U-LEARNING SCENARIOS WITHIN CONTEXT AWARE UBIQUITOUS LEARNING ENVIRONMENTS

Monica Vlădoiu

The PG University of Ploiești, Bd. Bucuresti No. 39, 100680 Ploiești, Romania

ABSTRACT

The combination of context-aware, pervasive and ubiquitous computing provides for environments that are able to adapt to user's identity, preferences, location, time etc. Lifelong and life-wide learning supported by these technologies are highly personalized and adaptive, supplying the user with the suitable learning content, at an appropriate place, and at the right time. In this paper we approach the problem of defining viable learning scenarios within context-aware u-learning environments, with accent on the facilities that are offered by our particular context-aware system, which is provides for sharing public interest information and knowledge that is accessible through always-on, context-aware services. The system makes possible context-aware u-learning that is supported by mobile devices, wireless communications and sensor technologies.

Keywords: *U-learning scenario, Ubiquitous learning environment, Context modelling*

1. INTRODUCTION

The time of the traditional, formal, and structured learning that was taking place mainly in classrooms, lecture theatres, laboratories, libraries, learning organization facilities etc., as the most important form of learning has now dawned. Unfortunately, the current generations of learning solutions mediated by technology - especially simplistic e-learning solutions, which make possible in fact the old information transfer paradigm by taking particular pieces of information and making them available to the learners via the Internet – do not provide for effective human learning focused on *knowledge construction using experiential and collaborative learning approaches in a contextualised, personalised and ubiquitous way* [1]. Several inherent shortcomings have been identified: *de-contextualisation of learning activities, no support for distributed learning activities and distributed notifications, no integration of personalised and contextualised support for lifelong learning, no continuous support and integration of formal and informal learning* [2]. What is more, the technology-driven e-learning solutions have failed identifying and implementing successful pedagogical models, which are ought to be collaborative, personalized, learner-centred, context-aware, realistic, ubiquitous, and so on. Contextualization entails a paradigm shift from the traditional view of stable online learning environments to more dynamic ones, which may evolve and change much more frequently [1].

However, recent progress of technology, especially wireless and sensors has lead to new emergent context-aware ubiquitous learning environments that are able to sense the situation of learners, and to provide support adaptively [2-14]. They are developed under the umbrella of Ambient Intelligence, a vision about intelligent environments in which humans are surrounded by intelligent interfaces based on computing and networking technology that is embedded in everyday objects such as furniture, clothes, environment etc. [4]. The environment is expected to be aware of the presence of a person (the user) and to perceive the (learning) needs of that person, and subsequently respond intelligently to those needs, in a relaxed and unobtrusive manner. Support coming mainly from three paradigms is necessary: Ubiquitous Computing – for addressing the aspects of technology accessibility through everyday objects available in user's environment, Pervasive Computing – for supporting the architectural aspects that are needed to realize the situation, and Artificial Intelligence – for providing the context awareness that is required to establish the user's needs and the appropriate response to them [4]. Ubiquitous computing appropriately supports these needs, by seamlessly integrating computers into almost every aspect of the real world, making this way possible ubiquitous learning (u-learning) within Ubiquitous Learning Environments (ULEs) that support diverse pedagogical models and multiple learning contexts, and that automatically adapt to them [1].

Moreover, nowadays learning is more than ever before a social process that relies heavily on collaboration and communities, and that takes place within dynamic contexts, in which learners acquire knowledge and skills during a reflective learning process that involves mutual trust, shared interests, goals, commitments, and obligations, exchanging of services, and, furthermore, a authentic, proactive, motivated attitude towards learning. Hence, learners are expected to be learning together, providing added value, sharing and executing tasks in order to reach a common aspiration, while communities will be establishing their own targets with respect to the knowledge and skills to be acquired, instead of using a predefined curriculum. These targets are expected to fully match the learners' needs, and to be highly dependent on the local culture and its priorities [1, 15]. There is more and more obvious that there is a major need to rethink education, training and learning within this new learning paradigm, which provides for lifelong and life-wide learning. Within these new learning environments, learners shift from consuming knowledge to socially constructing it for themselves, and also for their communities and organizations, being able to extract it from everyday life and to share it, along with their learning, with peers belonging to communities they share interests with, within learner-centred multi-dimensional learning spaces [15].

In this paper we approach the problem of defining viable learning scenarios within context-aware u-learning environments, with emphasis on the facilities offered by a particular context-aware system that we have developed, called ePH, which is a system for sharing public interest information and knowledge that is accessible through always-on, context-aware services [5, 16, 17, 18]. The system provides for *context-aware u-learning*, i. e. *learning with mobile devices, wireless communications and sensor technologies* [3], which is u-learning in the sense that it may happen anywhere and anytime, and it involves sensors, mobile and wireless technology. We take this first step towards our higher goal of defining a generic u-learning scenario with all its relevant facets.

Context awareness is basically the ability of a class of systems to use contextual information to supply better services to the user, in a flexible and manageable way. Since Schilit et al. introduced in 1994 the term *context-aware computing* [19, 20], various definitions of the term context have been proposed, Dey's being the most well-known and quoted: *context is any information that can be used to characterise the situation of an entity. An entity is a person, place, or object that is considered relevant to the interaction between the user and the application, including the user and the applications themselves*" [21]. Later this definition has been extended to include computational objects as well: *Context is typically the location, identity and state of people, groups, and computational and physical objects* [22]. A very powerful *operational* definition that allows a natural understanding of this concept to users and developers of context-aware applications is provided by Zimmerman *et al.* [20] who have build on top of the above general definition and added both a formal definition to describe the appearance of context and an operational definition that characterize the use of context and its dynamic behaviour. These authors consider that any information used to describe the context of an entity is part of the following categories: individuality, activity, location, time, and relations. The entity itself is described by properties and attributes (individuality) and has particular spatio-temporal coordinates (location, time), and it may be involved in various activities (activity) with several other entities (relations). What is more, they take into account the dynamic properties of context with respect to the transitions between the contexts of one entity and to the sharing of contexts between several entities. Our work subscribe to this definition.

For context-aware u-learning solutions context is essential as *the best instruction is highly contextualized* [23] and it may include learner's personal profile (identity, special needs, her current position(s) on learning topic trajectories, learning style preferences, record of previous achievements, and so on), his current location, her current interface options, audio, video or VR capabilities, available network QoS, existing computational capabilities etc. The contextual information is essential for selecting and generating of the appropriate learning services for a particular learner, at a given point in time (e.g. a low bandwidth connection would make possible different types of graphical output than a high-bandwidth one) [1]. A major advantage of the mobile services provided today, besides bringing together people that are geographically separated, is enabling them to take advantage of what and who is reachable locally, making possible this way that learners pursue their learning process socially interacting and collaborating with peers and not as isolated learners. Some challenges of context modelling when considering learning within a social context regard what could somebody learn from someone else, what other people are talking about, how they're reacting to what is being said, what they have access to etc. The social context of a mobile learner with a u-learning environment is important for maintaining the context of community, and for supporting the setting up of new communities.

Ubiquitous learning is expected to provide for: *permanency* (the learners will under no circumstances lose their work unless it is voluntarily deleted, and what is more important, all the learning processes are recorded each and every day, which allows for learning that is reflective), *accessibility* of the learning content from anywhere via active personalized services, *immediacy* (the content may be accessed instantaneously, and the learners may store it and retrieve it at anytime), *interactivity* between learners and facilitators or peers, which takes place both synchronously or asynchronously, *situated-ness* of the instructional activities (learning occurs naturally in everyday life in a context-aware manner), *adaptability* to learners' current situation, both in the virtual world and in the real world, which makes possible personalized active learning experiences), and, of course, *non-intrusiveness* (the ubiquitous technology should be as invisible as possible, resulting in natural interactions with users and, consequently, in seamless learning; moreover, the learning scenarios must not be interrupted by this technology or by her movement within the environment) [2, 3, 5, 24, 25, 27, 28].

However, despite existing numerous u-learning environments and experiences [2-14], u-learning is still to be defined and researched, especially with regard to the strategies for facilitating effective learning activities within such environments. Furthermore, curent solutions mostly focus on one specific learning scenario and often do not provide or envisage flexible integrated solutions for lifelong and life-wide learning [2, 3]. These solutions need to incorporate both those characteristics and features that are known to be effective in traditional and structured educational programmes and the new key elements, arisen within the crucible of the emerging *learning society and a knowledge economy*. They have to consider that today learning is an active learner-centered process that is blended into our day to day life, which requires the revision of the old educational frameworks (moving from *contents* to *context*) to provide for u-learning that takes place anywhere and anytime and across multiple learning contexts [2]. Having the learner at the centre of the learning process does not mean that s/he is the center of attention of well-meaning teachers and instructors, but the driving force of production of knowledge that may occur in a variety of contexts within multi-dimensional u-learning spaces. Thus, learners are ought to actively participate in learning communities (personal and professional), learning organizations, learning territories (municipalities, regions) and society, at large [15].

Within u-learning spaces, knowledge construction occurs dually by (1) *understanding of concepts through direct experience of their manifestation in realistic contexts (i.e. providing access to real world data and scenarios), which are constructed from sophisticated software interfaces and devices, and represented as services*, and (2) by social learning, mediated by technology, seen as *an active collaboration with other students, teachers, tutors, experts or, in general, available human peers, by using different kinds of collaboration technologies, especially enhanced presence* [1]. Of course, social learning is not a new phenomenon as even in classical learning frameworks and organizations learners used to help and collaborate with each other, to ask teachers or experts for help etc. What is new now consist of the never-ending appearance of possibilities to interact and collaborate with others, and to be involved in powerful and dynamic "real time communities". In this context, collaboration is seen as a complex ubiquitous conversational process that supports learning as a social process.

When looking at knowledge construction from a pedagogical point of view, we see that since the '80s the researchers of educational technology have been experiencing a paradigm shift from cognitivism to constructivism, which brought forward learning as an active process, based on the interaction between learners and their environments, in which the experiences and contexts that made the learners willing and engaged to learning had to be considered, along with social and cultural aspects. Learner had to be involved, challenged, immersed, emotionally aware, as *the understanding is not a vessel which must be filled, but firewood, which needs to be kindled; and love of learning and love of truth are what should kindle it* [2, 29, 30, 31, 32, 33].

Therefore, *since knowledge cannot be transmitted, instruction should consist of experiences that facilitate knowledge construction* [29, 34], where this process is seen as *an interaction, a communication, or interplay between the environments, the individuals and the behavioral patterns corresponding to given situations* [29]. Hence, ubiquitous learning should be first approached from the point of view of learning theories, by considering the facilities expected from u-learning environments: enabling experiential active learning (based on interactive, engaging and responsive learning resources), facilitating active socio-constructivism with respect to knowledge and providing for collaboration and social interaction within communities, allowing for multiple perspectives on learning, realism (using of authentic problems, incorporated real world input and simulations, ranging from simple interactive animations to immersive virtual reality), personalization (learner-centered learning experiences, which quality needs to be continually validated and evaluated; automatic real time translation), contextualization and adaptation, accessibility for persons with special needs, and, very important, endowing reflection about achieved knowledge [1, 2]. Ubiquitous technology provides for all these facilities and it is expected to fulfill entirely the requirements of the emerging models of instruction and education.

The rest of the paper is laid out as follows: in section two we will present some relevant related works, while section three will show the extended architecture of our context-aware system that provides for defining of u-learning scenarios, and for management of various communities of learners, along with our enriched u-learning contextual model. After that, section four will describe the significant user scenarios facilitated by ePH, each of them involving the opportunity to access whatever is relevant to one person's learning interest within a given (real or virtual) area. The last section gives some conclusions of the paper and provides an outlook to further research.

2. RELATED WORK

Context-awareness refers to the ability of a category of systems to use contextual information to supply superior services to users, in a flexible and manageable way. A context-aware system is able to extract, interpret and use contextual information, and, moreover, to adapt its functionality to the current context of use in order to make available the right services to particular people, place, time, event, etc. When considering learning from this perspective, we see that it is no longer an isolated endeavour, and it becomes a social process that relies on collaboration and communities. Context-aware u-learning is a promising paradigm, and during the last decade, there has been a real boom of ubiquitous learning projects around the world. Recently, several works have approached, besides the issues related to the ubiquitous technologies, the pedagogical aspects of context-aware u-learning. We shall present here the works that are most similar to ours with regard to both the learning approach and the pedagogical research.

In [23], the authors focus on the development of a conceptual model for the learning context within e-learning environments, which captures various aspects of learning situations: subject domain (structuredness, didactics), technological (hardware, software, networking), pedagogical (learning theory, instructional strategy), psychological (motivation, preferred senses, Kolb's learning style, Myers-Brigg type), organizational (formal, informal), and learning methodology (delivery models with respect to time, main figure, dependence on content, and virtuality).

The support that contextualized media offers to learning is approached in [2], along with a reference model for mobile social software that has five dimensions as follows: content, context, information flow, pedagogical model, and purpose. The content dimension describes the artefacts that are exchanged and shared by users: annotations, documents, messages, and notifications. The context parameters taken into account for learning support correspond to the operational definition of context from [20]: individuality, time, locations, environment, and relations. The information flow categorizes applications according to the number of entities that are involved in information flows and information distribution: one-to-one, one-to-many, many-to-one, and many-to-many. The pedagogical model that are taken into account are: behaviourist, cognitive, constructivist, and social constructivist. The purpose describes applications with respect to their goals and methods directed for enabling learning: sharing content and knowledge, facilitate discussion and brainstorming, guide communication, social awareness, and engagement and immersion. The context for communities and collaborative learning is approached in [4], where authors review the challenges that context modelling has to face in order to provide for mobile learning scenarios, and exemplify those issues in the case of a mobile collaborative language learner in the city.

The methodology of designing ubiquitous learning environments receives attention in [29], with accent on the most appropriate educational technology to be used. The socio-constructivism is correlated with the knowledge spiral theory, due to the authors believing that practical ULEs should be seen as complex, dynamic ecosystems within which a learner's knowledge develops continuously in the form of a spiral that includes both personal and social knowledge. They also consider the issues related to well-structured and ill-structured knowledge, as well as of tacit and explicit knowledge. Finally, the authors propose a framework of a learner development ecosystem purposed at designing a ubiquitous education infrastructure.

An interesting work that outlooks at the criteria, the strategies and the research issues of context-aware ubiquitous learning may be found in [3]. First, the authors establish the boundaries between ubiquitous learning, mobile learning, u-computing in learning and context-aware u-learning. The main criteria to define a context-aware u-learning environment are summarized as follows: context-awareness, adaptiveness, personalization, seamless learning and ubiquity with respect to the used mobile devices. Such environments include mainly a server for providing active and passive support to learners, mobile devices, sensors and wireless networks. For learning activities in the real-world five sorts of situation parameters have been identified by the authors: personal context (location, time, temperature etc.), environmental sensed context and environmental data retrieved from databases, feedback from learners, and personal data (learner's profile and portfolio, predefined schedule, learning place etc.). Twelve models of u-learning strategies are also synthesized: learning in the real world with online guidance or with online support, online test-based on observations of real world objects, real object observations, collecting data in the real world via observations or via sensors, identification of a real world object, observations of the learning environment, problem-solving via experiments, real world observations with online data searching, cooperative data collecting, and cooperative problem solving. Examples of putting in practice these strategies are also provided. The authors are also preoccupied with future research issues with respect to new pedagogical theories, tutoring and assessment strategies for context-aware u-learning environments, innovative and practical use of ubiquitous technologies for education, learning, and training, and psychological analysis for context aware u-learning and training.

The key roles of services, semantics and standards in meeting the pedagogical goals of novel learning situations are illustrated in [1]. The authors have been motivated by the failure of the technology-driven e-learning solutions, and their work resulted in the main pedagogical features that are necessary for construction of an infrastructure called *Semantic Grid for Human Learning*: collaboration, socio-constructivism, personalization, learner-centricity, context-awareness, realism, experiential and active learning, personal learning profiles, personal special needs, ubiquity, accessibility and availability. Their vision is that of the semantic grid for human learning making available a learning scenario with all its inherent knowledge: pedagogical model, learning goals, resources and activities, and so on, as a building block for developing more complex and interactive learning experiences. Moreover, once produced and virtualized as a *human learning service*, a learning scenario can be indexed and stored in a knowledge base, becoming this way a shared unit of knowledge that may be reused in other contexts. They demonstrate their ideas by articulating some scenarios that combine traditional learning contexts and novel ubiquitous opportunities.

3. THE ePH-BASED CONTEXT-AWARE U-LEARNING ENVIRONMENT

Before exploring the possible u-learning scenarios within the framework supported by ePH, some words about this system are necessary. ePH is a system that provides for building dynamic user communities that share public interest information and knowledge, which is accessible through always-on, context-aware services [15-18]. ePH has been built around a user-centered digital library that stores regional information and knowledge, which content is accessible via always-on context-aware services. Users can obtain it or contribute to it, according to their location: at home or office by using a computer, on road with a specific GPS-based device in the car (called gipix, developed in-house), or off-line/off-road via mobile phone. The digital library stores public interest information (drugstores, hospitals, general stores, gas stations, entertainment, restaurants, travel and accommodation, weather, routes etc.), historical, touristic, and cultural information and knowledge, users' personal "war stories" (tracks, touristic tours, impressions, photos, short videos and so on), and, in addition, their additions, comments or updates to the content. The content of the digital library becomes available to the ePH's users contextually. For example, for a traveler being in a given area, the system may suggest several locations to go to (and actions to execute to reach them): a restaurant to dine at, a museum or memorial house to visit etc. Moreover, if a learner is interested in something in particular, like learning about the specificity of the Byzantine architecture of the monasteries in our county, and s/he is located near such places reachable within a reasonable time frame, the system is able to show the tasks to be executed to guide her to reach those places [5, 18]. Hence ePH has a significant potential to support users in various ways: enhancing tourist experiences [18], enabling learning in multi-dimensional learning spaces [18, 35], increasing traffic safety [36] etc.

For the time being, the ePH architecture (shown in figure 1) includes the Communications Server, the Location Server, the CBR Engine, the Knowledge Base, the Context Middleware, and the multi-agent action subsystems [17, 18]. The Communications Server (CS) provides for the always-on kind of service, regardless of the location where the user is when s/he needs that service. The Location Server (LS) makes available the correct service according to the location. The CBR engine identifies the current problem situation, retrieves the past case that is the most similar with the one in progress, suggests a solution that uses that similar case, evaluates this solution, updates the system and learns from the current experience. If the new situation cannot be classified above a certain similarity threshold, then a new case is created and stored. Case-based reasoning has been used extensively in Ambient Intelligence for perceiving context, identifying situations, and selecting a suitable set of actions to be executed in order to intelligently support the user [4, 18].

The Knowledge Base includes both general domain-dependent knowledge and specific knowledge embodied in cases, which are used together to find the appropriate solution for a specific user's problem (for that reason the ePH architecture is considered knowledge-intensive and it has been called FACE and made look likeswise). The Context Middleware allows context management by gathering and maintaining contextual information, along with freeing the agents and the applications of this chore. A change in the context triggers a multi-agent sub-system, which contains various agents that deal with: the context itself, the CBR process, the task facilitation and decomposition, and the application-specific activities [35]. As the core digital library may be used both on- and off-line with ePH, it is not seen as strongly connected within this architecture. More details about this architecture may be found in earlier works [5, 17, 18, 35].

The current stage of the project is as follows: the geospatial engine unde.ro provides the basic ePH functionality [19], the GPS car device, gipix, is in current use, and the critical cores of both the CS and the LS are functional as well. Some experimental results are also available [18, 35, 36]. Currently we are working on the development of the following modules: the CBR engine, the knowledge base and the context middleware, while improving some modeling issues we have discovered along the way.

The ePH architecture had to be extended in order to make possible the construction of feasible learning scenarios within context-aware u-learning environments as follows: first, a *U-LEARNING SCENARIO BUILDER* has been included, which is necessary for the construction of viable learning scenarios. A simple learning scenario has the starting point in the main goal of the learning activity, along with the objectives of learning. Its desired results regard both the acquired knowledge and the reached objectives. The general purpose of a u-learning scenario is, of course, ... *learning*, in particular getting to know more on a particular subject or topic, acquiring specific skills, facilitating discussion and brainstorming, guiding communication, sharing content and knowledge, change attitudes, viewpoints, or feelings, social awareness, engagement and immersion etc. The learning purpose is pursued in various ways as follows: case studies (virtual field trips, observe-and-comment, prompted examples, mini-case studies), action learning, simulations, virtual worlds, learning games, activities webcasts (demonstrations, debates, interviews, Q&A, panel discussions etc.), scavenger hunts, guided analysis, guided research, problem solving, project-based learning, discovery learning, and so on. The basic problem to be solved is to retrieve information and knowledge, by finding the right learning objects, artefacts, cases etc. and by adapting their internal structure to learners, along with a set of tasks to be executed in order to reach them.

Learners interact often with various communities, at different times, for miscellaneous reasons and that interaction is very important, for example because it may affect or influence the context of the learner. The overlapping communities within the ePH-based u-learning environment may be communities of learners, communities of interest, local people in a particular cultural setting, contributors to the content etc. What is worth to mention are the persistent communities [4] that may be formed from people who contribute to the content, or from those who access it that grow and continue to exist over long period of time, and which are most likely to exist in an intelligent u-learning environments where collaborative design, work, learning etc. take place.

The ePH's context model has been enriched as well to encompass the specificity of learning experiences and education within u-learning environments. Thus, we use a multidimensional context model that subscribes to a meronomy that articulates various works from the literature [3, 5, 37-44]. Thus, the context has the following facets within the ubiquitous learning environment:

- *personal context*: *user's interests and intentions* (both general and current), *state of mind, feeling and emotions* - e.g focused or distracted, bored, tired, etc.), *knowledgeability* (education, profession, expertise etc.), *limitations* (health issues, disabilities etc., preferences - e. g. the preferred stimuli: visual, auditory, kinaestethic), *social customs and cultural habits* (being punctual, openess, friendliness, getting up late in the morning etc.), *motivation* (high, medium or low), *social abilities* (leadership, teamwork, communication, empathy etc.), *cognitive abilities* (alternating, divided, focused, or selective attention, conceptual reasoning, visual tracking etc), *learning style* (activist, reflective, theorist, pragmatic), *objectives and goals* (acquiring new knowledge, practical or transferrable skills, or change attitudes, viewpoints, feelings etc.), *learning portfolio* and *learning profile* (predefined schedule, constraints of a learning activity - expected starting time, acceptable duration, learning place, learning paths etc.), *feedback* (observed or sensed data of the target items – temperature, air pollution, shape, colour, machine status etc., acquired photos, and interactions with the learning system, if any) and so on;
- *task context:* operations, goals, operating mode – static or dynamic, etc;
- *device context:* mobile phone, gipix, PDA, laptop, desktop etc.;
- *social context:* friends, family, colleagues, acquaintances etc.;
- *spatio-temporal context:* date, time, user's location, orientation and movement, space – e.g. public, private, limitations – e. g. time interval, location area, etc;
- *environmental context* (things, persons, services, weather, indoor/outdoor, illumination, temperature, humidity, noise, crowded etc. from user's surroundings; data about the learning site: schedule of learning activities if any, management constraints, notes for using the site, available equipments, persons in charge etc.);
- *user interface*: textual, graphical, 3D, web-based, resolution, dimensions, versatility, etc.;
- *infrastructure*: network related (availability, bandwidth, stability, price, and so on), or other resources related (coverage, battery, charger etc.);
- *strategic context:* something important for a planned effect;
- *historical context:* for keeping trace of the past experience.

These all relate to *who* the learner is, *where* s/he is located, *when* s/he is using the service, *what* s/he is using the service for, who s/he is with, what s/he likes etc. However, considerations such as how young the user is, or whether the environment is noisy can be equally important.

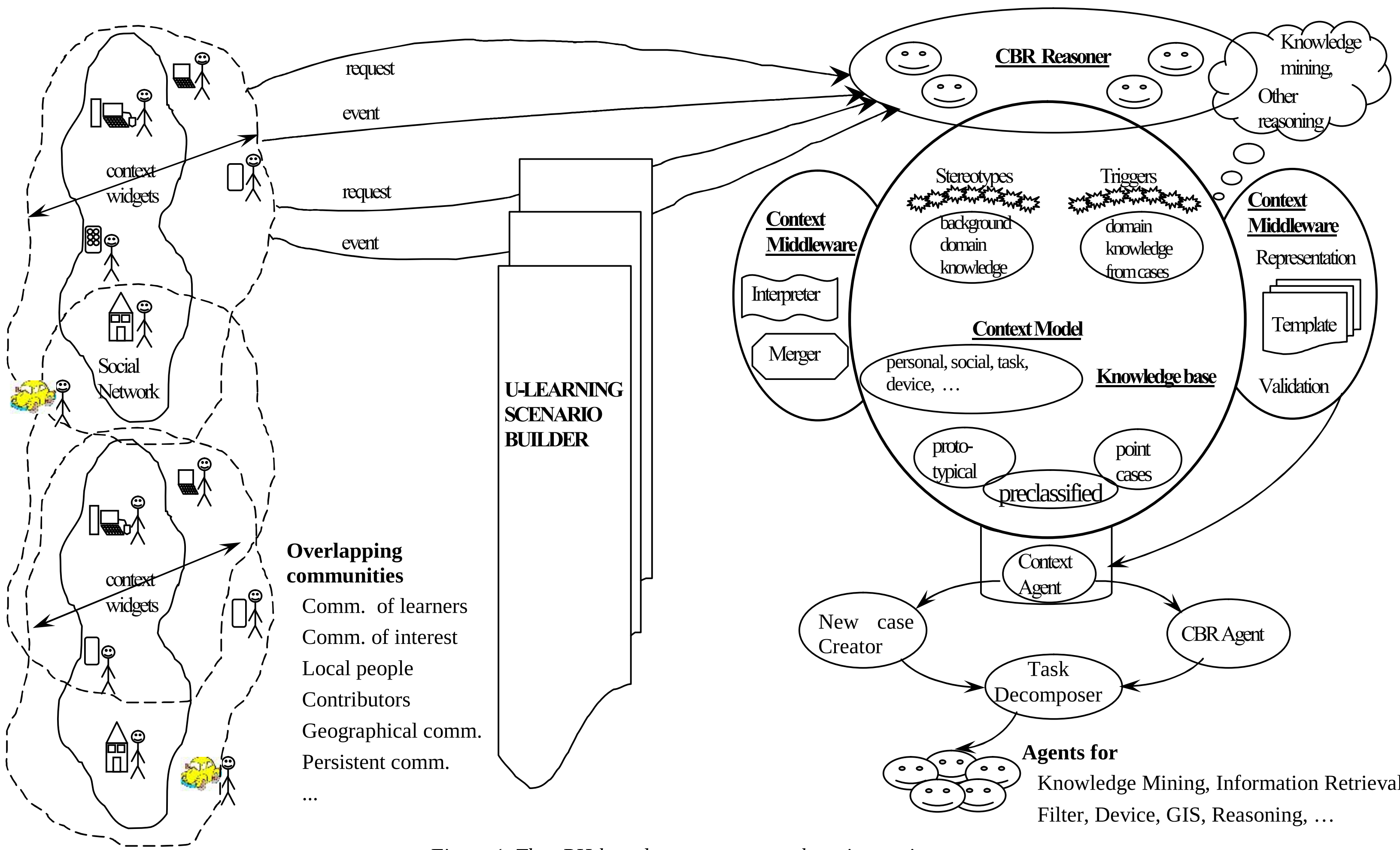

Figure 1. The ePH-based context-aware u-learning environment

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4. U-LEARNING SCENARIOS WITH EPH

There are two significant user scenarios when using ePH, each of them involving the opportunity to access whatever is relevant to one person's current interest within a given (real or virtual) area. First one is confined inside almost circular area (with a given radius), while the second one takes place along a particular segment of a track (with a given length). The system enables users to fulfil their specific (learning) goals in a context-aware fashion, by making recommendations on what is worth to be seen within the specified area, from a specific point of view, and by showing the tasks to be executed to guide the user to reach those places. Let us consider the opportunities that ePH provides for a user who is interested in learning experiences. The idea behind this kind of support has been to help a person who is at a given time in a certain location to experience as most as possible as a learner, in a personalized and effective way, both in the real and virtual world. Let us consider a scenario, in which Kim, a Vietnamese student at the local university, who is also an ePH user, is interested in getting to know more on Romanian culture, either locally originated or locally available (traditions, music, artefacts, theatre, literature, architecture etc), and also in interacting with local people, and becoming familiar with the city and its surroundings. Kim may be planning her learning trip prior to the journey itself or he might adjust her excursion dynamically, as she gets close to some Points Of Interest (POIs) that are relevant to her.

Kim will be provided with the main Points Of Interest (POI) within the town area, along with their specific constraints (appropriate time to visit, ticket availability, special offers, and so on). These points may be grouped together in several one-day scenarios, from which Kim may choose the most appropriate one according to her current option. For example, she can visit The Clock Museum, which is unique in Romania, The Art Museum, The History Museum, and the traditional products' market in the city centre (Figure 2, tour 1). While moving from the History Museum to the market, Sofia will be passing by the Toma Caragiu Theatre and she can get notification that there are still tickets for the evening representation. She can be pointed out that other online ePH friends are in the area and she can ask them if they want to join her for one or more of the undertaken activities. When she arrives in the market she can have a traditional snack, with sheep cheese and smoked mutton (the glossary service helps her find more about these meals). More, each POI's specific restrictions are both displayed on her device and considered when ePH builds the one-day scenario. Another possible scenario includes The Memorial House of Nichita Stanescu (the second major Romanian poet) and the one of Ion Luca Caragiale (the best Romanian playwright), The Central Market Hall (where she can also eat), and the Saint John Cathedral (Figure 2, tour 2). If she has interest in classical music, she can choose to close her day with a concert at The Paul Constantinescu Philharmonic Orchestra.

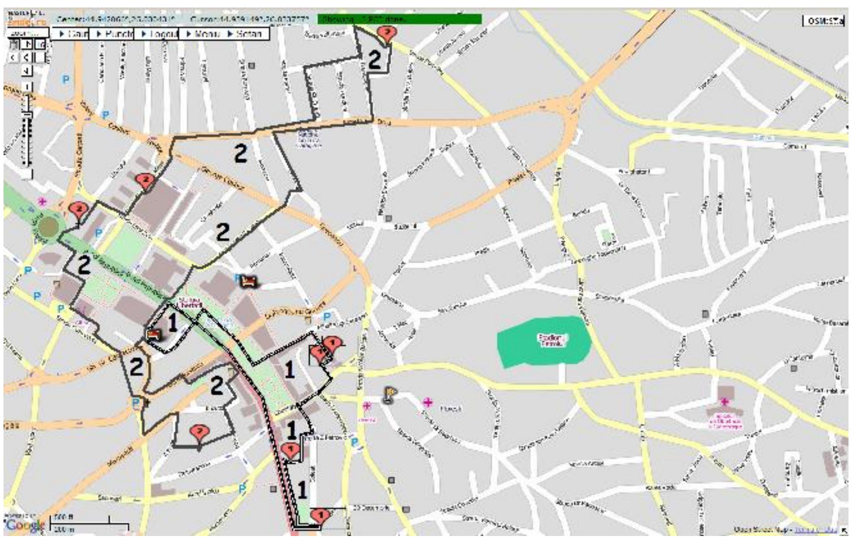

Figure 2. Two possible one-day u-learning scenarios

During her learning experiences, Kim may interact with her colleagues, either from her undergraduate class or from the language learning class. They may share their experiences and discuss common issues, learning from each other. She may also become friend with local people whom she has met while walking around. She may also interact with Vietnamese living in our town, to have the opportunity to speak her language or to share Vietnamese cultural activities (geographical community). This collaboration within various communities of learning is beneficial for Kim's continuous learning process, as a mobile collaborative learner.

5. CONCLUSIONS AND FUTURE WORK

The combination of context-aware, pervasive and ubiquitous computing provides for environments that are able to adapt to user's identity, preferences, location, time etc. Lifelong and life-wide learning supported by these technologies may benefit from a high level of personalization and adaptiveness, supplying the user with the suitable learning content, at an appropriate place, and at the right time [2]. Within the emerging u-learning environments, computing, communication, and sensor-based devices are ought to be embedded and seamlessly integrated into learners' everyday life resulting in immersive learning experiences [3, 45]. U-learning has obvious advantages, besides the general anywhere, anytime, anyhow paradigm, such as quick notifications, reminders and alerts, personal knowledge management, P2P communication, boosting of facilitator-learner interactions and in-class participation, increasing engagement and promoting active learning etc. [29], and it provides for a major paradigm shift from the traditional information transfer (being it in a classical setting or in poor e-learning) towards a user centred, collaborative and knowledge-based approach that is unfolding within the social context in which the learning process takes place [1].

This paper aimed at approaching the problem of constructing workable learning scenarios within context-aware u-learning environments, and we have rooted our endeavour in the opportunities provided by our context-aware multiagent system, which allows free sharing of information and knowledge. We consider this the first step towards the greater goal of defining both generic u-learning scenarios and of some support tools. Another future work direction is concerned with the integration of the informal learning scenarios presented here in a combined approach with more formal ones. By using u-learning becomes possible to set up ubiquitous communication channels between different contexts of our lives, which facilitate the creation of a ubiquitous dialogue framework within which teachers, learners, digital technologies and resources etc. can guide, support, and collaborate with individual learners, keeping them on the right learning route and preventing them from getting lost on their way.

We need to research further the most appropriate, new or adapted, pedagogical theories that match the context-aware u-learning environments, of the best practices, along with means of measuring the effectiveness of the learning processes. New ways of assessment may be necessary within ULEs. Psychological aspects of training and learning within such environments have to be explored as well, because better understanding of psychological factors, of each individual learner's electronic information and portfolio, and of learners' motivation may help educators and designers to develop suitable ULEs for improved learning experiences. Of course, there are also many technical limitations of mobile devices and ubiquitous services to be tackled. Collecting data about the usage of the ULE by learners is also important, no matter if it is some sort of log that documents all learners' activities (frequency of login sessions, learning time, frequency and quantity of notes and comments etc.) or some comments, feedback or assessment from teachers, facilitators or peers. Furthermore, the integration of existing and upcoming ULEs within a worldwide flexible infrastructure, maybe the semantic grid for human learning [1], has to be approached as well.

6. REFERENCES

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