# Planning for Ubiquitous Learning in PLAN

Timothy Arndt
Department of Information Systems and Department of Electrical Engineering and Computer Science
Cleveland State University
Cleveland, OH, USA
t.arndt@csuohio.edu

***Abstract*— The rise of e-Learning as a primary platform for higher education promises to open up higher education to a wider range of learners than ever before. In order to best cater to this ever more diverse group of students, a personal learning system, which reflects the individual student's learning style and needs, would be valuable. Such a system would successfully integrate a user's learner profile, as well as his or her social networks, and big data sources, as well as time and location information in order to support ubiquitous learning. In this paper, we review PLAN (Personal Learning AssistaNt), our model for personal recommendation systems for students of higher learning and explore how ubiquitous learning fits in with our system.**

***Keywords-* *ubiquitous learning; e-learning; personalized learning; recommendation systems.***

## I. INTRODUCTION

In [1] we presented a formalism for our personal learning assistant called PLAN (Personal Learning AssitaNt). The formalism integrates Big Data (learning and social network) analytics, a finite state transducer which acts as a recommender system for the learner, the learner's calendars, location, a learner profile, etc. into a complete system for assisting the student to achieve his or her personalized goals. The aggressiveness of the recommendations can be controlled by the user. We laid out several scenarios of the system in action which help to explain how it will be used in practice. The cloud-based architecture of the system with a mobile app user interface was also described. The formalism is currently being implemented as a prototype system for experimentation purposes.

Previously, we reported the results of a survey of university students on their attitude towards ubiquitous e-learning [2]. The attitudes reported were quite positive. This confirms the impressions one has that today's generation of students is not only open to, but desirous of ubiquitous learning platforms to help them reach their learning goals.

Therefore, we have begun to consider adding support for ubiquitous learning to the prototype system currently being developed based on our PLAN formalism. This paper reports our initial reflections on this subject. The next section is a brief survey of some previous research in the area of ubiquitous learning. Section 3 gives our reflections on how ubiquitous learning can be integrated into the prototype learning recommendation system currently being developed based on our prototype. Section 4 gives some further discussion and sketches future research.

## II. RELATED RESEARCH

Much research has been done in recent years on ubiquitous learning. In this section, we will briefly review a small portion of that work.

A review of research trends in mobile and ubiquitous learning as reported in selected journals between 2001 and 2010 is given in [3]. The authors use the definition of ubiquitous learning as 'learning anywhere and at anytime'. Ubiquitous learning experiments have been carried out in classrooms, museums, labs, as well as outdoors, for example observing nature in a natural science class.

The authors chose six major technology-based learning journals and looked for studies in the given area published between 2001 and 2010. They found 154 total articles which met their criteria and noted that the number of publications increased greatly starting in 2008. One expects that this trend has continued. They also found that while the US authors contributed the most publications in the first four years of the study, Taiwanese authors had a very large number of contributions in the later years, and other countries were well represented as well.

A very influential system for ubiquitous language learning is reported in [4]. Two different systems are actually described. The first, JAPELAS (JApanese Polite languagE Learning Assisting System) is a context-aware language-learning support system for learning Japanese polite expressions. JAPELAS provides the learner with the correct polite Japanese language expressions based on the learner's situational context and personal information. This is especially appropriate, since Japanese polite expressions are very context-sensitive.

The second system, TANGO (Tag Added learNinG Objects), uses RFID (Radio-frequency identification) tags to detect objects near the learner and to provide him with educational information concerning those objects. This was an early example of the importance of RFID technology in ubiquitous learning.

The basic criteria, strategies, and research issues of context-aware ubiquitous learning are given in [5], which also identifies the check items for the development of such learning environments.

Technology which enables context-aware learning via ubiquitous computing includes sensors and actuators, RFID tags and cards, wireless communication, smartphones, PDAs (Personal Digital Assistants), and wearable computers. A ubiquitous system interoperates spontaneously with changing

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environments incorporating these and other technologies. A ubiquitous system must seek out new devices as they come into range, and interact with those devices. These devices form part of the user's context, and must be incorporated by a ubiquitous learning system in order to support a form of the pedagogical theory of constructivism.

The authors define their context-aware ubiquitous learning as learning with mobile devices, wireless communications and sensor technology. Such learning systems are more specialized than the broader mobile-learning systems since they focus much more closely on the users' contexts (e.g. location and body temperature). Contexts include: personal contexts sensed by the system; environmental contexts sensed by the system; feedback from learner via the mobile learning device; personal data retrieved from databases; environmental data retrieved from databases. These are called situation parameters by the authors, and based on them, twelve models for conducting context-aware ubiquitous-learning activities are defined.

The notion of context-aware ubiquitous learning environments for peer-to-peer collaborative learning is the topic of [6]. The author sees the ubiquitous learning environment as providing an interoperable, pervasive, and seamless learning architecture to integrate three major dimensions of learning resources – learning collaborators; learning contexts; and learning resources.

Ubiquitous learning must provide innovative and effective ways to identify and utilize learning collaborators, learning contexts and learning resources. In other words, the context of the learner is key to this type of learning. Virtual learning communities, which provide geographically dispersed users a means to collaboratively learn, have been described, without being precisely defined. It is recognized, though, that the collaboration is an important element of such communities.

Collaborative efforts of users to manage knowledge, enhance the reservoir of knowledge, and to help each other accumulate and build knowledge in a given domain is a key component of virtual learning communities. The author uses a peer-to-peer approach to building a system for ubiquitous learning environments for collaborative learning.

An ontology based context model is used to describe the context of learners and services. The Protégé system [8] is used to build the learner ontology and service ontology. Three context acquisition methods are then used: form filled, context detection and context extraction in order to obtain context information. In order to define the functionality of the peer-to-peer collaborative learning system, a study which identifies the most wanted learning services in such a system is used. The services are: who is currently online; instant message; learning content search; personal annotation; and recording of personal learning portfolio. The system developed supports these services, as well as multimedia real time group discussion. A scenario for the usage of the peer-to-peer system is given.

The question of how effective and meaningful learning is in a ubiquitous learning context is considered in [7]. While ubiquitous learning seems to be a great idea, and is certainly exciting for researchers and teachers, we need to be sure that the techniques that we are using are providing meaningful learning experiences to learners and are not inefficient or do not lead to reduced learning experiences, especially for low-achieving learners.

The authors investigate the impact of a meaningful learning-based evaluation on ubiquitous learning, in order to enhance the system being evaluated. A quasi-experiment is described in which both post-evaluation and refined ubiquitous learning activities are adopted for the experimental group, while a control group works without the proposed evaluation method. The results show that the evaluation technique can be used to greatly enhance the outcomes and learning effectiveness, especially in the case of low-achieving learners. High-achieving learners did not have such dramatic results. In sum, a meaningful learning-based evaluation method is an effective way to find out how the ubiquitous learning environment needs to be improved.

## III. PLAN

In this section we will describe our personal learning assistant PLAN (Personal Learning AssistaNt) [1].

A personal learning assistant supports a user in achieving desired learning goals. The formal definition of a personal learning assistant is described in this section.

A personal learning assistant uses multiple sources of information to provide appropriate recommendations and alerts when active. Some data are collected through the direct interaction with the user, while other data are mined by searching across available data sources. The first source of information used by the personal learning assistant comes from the user's learning profile. An additional source of information is provided by the user's social network from which desired data are extracted. Finally, additional data are mined from the multiple data sources available across the networks.

Mining significant data from data sources means to be able to identify data that can be of interest to the user. So, while an event can be considered interesting for achieving a learning goal, that event could be irrelevant if the user is unable to participate in it. This means that there are constraints that should be taken into account in order to select significant data and provide useful recommendations.

The two primary constraints come from the spatial and temporal information associated with the user. The temporal information is derived from a calendar. The spatial information is derived from the user's geolocation which, from the implementation point of view, is associated with the GPS (Global Positioning System) coordinates extracted from the sensor of the device where the personal assistant has been launched from. The amount of information produced by the personal learning assistant could be very large and overwhelm the user. A level of aggressiveness must be used to customize the personal learning assistant to a user-desired level. An aggressiveness level of 0.0 will result in no recommendations being generated by the personal learning assistant, while 1.0 will result in a maximum number of recommendations being generated.

The activity of the personal learning assistant PLAN is formally described by a learning finite state transducer

(LFST). The LFST moves from state to state in order to reach the desired learning goals and in each transition produces zero or more outputs.

When the system is initialized for a user, the PLAN generates the user's learner profile based on an interactive process with the user, as well as on the basis of a default profile. The learner profile may be refined as the learning process advances. The system also interrogates the user to determine the user's set of learning goals. The learner profile and learning goals are then used by the system to generate the LFST.

Data is mined from key-value data stores, as well as from the user's social networks, using traditional data mining processes. This results in knowledge items being discovered as data mining proceeds. Each time a knowledge item is discovered, the state transition function may result in a transition to a new state in the LFST. Calendar events from the user's calendar set may also be generated as time passes. These calendar events are treated as knowledge items by the LFST.

A state transition generally results in zero or more recommendations (i.e. the output function of the LFST) being made to the learner (e.g. to take a section of a particular source). On the other hand, some action of the learner may result in a state transition (e.g. the user successfully completing a course).

The architecture of the system is structured as a mobile app which communicates with a cloud service which performs the main share of the computation. The PLAN Cloud Service interacts with standard data mining processes which run in the cloud and which work on two categories of data: the key-value data stores and the user's social networks. The key-value data stores represent the raw matter used for learning analytics. Sources of the data which can be analyzed include institutional data about students, courses, applicants, as well as a particularly rich field to mine for data - that are associated with online courses and Course Management Systems (CMS) [9].

In addition, the data mining processes interact with the student's social networks – both online social networks such as Facebook and Twitter, as well as more informal social networks such as those identified by email and text message communication as well as those which are deduced by examining the course rosters of the courses the students are enrolled in. These social networks form another important asset in the student's learning process, being sources of expertise in course topics, various university processes, job markets and so on. The data mining processes can interact with online social networks through the APIs (Application Programming Interface) that they provide and through the more informal social networks through custom processes which may be developed.

## IV. DISCUSSION AND FUTURE RESEARCH

In this section, we discuss how ubiquitous learning can be added to the PLAN model discussed in section 3.

A number of issues related to ubiquitous learning can be identified from the related research as surveyed in section 2, including the following.

- Context-aware
- Sensor networks and RFID
- Peer-to-peer communication
- Resource discovery
- Learner discovery
- Collaborative learning
- Others

How are these issues handled in PLAN, and if they are not currently handled in PLAN, can the PLAN model be extended so that they are handled? We will look briefly at these issues in the following.

The current PLAN system model handles context-awareness in a limited way. The current location is one of the parameters of the model and can be used to generate a suggestion which the learner can choose to follow or not, as he should desire. The graph associated with LFST forms a type of context, but not, certainly, as specific as the ontology-based context of [6]. Further work on incorporating context-awareness into the system, possibly via system-driven user interrogation, would be useful.

Sensor networks (sensors and actuators) and RFID are not currently supported by the PLAN system. The PLAN system is oriented towards higher education learning, while most of the ubiquitous learning scenarios involving RFID, etc. are oriented towards primary and (somewhat) secondary schools, for instance learning in a museum. This is a bit of a different emphasis on ubiquitous learning from ours, where we are more concerned with enabling students to learn at anytime than interacting with (a limited set of) real-world objects. If desired, we could extend our model by incorporating sensor networks as a component, as we do social networks.

Peer-to-peer communication is enabled in our system through our incorporation of a learner's social networks. By accessing the location or other data of a learner, along with those of his friends/classmates in his social networks, PLAN can suggest collaboration with other learners. The actual communication is outside of the model, and how it is implemented will depend on the software/tools used in the implementation.

Resource discovery is not specifically foreseen in our model. It could be incorporated by reference to the data mining process which continuously discovers knowledge used to make suggestions. Resource discovery techniques can be modeled as one particular type of data mining process. It might also be useful to make resource discovery more apparent/specific in the PLAN model.

Learner discovery in the PLAN model is already foreseen and is accomplished through the use of social networking platforms and the geolocation information associated with users of those platforms. This could be extended to a more general learner location process if multiple learners are using the PLAN system, since the location information of users is one of the system parameters.

Collaborative learning is supported by inclusion of users social networks as in the above paragraphs on peer-to-peer communication and learner discovery. A more precise mechanism for knowledge sharing could be incorporated for multiple users of the PLAN system.

As the above considerations show, while PLAN has many aspects which support ubiquitous learning currently, there are many ways in which it could be enhanced to further support ubiquitous learning. We are currently implementing a prototype system, and will consider modifying and/or extending the system in such ways. These decisions and the prototype system itself will be reported in a future publication.

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