have been carried out to analyze how Web 2.0 applications such as Blogs (Farmer, 2005; Holzinger et al., 2009; Ebner et al., 2007), Wikis (Augar et al., 2004), Podcasting (Towned, 2005) as well as Microblogs and Social Networks generally(Ebner and Maurer, 2009; Ebner et al., 2010a) influence users and can enhance education. Various studies on Web 2.0 usage amongst students (Ebner and Nagler, 2010) outline how hard it is to follow the trends and even more to monitor them in an appropriate way. Mashups (Tuchinda et al., 2008) and personalization can be used to manage this challenge in learning environments. Nowadays, with increasing number of smart phones the online presence is getting more intensive for a huge population of users. They share different resources and contribute to the Web with their mobile devices. This trend applies also for teachers and learners in context of E-Learning (Ebner et al., 2008). Those activities consider also Web 2.0 applications and services raised like YouTube (for sharing Videos), Flickr (for sharing pictures), Slideshare (for sharing presentations), Scribd (for sharing documents), Delicious (for sharing bookmarks) etc. The huge amount of such applications and their usage in learning and teaching has changed the online behavior and attitude of learners in respect to the new arising technologies (Downes, 2005). This led to the idea of Personal Learning Environment (PLE), where tiny applications (widgets) can be integrated and combined within a learning environment managed by the learners according to their actual personal needs. Such approach resembles to the mobile application environments in many ways, i.e. a widget store is offered where the learners can install widgets on one or many spaces or personal desktops. Due to the fact that mobile technologies and social web are available ubiquitously as well pervasively used, they have influence our every day life and learning environments (Holzinger et al., 2005; Klamma et al., 2007). It is quite challenging for education not to be overwhelmed by all these various opportunities within a learning environment. Todays learning process became more individual, multi facetted and activity driven with the tendency to ad-hoc initiated collaboration and information exchange. All these parameters increase the complexity of online learning platform design and organization. Dynamics involved in this process require nowadays shorter optimization cycles in adaptation process of Learning Management

*http://www.w3.org/RDF/

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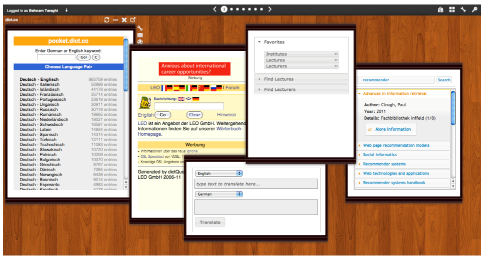

Figure 1: PLE Desktop at Graz University of Technology.

Systems and Personal Learning Environments. In order to provide the learners an attractive surrounding and to tackle the named problems use of learning analytics regarding activities and trends for optimization of learning process and design of learning surrounding emerges as the time passes by. Such data contributes to the personalization and adaptation of the learning process and belonging hosting environments. For these purposes we logged in anonymous way user data regarding activities on widgets in our PLE for last two years and modeled them into learning context using RDF in order to generate statistics that would help us to improve the concept of the widget based PLE. For querying the the context we used semantic retrieval standard SPARQL[2].
In following sections we will offer a short overview over related work and explain how we managed to model the activities in order to track them. We will also show some preliminary results on current production system. This paper will be concluded by the discussion about the first results and some future work announcements.

2 RELATED WORK

The main idea of using and developing a widget based PLE at Graz University of Technology[3] was to combine and integrate existing university services (Ebner and Taraghi, 2010) as well as resources and services on the World Wide Web in one platform and in a personalized way (Ebner and Taraghi, 2010). It bases on meshup of widgets (Taraghi et al., 2009a; Taraghi et al., 2009b; Taraghi et al., 2009c) that represent the resources and services integrated from the World Wide Web within the PLE. On the other hand Web provides lots of different services; each can be used as supplement for teaching and learning. The PLE has been redesigned in 2011, using metaphors such as apps and spaces for a better learner-centered application and higher attractiveness (Ebner et al., 2010b; Taraghi et al., 2012). A sample of PLE Desktop with Widgets can bee seen in figure 1. The PLE has been running since two years. In order to enhance PLE in general and improve the usability as well as usefulness of each individual widget a tracking module was implemented (Taraghi et al., 2011). Different works outlined the importance of tracking activity data in Learning Management Systems (Santos et al., 2012; Verbert et al., 2011). None of them addressed the issue of intelligently structuring learner data in context and processing it to provide a flexible interface that ensures maximum benefit from collected information. The Semantic Web standards like RDF and SPARQL where data is structured and queried as graphs and projected on specific knowledge domain using adequate ontologies has been fairly successful used to generate correct interpretation of web tables (Mulwad et al., 2010) to advance the learning process (Prinsloo et al., 2012; Jeremić et al., 2012) as well to support the controlled knowledge generation in E-learning environments(Softic et al., 2009). The retrieval standard provided by Semantic Web named SPARQL enables easily querying of semantically enriched data. This potential was also recognised by current research in the EU project Intelligent Learning Extended Organisation (IntellLEO)[4] which produced in the published ontology framework: ActivitiesOntology[5] to model learning activities and events related to them along with the surrounding environment and Learning Context Ontology[6] which offers formalization of learning context as general learning situation. Due to their accuracy to the problem that is addressed by this work these ontologies have been used to model the context of analytic data collected from user logs in this work. Our method is based on a tracking model as a knowledge domain related context using ontologies and query languages like SPARQL similar to current research in the area of Self-regulated Learners(SRL)(Jeremić et al., 2012). Exploratory graphics show that the sum of (web) user data on the access paths and the linkage of the resources within an environment(site) at a particular time window gives sufficient insight at what constitutes relevance; important properties and linkages between data resources(Siadaty et al., 2011). The overall goal of is summarization of visualizations and evaluation of statistic data that enable the PLE optimization and present the research community used generic techniques and metrics for problems in design and adaptation of learning environments.

[2]http://www.w3.org/TR/rdf-sparql-query/
[3]http://ple.tugraz.at
[4]http://intelleo.eu
[5]http://www.intelleo.eu/ontologies/activities/spec/
[6]http://www.intelleo.eu/ontologies/learning-context/spec/

3 ANALYTICS FROM LEARNERS LOGS

3.1 Modelling User Activities

The main objective for tracking is appropriate modelling since RDF offers only the framework how the data is aligned and organized in such constructions. This task concerns mostly the choice of the right vocabulary or ontology. A bunch of experience is usually necessary to complete such effort especially when ontology has to be designed on your own. In current research in *IntellLEO* EU project however this objective has been practically implemented. One of the main goals of this project according to the statement from project page is building an *innovative ontological framework for learning representation which includes learners, context and collaboration models, serving to achieve the targeted synergy*[7]. In the realm of the *IntellLEO* project inside the provided ontology framework two special ontologies are eminent for current work. The first is the Activity Ontology which offers a vocabulary to represent different activities and events related to them inside of a learning environment with possibility to describe and reference the environment (in this case PLE) where these activities occur. The second contribution from current Ontology research work in *IntellLEO* project is the Learning Context Ontology which describes the context of a learning situation. We used as it will be shown in following sections this Ontology to reflect the user activity context.

Formulation in listing 1 depicts an instance of `lc:LearningContext` class in compact N3 RDF Notation derived from our tracking module that stores them into a RDF Store and makes them accessible via relying SPARQL Endpoint. Translated into natural language this instance from listing 1 reflects that a `ao:Logging` event which tracked the learning activity of `ao:Viewing` by certain anonymous `um:User` inside the learning widget named *LatexFormulaToPngWidget* as `ao:Enviroment` at certain time point. As shown in this sample modeling example vocabularies and ontologies which fit appropriate for the special case can enable a high level of expressiveness in a very compact manner.

Listing 1: Sample model of a learning context in N3 notation.

```
@prefix ao: <http://intelleo.eu/ontologies/activities/ns/> .
@prefix foaf: <http://xmlns.com/foaf/0.1/> .
@prefix lc: <http://www.intelleo.eu/ontologies/learning−context/ns/> .
@prefix rdfs: <http://www.w3.org/2000/01/rdf−schema#> .
@prefix um: <http://intelleo.eu/ontologies/user−model/ns/> .

<https://ple.tugraz.at/ns/activity/#Viewing>
    a ao:Viewing .

<https://ple.tugraz.at/ns/users/#FSKSN>
    a um:User;
    foaf:name ”FSKSN” .

<http://ple.tugraz.at/ns/events/log/#7912>
    a ao:Logging;
    ao:performedBy <https://ple.tugraz.at/ns/users/#FSKSN>;
    ao:timestamp ”2012−10−04T07:52:52” .

<https://ple.tugraz.at/ns/widgets/#LatexFormulaToPngWidget>
    a ao:Enivironment;
    rdfs:label ”LaTeXFormulaPNG Converter” .

<http://ple.tugraz.at/ns/learningcontext/#7912>
    a lc:LearningContext;
    lc:activityRef <https://ple.tugraz.at/ns/activity/#Viewing>;
    lc:environmentRef
    <https://ple.tugraz.at/ns/widgets/#LatexFormulaToPngWidget>;
    lc:eventRef <http://ple.tugraz.at/ns/events/log/#7912>;
    lc:userRef <https://ple.tugraz.at/ns/users/#FSKSN> .
```

3.2 Querying of User Activities Trends

In order to retrieve the data relevant for the analytics RDF instances that reside in a RDF Store at our PLE environment SPARQL query language has been used. Operability over the data is much easier then in the case if the log data would be stored in specific structure without standardization. In this way we are able to answer the questions like ”Show me the a monthly activity intensity for year 2012?”. Listing 2 represents exactly the question stated in the manner of SPARQL syntax. The advantage of this approach is that data formulations are flexible and tolerant against any extension of representation schema, which means that adding supplementary properties would not change the expressiveness and retrieval of already existent information. Further since Semantic Web support the Open World Assumption (OWA), an answer whether or not is something reproducible out of the knowledge base is guaranteed.

[7] http://intelleo.eu/index.php?id=5

4 PRELIMINARY RESULTS

As preliminary result we are able to track the activity trends overall time periods like presented in figure 2. This violin graph depicts the visual answer of the query from listing 2. We can see that for year 2012 top three favored activities were ”Reading”,”Search” and ”Authoring” while activities like ”Quizzing”,”Computing”and ”Listening” are least frequent ones. Also the intensity shows that as expected that most activity happens at the beginning and at the end of academic terms when PLE is presented in introductory lectures to the newcomers and freshmen.

Listing 2: Querying the intensity of all activities in PLE after certain date.

```
PREFIX ao: <http://intelleo.eu/ontologies/activities/ns/> .
PREFIX foaf: <http://xmlns.com/foaf/0.1/> .
PREFIX lc: <http://www.intelleo.eu/ontologies/learning−context/ns/> .
PREFIX rdfs: <http://www.w3.org/2000/01/rdf−schema#> .
PREFIX um: <http://intelleo.eu/ontologies/user−model/ns/> .

SELECT ?actname, COUNT(?actname)
WHERE
{
 ?x rdf:type
     lc:LearningContext;
     lc:activityRef ?a;
     lc:eventRef ?e;
     lc:userRef ?u.

 ?e rdf:type
     ao:Logging;
     ao:timestamp ?date.

 ?a rdf:label ?actname;

  FILTER ( ?date > ”2012−01−01T00:00:00Z”ˆˆxsd:dateTime )
}
```

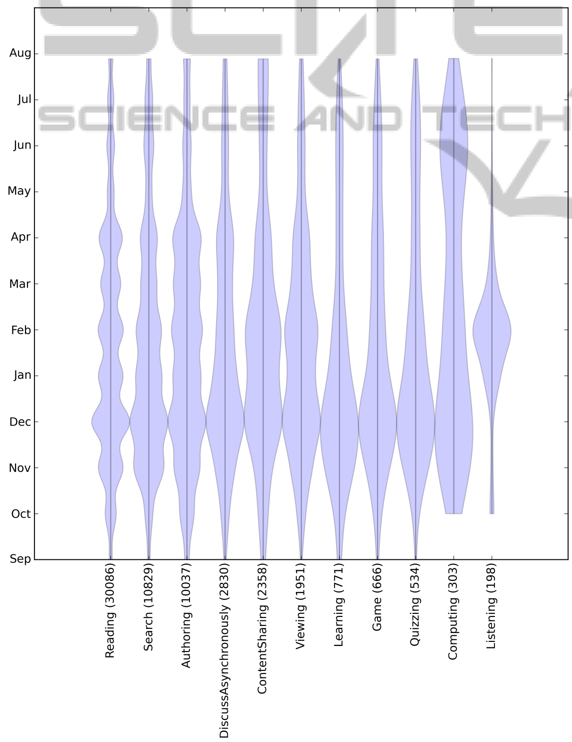

Figure 2: Tracking the intensity of activities for year 2012.

We have chosen this example to demonstrate the usefulness of semantic approach in a very simple case where a vast of e.g. usability and improvement input can be generated with a simple query and a visualization interface. Demonstration like this reveals in a very efficient manner which potentials are hidden in appliance of Semantic Web for learning analytics.

5 CONCLUSIONS AND FUTURE WORK

The overview over distribution of activities can reflect the overall interest of the learners within PLE. It can be concluded that in case of our PLE users are more consumers that contributers. Visualisation of statistics can help to improve the PLE usability in general. Activities such as e.g. ”Quizzing” and ”Listening” (from some learning object widgets) are not quite popular. Corresponding widgets that support those activities must be revised regarding usability. The statistics visualisation help us to gain deep insight into the behaviour of a single user in a certain period of time. In this simple case we demonstrated that using semantic technologies enables the extensibility of learning analytics. Our approach generates uniform interfaces for information exchange, enables flexibility for visual evaluation, and also includes the scalability regarding the enrichment of learning analytics data, since it is tolerable because of the RDF to the schema changes. Our future efforts are aiming the improvement of semantic structure data layer in order to reflect as many aspects as possible. We also want to review our widget store regarding the generated results in order to decide which widgets will further provided in our PLE and which of them need to be re-factored.

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