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Contextual Mobile Learning for professionals working in the "Smart City"

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Abstract. In this study, we propose an innovative approach using the "Contextual Mobile Learning System" based on the "Electronic Performance Support System" (EPSS) to support efficient just-in-time learning for professionals working in the "Smart city". In this paper, we present the principle and the structure of our contextual mobile learning system, which uses a search engine to find appropriate learning units in relation with working activities and conditions and the user's / worker's profile. We further discuss the proposed system structure, supportive process and context-driven engine. Finally, we describe a scenario using our contextual mobile learning system.

Keywords: smart city, contextual learning, EPSS, collaboration community, learning engine

1 Introduction

Cities throughout the world face the challenge of combining competitiveness and sustainable urban development simultaneously [1]. This challenge has an evident impact on issues of urban quality, such as economy, culture, industry and social aspects. The term "Smart city" focuses on a city's forward-looking development approach, which includes issues such as awareness, flexibility, transformability, synergy, individuality and self-decisive and strategic behavior [1]. For professionals working in the "Smart city", their work efficiency is crucial for maintaining availability of proposed services.

The study of working – learning conditions of professionals in the "smart city" seeks out solutions for the problem: how to create or to maintain professionals' working environment and professionals' working conditions, in order to improve working efficiency and enhance their companies' performance. In our study, we focus on providing professionals with efficient learning methods in the "smart city". We propose inspiring professional learning methods to contribute to "smart city" equipment mastery and maintenance by providing professionals with the right approach to acquire knowledge and skills wherever and whenever they so require.

To provide a valid solution, it is important to analyze what kind of learning contents, including knowledge and skills, are needed to learn and understand in each professional field. The learning process for acquiring professional skills can be summarized in three categories [2]:

1. Before work studies: this category provides learning contents before starting professional work, mainly during school studies. It offers theories and generic methodological approaches. However, due to time limitations and lack of a precise technical environment, learning contents in this phase are still generic and mainly theoretical.
2. Professional training: this category provides more practical learning contents at the beginning of and during professional work at a fixed period of time and in a precise environment, during training periods. It offers more specific and precise information about the company and products, and explains the solutions to typical problems which emerge frequently during work. However, professional training cannot involve all tricky problems, and cannot offer the learning contents appropriate for all professionals according to their various profiles.
3. Workplace Learning: this category provides learning contents during professional work wherever and whenever the problems occur. In this phase, learners can acquire appropriate professional knowledge and skills for specific issues according to the context and learners' profiles. Learners could master specific equipment and appliances as well as special tasks, methods, tools and gestures in relation with and by practicing in the real environment.

We focus our research on workplace learning, which is a practical approach to solve specific problems. We tackle the process of problem-solving in relation with a task. Three learning periods in relation with a precise task can be identified, namely [3]:

1. Before the task: to learn about future actions.
2. During the task: to master the problem just-in-time by "learning by doing".
3. After the task: to learn about past actions to improve understanding of what happened and accumulate experience.

Contextual Mobile Learning is an appropriate method used in workplace learning [4]. Based on its conception, a system could provide "just-in-time" learning contents, and implement a "learning by doing" process. In order to provide learning contents in response to context change, a workplace learning system should be aware of learning contexts. Learning contexts include any information which can be used to characterize the learning entities' situation and which are considered relevant to interactions between a learner and an application [5]. Mobile devices, which are equipped with many sensors and are characterized by mobility, can seek contexts more freely from both physical and virtual domains, and allow the mobile learning system to construct learning contents based on contexts [6]. Application of contextual mobile learning in the professional field has major advantages: increase learning flexibility, promote problems solving efficiency, shorten learning time, and enhance company performance.

In this paper, we describe the principle and the structure of our contextual mobile learning system, and its context-driven engine. We then present a scenario ALF (French abbreviation for “in city goods delivery system”) using this learning system. ALF could use the contextual mobile learning system to increase the use of delivery areas by prior reservation and dynamic adjustment if necessary.

2 Related work

A number of contextual mobile learning systems have been identified or created. Bristow [7] has demonstrated an approach which shows that simple sensor input indicating user status could provide effective context-dependent content provision. The result of this research indicates that context awareness can improve user performance on information retrieval tasks, and leads to considerable improvements in user tasks.

The MOBIlearn project explored the ways in which the mobile environment could be used to meet learners’ needs. It provided an m-learning architecture to support learning contents’ creation, storage and delivery. Peter Lonsdale presents an object-oriented, feature-based architecture for a context-awareness subsystem to be implemented within the MOBIlearn project, and considers the implications involved in the use of such a system for mobile learning [4].

While all the works mentioned above focus on how to classify and collect contexts, they ignore the approach used to provide abundant and appropriate learning contents according to those contexts.

3 SAMCCO system characteristics

Through comparison with other contextual mobile learning systems for providing comprehensive professional learning contents in the PhD thesis carried out in our laboratory and defended in 2010, Chuantao YIN proposed the design for a contextual mobile learning system known as SAMCCO (French abbreviation for “contextual and collaborative mobile learning system for professional fields”) [8]. This system is based on EPSS (Electronic Performance Support System), the goal of which is to group storage of technical, working and learning data in order to provide just-in-time, just enough training, information, tools and help for mastering or repairing equipment, appliances or products disseminated in the smart city environment. This system is able to provide appropriate information designed to maintain or ensure appropriate performance of smart city users when and where needed, thereby also enhancing the performance of the company as a whole and industry [9]. EPSS is used to store and deliver plant reference materials including: training documents, operating procedures and historical maintenance information. SAMCCO edits and organizes learning contents stored in the EPSS information database, which is an essential professional learning resource offering abundant and well-structured learning contents.

SAMCCO is based on AM-LOM metadata, an ontology, which are used in the learning unit model to describe and identify contextual mobile learning contents in a particular professional field. The goal of this model is to characterize learning units which will be explored by the search engine in order to provide appropriate "just-in-time" learning contents. SAMCCO's main component is the search context-based engine.

3.1 Metadata

Proposed learning units are expressed complying with a learning unit context model, which can be searched by a context-driven engine. SAMCCO defines a learning unit model, AM-LOM (Appliance Mastering Learning Object Metadata) to describe learning contents. AM-LOM is an extension of LOM (Learning Object Metadata), a standard metadata to describe a learning resource with 9 categories. AM-LOM inherits, redefines and adds elements to LOM for describing contextual mobile learning contents in a professional field. AM-LOM is expressed and can be edited as XML (eXtensible Markup Language), which provides the opportunity to exchange information between different databases and platforms, and reorganizes the learning contents into learning units. The structure of SAMCCO's learning unit is shown in Fig. 1.

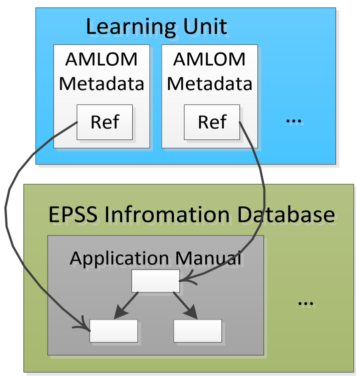

Fig. 1. Learning contents stored in EPSS identified by AM-LOM metadata

3.2 Context model

SAMCCO proposes a learning activity context model able to describe the main aspects of the contextual mobile learning activity in a professional field. By analyzing several learning scenarios in a professional field, involving just-in-time learning and collaborative learning, we defined a general context model for the contextual mobile learning activity. This general context model is based on six metamodels: actor, equipment, environment, activity, learning method and collaboration. Each metamodel has its own context elements. The general context model of the contextual mobile learning activity is shown in Fig. 2. Each specific learning activity is able to provide its learning contexts according to this general model.

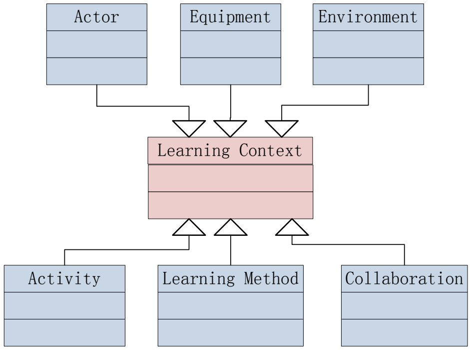

Fig. 2. General context model used for characterization of learning activity

3.3 Context-driven engine

The main goal of the SAMCCO context-driven search engine is to find appropriate learning unit(s) in relation with contexts (complying with the general context model). This engine works systematically in four steps: grasp the learning context, select appropriate learning units, process the most appropriate contextualized learning unit, consolidate or finish the learning activity. The engine work process is shown in Fig. 3.

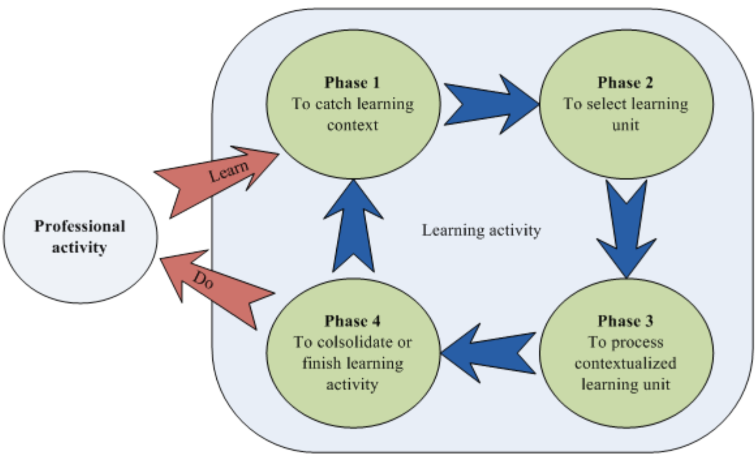

Fig. 3. Working process of the context-driven search engine

3.4 Principle and structure of our Contextual Mobile Learning System

The overall structure of our system is shown in Fig. 4. Professionals work on an application that allows them to perform a specific task. The application collects the contexts of learning activity while professionals are working (e.g. professionals' profile, operating records). When professionals encounter a problem, the application sends contexts of learning activity to the contextual mobile learning system. Based on a series of strategies, the context-driven engine provides just-in-time learning contents stored in the learning engine database or indicates how to establish contact with partners to create a collaboration community. If the collected contexts are not sufficient to locate learning contents, the context-driven engine can ask the context-aware devices or the system for additional information to specify the context, and repeat the engine process.

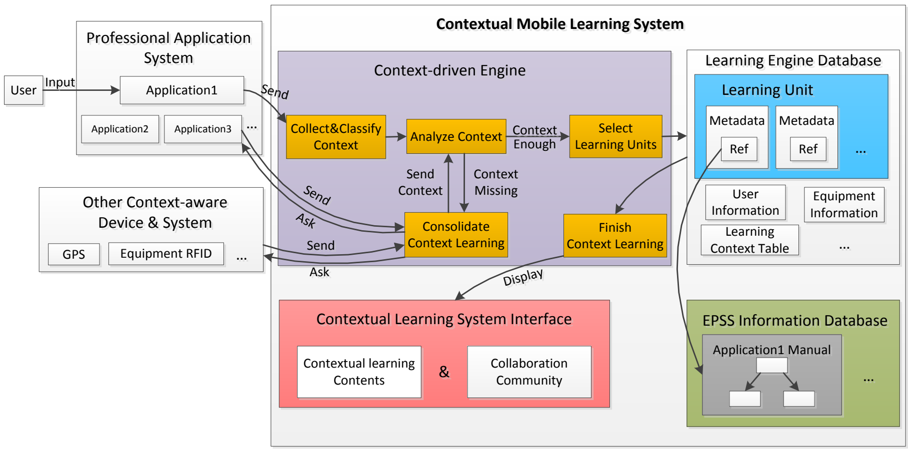

Fig. 4. Overall structure of the contextual mobile learning system used in a professional situation (application)

Globally, our contextual mobile learning system is divided into four parts: the EPSS information database, the learning database, the context-driven engine and the contextual learning system interface. The EPSS information database is the main source of professional learning contents. The learning database contains learning unit characterization by contextual metadata expressed in AM-LOM. These data are used to locate the learning contents by contextual searching, such as learning units, professionals' information, equipment information, learning context table and so on. The context-driven engine is the main part of our learning system. It provides a number of services to implement engine functions, such as collecting and classifying learning contexts, analyzing learning contexts, selecting learning units, and consolidating or finishing contextual learning.

3.5 Working process of the context-driven engine

To analyze whether or not collected contexts are sufficient to search for learning units, we have designed a learning context table stored in the learning engine database. Before applying the contextual mobile learning system, an application needs to register this learning context table. This table concludes the application ID and all the contexts mentioned in SAMCCO's general context model. Three states are defined to mark contexts. They are either compulsory (C), optional (O) or unnecessary (U). Applications register the learning context table on the basis of their own context needs. For example, application1's ID is 1, and its compulsory contexts are context1, context2 and contextN, the optional context is context4, the other contexts in the model are unnecessary. Application1 needs to register the learning context table as in Fig. 5.

Application ID	Context1	Context2	Context3	Context4	...	ContextN
1	C	C	U	O		C

Fig. 5. Example of a learning context table

We construct the framework of the context-driven engine and give an accurate definition of its process. The process is shown in Fig. 6 and can be described as follows:

- **Collect and Classify Contexts**: In this step, contexts are input by professionals (e.g. professionals' profile Id and level) or recorded by applications (e.g. operation process). The context-driven engine collects these contexts and classifies them to form a current collected context table.
- **Analyze Contexts**: In this step, the context-driven engine selects the specific application's context item from the learning context table and compares the selected item with the current collected context table. If compulsory or optional contexts are missing, go to "Consolidate Contexts"; else go to "Select Learning Units".

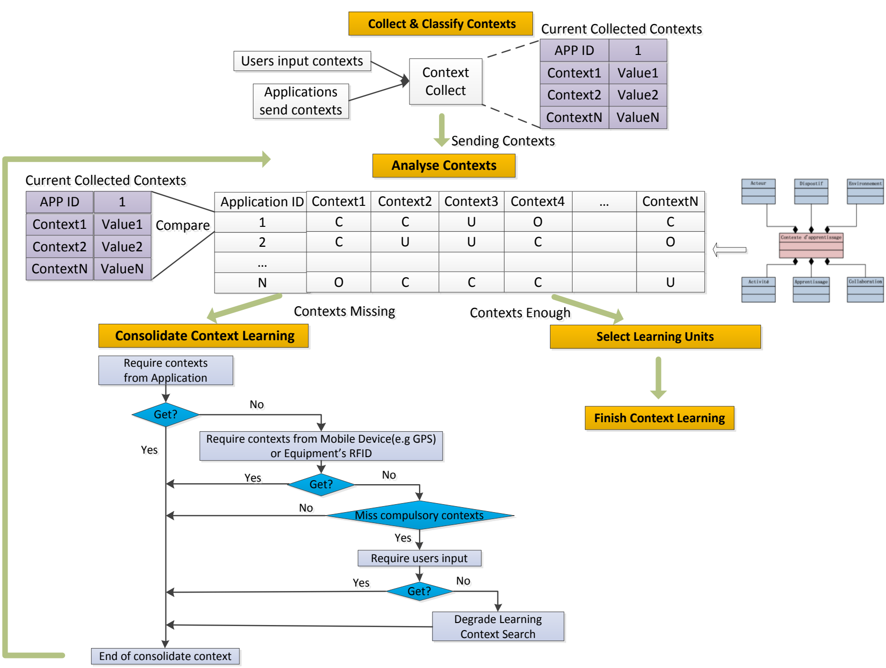

Fig. 6. Context-driven engine process

- **Consolidate Contexts:** In this step, first the context-driven engine acquires the missing contexts from the application. If this is not possible, the context-driven engine acquires the missing contexts from the mobile device (e.g. GPS embedded in mobile device) or workplace equipment (e.g. equipment RFID). If contexts could not be acquired, the context-driven engine estimates whether the missing contexts are compulsory. If they are not, the engine stops consolidating contexts. Otherwise the engine continues to consolidate by sending messages which will be displayed in the application to ask for users' inputs. If users could not input, the searching context learning unit is degraded.

- **Select Learning Units**: According to the collected contexts, compulsory or optional, the context-driven engine selects learning units in the learning engine database. The context-driven engine then sorts the selected learning units by priority: top priority is given to those learning units conforming both to compulsory and optional contexts. Besides, if so required by the learning activity, the context-driven engine selects experienced professionals and places them in a community to encourage collaboration.

4 A scenario using the Contextual Mobile Learning System

To illustrate our explanations, we present an actual example of use. In our work on Smart City problems [10] we work on a project called ALF (French acronym for "in city goods delivery system": "Aires de Livraison du Futur"), the goal of which is to increase the use of delivery areas by prior reservation and dynamic adjustment if necessary. Information Technologies (IT) with mobile communicating devices and in-roadway sensors are used to support the process management system. The ALF system is developed by a consortium in which we are the leading partner [11].

Transport and delivery of goods requires mastery of logistics in order to obtain coordinated transport of goods, transport chains, freight handling, respect of time windows, and planning arrangement [12]. A number of transport management software was designed to produce a well-organized workflow and ensure maximum efficiency. However, in reality, traffic jams are very common and all the odds are against application of off-line elaborated journeys. In the ALF project we examine the possibility of reserving delivery areas in the same way as conference rooms. A logistician can thus prepare a journey, organizing not only the trip, but also reserving delivery areas complying with delivery constraints such as client time availability. At the beginning of the journey, the driver – delivery person receives on his/ her handheld computer (tabletPC or Smartphone) a precise description of the journey. However, during his/ her trip he/she may encounter unpredictable situations such as an accident, roadworks, etc., and he/she must study how to obtain a more appropriate journey. These situations need to learn "just-in-time" about the right behavior to adopt. Appropriate learning units are proposed to take into account the delivery person's profile (beginner or expert) and the different situations to be studied. We identified several scenarios, to arrange delivery journeys, reserve or free delivery areas and promote communication among users. A picture of a tablet using the ALF system is shown in Fig. 7.

ALF applies our contextual mobile learning system to improve the learning capacity of transport companies by offering "just-in-time" learning contents (e.g. operating steps, solutions for exceptions, current traffic situation) as well as a collaboration community among relevant delivery persons and logisticians. Two tasks should be performed beforehand:

1. Produce ALF system learning units: because ALF is a new application system, its manual should be added to the transport companies' EPSS information database. Then we fragment all the documents and multimedia materials stored in EPSS into learning fragments. By editing the fragments with AM-LOM metadata, we obtain the ALF learning units.
2. Register ALF learning context: in the ALF system learning activity, we are mainly concerned with professionals' contexts (such as id and level), environment contexts (such as traffic jams) and users' operating contexts. We then register the learning context table by filling in the ALF ID and marking each context.

Fig. 7. A tablet using the ALF system

The ALF system procedure can be described as follows: a logistician defines a delivery plan and reserves delivery zones on the ALF system. Then he/ she sends the delivery journey to a delivery person. This person then takes a mobile device running the ALF system. He/ she logs into the ALF system by inputting his/ her ID and executes the delivery journey by following the instructions displayed on the mobile device. The ALF system records the delivery person's operating steps. The mobile device detects the entire external environment. If the delivery person does not know how to operate the ALF system, ALF sends the delivery person's operating steps as operating contexts to the contextual mobile learning system, and the system returns the right operating instructions. If the truck is blocked in a traffic jam which can be detected by the speed sensor embedded in the mobile device, ALF sends the environment contexts to the contextual mobile learning system, and the system builds a collaboration community between the delivery person and the logistician to reorganize the delivery journey.

5 Conclusion

In this paper, based on our contextual mobile learning vision, we described our learning system which combines abundant learning contents in an EPSS information database and encouragement for collaboration. We elaborated the principle and structure of our contextual mobile learning system, and the process of its context-driven engine. Finally, we discussed a scenario using our learning system. The features of the proposed system can be summarized as follows: (1) reorganizing learning contents, so that information in different systems could be shared between professionals; (2) providing professionals with "just-in-time" learning contents anywhere and anytime; and (3) increasing the probability for collaborating in workplace learning. Our future works include (1) implementing the prototype of the contextual mobile learning system using the context-driven engine; (2) designing other professional scenarios to evaluate the learning system; (3) adapting our contextual mobile learning system to other fields in the "Smart city" on which we are working [10]: a few examples are dynamic lane management, bus shelter use for traffic, and neighborhood social life.

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