16 Analysis of Means for building Context-Aware Recommendation System for Mobile Learning

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Abstract
One of the rapidly developing tools for online learning is learning through mobile environment. Therefore, developing and improving of mobile learning environment is an active topic now. One of the ways to make learning environment more accurate to user's needs is to use his context. Context of user consists of current context in online learning environments and physical context. This paper concentrates on physical context and way to improve user's experience in learning environment by using it. For this an ontology-based system is presented and Learning Context ontology was extended for user context ontology. Set of use-case scenarios is provided to show situations which will be covered by such approach.

Keywords: Context, Context-awareness, Adaptive learning, Learner-centred learningn, Mobile learning

16.1 Introduction

In recent years, we are witnessing a rising interest in and acceptance of Vygotsky's Social Development Theory (Wertsch & Sohmer, 1995), connectivism (Siemens, 2005) and other modern pedagogical theories, which argue for learners' active involvement in the learning process and construction of knowledge through social interactions.

Success in online teaching and learning can largely depend on the available means or tools students have to be connected to pedagogical resources. These, in turn, rely on information related to the learners' current context in online learning environments, as well as in online social networks, instant messaging systems, and furthermore physical context as locations, current activity or place. Such information reveals how present is the student and what could the accurate resource it could be interesting to recommend to enforce his learning strategy. If employed in an appropriate way, this information can greatly increase the learning efficiency.

One of the main development of the online presence approach concerns mobile learning environments. Indeed, mobile learning environments have to take into account many parameters of the learners' context including location, current state of mind, activity and user's environment. Furthermore, mobile learning environment, because of the world wide deployment of smartphones, are one of the most active developing fields now: for example, e-learning applications take 10% of all mobile applications (Focus RH, 2017). Thus, designing an app which is able to recommend the appropriate pedagogical resource according to the physical context of the learner is an important challenge. Learners are connected through the mobile phone, and this mobile phone is like a "part of them". So, for efficient user-application interaction mobile phone should provide an automatic adaptation of its content and system behaviour to learner state and needs.

The purpose of this project is to provide design of individual learning environment that will improve learner productivity and help him not to lose motivation to study by providing needed

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learning material in an appropriate time and situation. This design based on ontology approach. m-LOCO project (Torniai, et al., 2008) inspired us to make this work. In this project, authors provide an ontology-based framework that capture contextual information in mobile learning environments and use it for providing recommendations. Also, there was considered spatial and temporal attributes as main characteristics of user context. Proposed project uses extended notion of user context provided in paragraph 2.1 and doesn't take in account internal structure of learning object. Instead of using internal structure of learning object it uses annotations of learning objects and relationship between them provided in LOM ontology. Such approaches allow to concentrates on providing recommendation, not on building learning object.

The paper is structured as follows. Section 2 offers an overview of the literature as regards user context and e-learning ontologies usages to model user's needs. Section 3 is dedicated to the presentation of designed system and providing context-aware recommendations. Section 4 presents the analysis of the designed system and discussion about future works. In our case, we use the term of context.

16.2 Related Work

Context-aware applications have been the subject of debates among researches in different domain areas. Based on the requirements and characteristics of each of these domains, the term "context" has been interpreted in different ways and different approaches have been applied to capture the contextual information. One of these domains is Ubiquitous Learning environment. In particular a ubiquitous learning environment encompasses two underlying contexts, namely the learning context and the mobile context.

16.2.1 Definition of Context

Definition of context can be various in different areas or when it was selected from different point of views (Bazire & Brézillon, 2005). We make use of following notion of context: "context is any information that can be used to characterize the situation of an entity. An entity can be a person, place, or object that is considered relevant to the interaction between a user and an application, including the user and applications themselves" (Anind, 2001).

In suggested project, context dimensions are time, physical user's activity (walking, biking, running etc.), user's location and calendar information.

Learning situations were presented as a set of parameters: 1) learning activity; 2) learning content; 3) learner – is a user involved in learning process; 4) context of the learner. All learning situations are related to a specific domain.

16.2.2 Formal Description of Domain

For providing common underlying language of the items in domain, ontology approach is chosen.

In this research interlinked set of ontologies is used. These ontologies represent in a formal way all learning situations.

Learning content should be structured, clear, atomized and be divided in small pieces. This will allow system to recommend them as independent pieces of knowledge. Combining them, the system provides the user appropriate material to help him to optimize time that he can spend online.

Several metadata standards are present for description of learning objects. The Dublin Core metadata initiative (dublincore, 2017) contains base description of learning resources, but it does not contain attributes describing the pedagogical perspective of a document. Also, there is IEEE LOM (Learning Object Metadata) that was developed under (imsglobal, 2006) and its extension for France LOM-FR (LOM-FR, 2017). IEEE LOM has technical standards, recommended practices, and guidelines that make using this standard simpler. Technical standards allow taking into account more details about learning objects to make recommendations more accurate. So, in this work LOM-FR will be used.

To keep attention on the main problem of this paper, assume that learning items were already provided with LOM annotations. According to the best practices of reusing domain ontologies, most of using ontologies was inherited. Therefore, consequent existing ontologies will be used for describing learning system:

- LOM-FR;
- Learning Context ontology (IntelLEO - Intelligent Learning Extended Organisation, Deliverable D3.2 IntelLEO Implementation Framework, 2010);
- User Model ontology (IntelLEO - Intelligent Learning Extended Organisation, Deliverable D3.2 IntelLEO Implementation Framework, 2010);
- User Context ontology;
- Competences ontology (IntelLEO - Intelligent Learning Extended Organisation, Deliverable D3.2 IntelLEO Implementation Framework, 2010);
- Mobile ontology (Torniai, et al., 2008);
- Activities ontology (IntelLEO - Intelligent Learning Extended Organisation, Deliverable D3.2 IntelLEO Implementation Framework, 2010).
- Annotations ontology (IntelLEO - Intelligent Learning Extended Organisation, Deliverable D3.2 IntelLEO Implementation Framework, 2010)
- Below, there are brief descriptions of all mentioned ontologies.

LOM (Learning Objects Metadata) represent data model for describing learning objects, relationships between them and properties vocabularies. This model allows building hierarchical structure of learning objects that allows navigate easily through learning objects. Architecture of specified data model consists of 9 categories that contain sub-elements. Sub-elements can be simple objects or can contain element. We will operate LOM objects as solid independent items for providing recommendation, therefore, we don't need description of internal structure of LOM object (such as Paragraph, Section, Table etc.). Reusability of learning objects, aid in discoverability, and facilitating learning objects interoperability properties belongs to LOM data model that make it efficient to design e-learning system.

Learning Context Ontology describe learning situations: learner activity and result of it, time when activity takes place, online environment where it takes place etc. This data will be used for analysing user's behaviour and determining his preferences.

User Model ontology provides formal representation of learner: his basic information, goals and preferences.

User Context ontology represents context of learner based on concepts such as Time, Place, Calendar, PhysicalActivity. Figure 16.1 illustrates this ontology. It is based on (Madkour, Driss, & Maach, 2013) User Context ontology.

Competences ontology provides information about level of skills that has subject. Subject can be represented as user or LOM object. This ontology allows competences cooperation of current user state and state that he wants to achieve.
Mobile ontology provides information about equipment (smartphone) that was needed to use this system.
Activities ontology allows modelling learners activities as reading, quizzing etc.

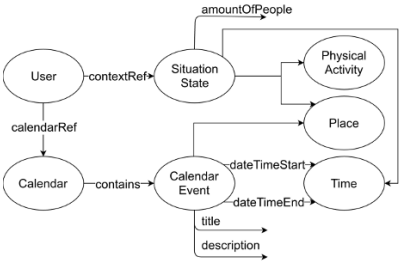

Figure 16.1: User context ontology (own Figure).

Annotations ontology allows modelling user's ratings of materials for keeping it as user's history. Figure 16.2 illustrates basic ontologies interaction and relationships which are connected by properties. In particular, learner (um:User) with some competence (c:CompetenceLevel) and physical context (uc:SituationState) opens smartphone (a:DeliveryMedia) and start using designed application (lc:LearningContext). While using application user gets recommendation to read some learning material (LOM) and make activities (a:Activity). Results of working with learning objects, for example, activity execution, are written to his history (ann:Annotation).

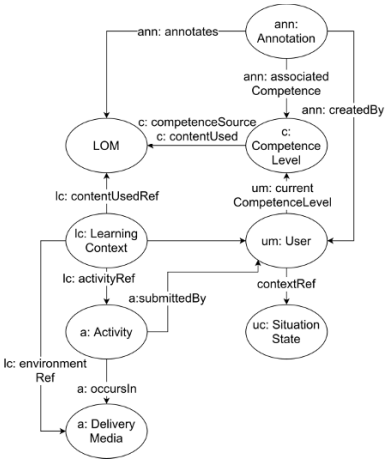

Figure 16.2: Ontologies structure (own Figure).

16.2.3 Pedagogical Approach

In eLearning context, learner should often process and work with information and tasks by himself. This makes him responsible for his learning process: time, speed, effectiveness. Therefore, this approach is `Learner centred´.

There are various possible models of interaction that can be present in e-learning system: learner to instructor, learner to learner, learner to content, learner to context. To focus on recommendation of e-learning items, learner to context approach is used. This system doesn't have teacher, it provides automated methods to recommend materials, evaluate and check user's knowledge.

Learning cycle of proposed system is designed in this way:

- Setting profile;
- Setting goals;
- Choosing courses. (They have linear structure);
- Study by taking items or quizzes (provide evaluation of part or whole studied topic) that are recommended by the system. If learner gets bad results system gives him recommendation to repeat this material after some time

User state consists of the following parts: profile, preferences, current knowledge, short / long term goals etc.

Learner profile is based on information provided by him. It includes learner's preferences. User model contains learner profile, dynamic information that derived from user's history, behaviour and material generated by user.

16.3 Results

Despite of the fact that provided recommendation system take in account long-term user's goal, it makes simultaneous recommendation and doesn't provide plan for future learning. When user opens system at the first time, he makes his model by fulfilling some profiling information. Then, while using the system, it specifies user's model. While user was out of the system, his model can be changed. To take into account these changes, user's calendar will be used.

Considering user as person that support life-learning approach. In this case, it has some learning strategy.

Therefore, following user's characteristics can be specified:

- User has e-learning resource system that specifies material that user learns by its own or in school / university (e.g. university system that provides structured learning content divided for lessons. Assume that learning content already has LOM annotations);
- Make planning in calendar and connect calendar events to learning material in e-learning resource system if it is possible. If it is not, user comments events by adding keywords or topics that was considerate on event. Also, user makes notes was event accomplished or not.

16.3.1 Architecture of Learning Environment

Smartphone was considered as equipment from user's side. Hard ontologies representations

(e.g. XML files) we stored in repositories as presented on Figure 16.3. Ontology repository is the persistent storage on ontologies data (Schmidt & Winterhalter, 2004).

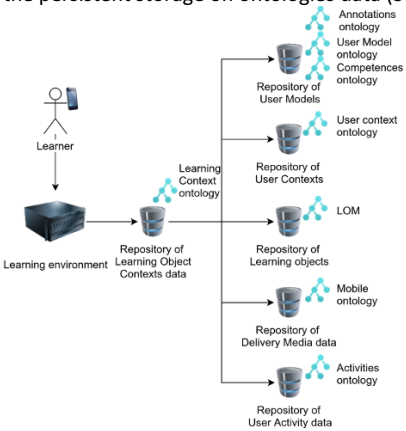

Figure 16.3: Architecture of learning environment (own Figure).

Actions provided by the system when the user opens the application are provided bellow. First, it gathers information about user's context:

- His local time;
- Where he is (location);
- His activity (understudied by user's speed);
- Suggest approximate amount of people who surround him (many people, few people, nobody);
- Check if headphones are plugged in or not;
- Check does user moves close to the specific coordinate.
- Second, it checks user's calendar:
- Process all events, which were happened from the last opening session. Processing events mean enrich user model with abilities that user get or enlarge while he wasn't in system. If the learning event was specified in calendar and learning material is attached system should analyse LOM description of learning object and add its result to model of user;
- Determine upcoming user events and extract user simultaneous needs;
- Predict time that user could spend at system;
- Then, system makes recommendation:
- Determine and range domains, topics or keywords that will be interesting based on gathered information and base information like user's profile, user's history, long-term goals etc.;
- Find existed user knowledge in these areas. It will be useful if user forget some material and will want to refresh material. Also, it is easier to learn new material by making associations rules with present material;
- Make recommendation of learning material as presented on Figure 16.4.

16.3.2 Design of Recommendation System

E-learning services depend on purpose of system. Some examples are voice reader, voice recorder, spell checker, quizzes engine, viewer (text, audio, video) etc.

Type of activity is determined as composition of educational learning resource type (evaluation, questioner, guide etc.) and technical format.

LOM allows making composite learning object with combination of atomic learning objects. Learning object can be presented as combination of learning pattern and learning data. Learning pattern is way of learning data representation. Examples of learning pattern are different types of quizzes (yes / no question, with one right answer, many right answers etc.), video / audio / text material with / without quizzes inside / at the end etc.

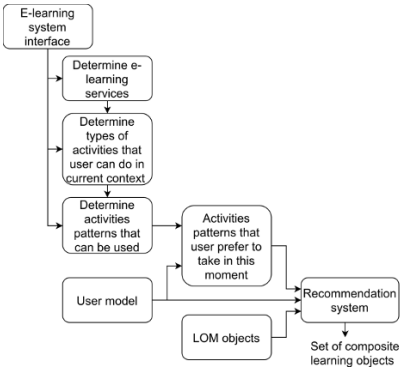

Figure 16.4: Structure of the proposed recommendation system (own Figure).

Figure 16.4 shows structure of recommendation system in terms of e-learning services, activities patterns and composite learning objects.

16.3.3 Use Case Scenarios

Consider three possible use-cases (UC) of using system.

Use Case 1: User is a student. University provides him with an e-learning resource system that contains a lot of different learning materials with different types for each subject. Also, he uses calendar for planning his time. In this calendar, user provides detailed information of events such as description, topics and place. Now, user is going by tram to lessons. Usually he has few different lessons in day. So, he has a big variety of things to repeat: some staff for preparing to lessons, for future events, things that he like etc. To cope with this amount of learning material, user uses provided system. This system doesn't make choice for him, but it provides user with recommendations what to study in current period of time taking in mind his day planning and amount of time, that he could spend at system. After system approve with user amount of time that he plans to study it provide him with learning material.

Use Case 2: After that, in the evening, user walking in the park and open system. System gets information about his context and proposes him appropriate audio material. When he

comes to cafe and sit there, learning system provides him another recommendation (quizzes, text material or video material if user have his headphones plugged in).

Use Case 3: Also, as mentioned in (Siadaty, et al., 2008), learner can use such system for viewing and repeating all relevant material in preparing to some event like test, exam, etc. In ideal case, system will determine user's knowledge gaps in area specified by user and give him appropriate learning material. One of ways for determining user's gaps was presented in work (Bauman & Tuzhilin, 2014).

16.4 Conclusions

In this work, we design the architecture of context-aware e-learning system. To enrich user's model with user context that give opportunity to accurate recommendation. To demonstrate the performance of designed system we set three use-cases. Our next step will be to implement to whole system and to evaluate its' effectiveness in real environment. One of the ways for future work is to connect calendar events with learning objects provided in external e-learning resource system and then take them in to account when measure growing user's competence outside of provided system.

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