A Context-Aware Approach for Modeling Bijective Adaptations Between Context and Activity in a Mobile and Collaborative Learning

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***Abstract*—Context-awareness is becoming a key aspect of mobile learning systems. In fact, an efficient mobile learning system has to be sensitive to the context that characterizes the interactions between humans, applications and the surrounding environment. Researches in context-aware mobile learning have concentrated on how to adapt application to context. In this paper, we present an innovative approach for modeling bijective adaptations between learning activities and context because they influence each others in learning processes. First, we identify contextual elements and their features relevant for mobile and collaborative learning. Then, we propose a multi-layer middleware that supports tasks for managing and adapting context. The originality of this middleware comes especially from its top-most layer which is an adaptor that defines two classes of functionalities: the adaptation of learning activities to context and the adaptation and updating of context to learning activities. Finally, we present a simulator that implements this adaptor and our bijective adaptation approach. This simulator based on context-aware and mobile learning scenario, makes possible the interactions of mobile learning applications with context (environment) in such a way that they can detect the contextual elements values changes in order to, on the one side, adapt their learning activities to provide services more appropriate to new values of the environment. On the other side, adapt and update contextual elements to the needs of their learning activities and preferences of the mobile user to create more adequate learning environment which helps him/her concentrate better on his/her learning activities.**

***Index Terms*—Mobile and collaborative learning, pervasive middleware, bijective adaptation, context, learning activity, Context-aware learning.**

I. INTRODUCTION

Mobile learning allows learners to access learning material related applications anytime and anywhere through several devices (PC, PDA, Smart phones, etc…) [1]. In this field, taking into account learner's context is becoming a major requirement. Context-aware mobile learning is a very active area of research but a review of past researches in context awareness shows that researchers have focused on the adaptation of mobile learning applications to context. In this paper, we propose an innovative approach based on a bijective adaptation between context and learning activities. This approach can be used as a framework in the implementation of contextawre systems within collaborative and mobile learning environments. Such a bijective adaptation aims to facilitate the learner's life and to create an adequate learning environment. Which helps him/her to concentrate better on her/his learning tasks.

In previous work [2], we have presented a middleware level support between M-learning and the context for managing and adapting that context.

This middleware provides support for most of the tasks involved in dealing with context: acquiring context from various sources, interpreting context, modeling context, storing context in knowledge base, reasoning context in order to extract new implicit contextual elements by commanding them automatically. This middleware includes four layers: context management, context storage, context reasoning and an adaptor for bijective adaptation.

The major steps of this work are:

- Identifying and classifying the contextual elements relevant to mobile and collaborative learning.
- Proposition of a Pervasive middleware between learning activities and the context for managing and adapting that context.
- Presenting an adaptor that makes possible the visualization and automatic execution of all adaptations needed to model relationships between context model and learning activity within a mobile and collaborative learning. Those adaptations involve two major tasks: the adaptation of learning activity to context and the adaptation of context to learning activity
- Proposing a context-aware scenario to explain our motivations to conduct this study on how to guarantee bijective adaptations between learning activities and context within a mobile and collaborative environments.
- Development of a simulator which illustrates the usefulness of our approach.

The rest of this paper is structured as follows: section 2 overviews some concepts, Pervasive Learning, context and context-aware systems. Section 3 identifies, classifies and models contextual elements relevant to the field of mobile and collaborative learning. The multi-layer middleware functionalities are specified in section 4. Section 5 presents an adaptor for a bijective adaptation between context and learning activities. A contextaware mobile learning scenario description and modeling and the prototype functionalities are presented in section 6. Section 7 describes the simulator that implements the proposed mobile learning scenario and highlights the usefullness of our approach. Section 8 concludes the paper and suggests future research directions.

II. DEFINITIONS

A. Mobile learning

We defined the mobile learning as being any learning which occurs when the student is not in a predetermined fixed location or a training which occurs when the student benefits from the opportunity offered by mobiles technologies. [3]

Thus, learning is not only the simple use of mobile devices for pedagogical purposes; even if this mobility favours the distance learner; but it gives a broader definition of mobility. It is interested in continuous connectivity (anytime and anywhere), it also explores the dynamic correlation between wire or wireless devices (where the tasks distribution is based on performances), people (intense interactions) and their environment (powerful support for effective training)

B. Pervasive learning

In the last years a new concept has appeared to translate the potential of Ubiquitous or Pervasive Computing in education. This new way to use technologies to support the learning processes has been called either "Ubiquitous-Learning" (or u-Learning) [4]1) [4] [5], or Pervasive-Learning. [6]. As for m-Learning, most of the authors mention that pervasive Learning goes farther than uses of new technologies provided by recent research in pervasive computing to support e-Learning traditional views, but that it enlarges also the view of the learning process itself and offers a new paradigm in which computing systems are seamlessly integrated into the lives of everyday users and their use should be as natural as using non-computing technology.

For example for [7]: "Ubiquitous learning is the next step in performing e-learning and by some groups it is expected to lead to an educational paradigm shift, or at least, to new ways of learning. The potential of ubiquitous learning results from the enhanced possibilities of accessing learning content and computer supported collaborative learning environments at the right time, at the right place, and in the right form. Furthermore, it enables seamless combination of virtual environments and physical space". And she precise the mains characteristics of u-Learning is terms of: Situating of Instructional Activities, and Adaptability.

C. Context

Based on previous definitions [8] [9] [10] [11] [12] [13] [14] and previous work [15], we provide our definition of context for mobile and collaborative learning. Given the diversity of context information, it is useful to attempt to categorize it to make it easier to apprehend in a systematic manner. To this aim, we introduce a simple classification of context information, based on categories of contextual information.

We introduce two essential categories of context information—individual context and shared context [15].

Individual context includes information relevant to the interaction between the learner and m-learning applications.

Shared context includes information relevant to collaborative group work or learners sharing common interests.

The context categories we have identified can be used in a number of ways by context-aware mobile learning applications. To further clarify context and its uses, we now turn to functions that make an application context-aware.

D. Pervasive Context-aware systems

Context-awareness is a key aspect of pervasive computing systems. A system is Context-aware if it uses context to provide relevant information and/or services to the user, where relevancy depends on the user's task.

We define the context aware by identifying the following features of context aware applications [15]:

- Ability to acquire the current context;
- Ability to interpret the current context;
- Ability to model context;
- Ability to store context in order to construct a context history and to predict or anticipate future context;
- Ability to make possible sharing experiences with other learners based upon specific (context) information
- Ability to reason about context for deducing new contexts;
- Ability to filter context;
- Ability to adapt the behaviour of M-learning application to meet the dynamically changing contextual requirements, this adaptation includes content adaptation and presentation adaptation;
- Ability to adapt context for creating a favourable learning environment.

III. LEARNER CONTEXT FOR PERVASIVE AND MOBILE LEARNING

Most of previous and current works on adaptive e-learning focus on user model [16] [17] which takes into account only internal environment of the user: personal information, interest centers, preferences…etc. but the rush of the wireless and mobile technologies creates a move from e-learning to m-learning and P-learning (pervasive learning). An efficient pervasive learning system has to be sensitive not only to the user model informations but to the whole context that characterizes the interactions between users, applications and the

surrounding environment. For that, we attempted to extend the user model into more abstract context model that includes the user model and gathers all contextual elements relevant to pervasive and mobile learning systems (cf.Figure1).

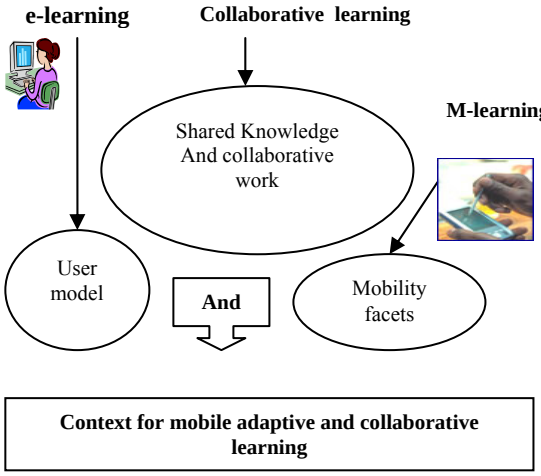


Figure 1. Context for mobile adaptive and collaborative learning

A. *Classification of context for pervasive learning*

According to our definition of context given in section 2, we divide a mobile and collaborative learning context into two major categories: individual context and shared context.

Description of individual context

According to Table 1, Individual Context includes:

- *Internal environment* which includes information about the learner itself: his/her user model and his/her current state during interaction with M-learning application.
- *External environment* which includes information about the learner's surrounding environment (social environment, physical environment, temporal environment and software and hardware environment).

TABLE I.
INDIVIDUAL CONTEXT

Category	Sub category	Contextual element
Internal environment	**User model**	Personal information Knowledge Experience and practices Competences Preferences Interest center Goals Health state
	Current state of learner during interaction	Previous activities Agenda Concentration degree Physiological state Psychological state Type of Mobility Current activity
External Environment	**Physical environment**	Location and orientation Noise level Weather temperature Light
	Temporal environment	Date Hour Season
	Hardware environment	Device capabilities bandwidth processor speed storage capacity resolution sound quality sound power battery network capacity connectivity
	software environment	Plug in OS
	Social environment	Connected people People around the learner

Description of shared context

According to Table 2, Shared Context includes:

- Shared individual contexts of teamwork's members (practices, common errors, experiences).
- Collaborative work environment (production environment, communication environment and coordination environment

TABLE II.
SHARED CONTEXT

Shared individual contexts of teamwork's members	practices common errors experiences knowledge	Obtained from individual contexts of teamwork's members
collaborative group work environment	communication environment	Available tools that help learners to accomplish their tasks Resources needed to help learners in specific fields.
	coordination environment	Synchronous Communication (chat, visioconference) Asynchronous Communication (FAQ, forum, mail)
	production environment	Tools making coordination between teamwork members (e.g., schedule tools)

B. Contextual element features

In order to manage Contextual elements, we must differentiate between them by giving them different features. Table 3 illustrates these features: nature, acquisition type, acquisition mode, relevance, evolution, adaptation and frequency of updating.

TABLE III.
DESCRIPTION OF CONTEXTUAL ELEMENT FEATURES

Contextual element features	Possible values
Nature	*Natural: temperature* *Artificial*: the sound of the stereo channel
Acquisition type	*Explicit acquisition*: contextual element is directly acquired. Automatic acquisition: contextual element is sensed automatically (e.g., by sensors) Manual acquisition: contextual elements are given by learner. *Implicit acquisition*: contextual elements are inferred from others stored contextual element.
Acquisition mode	*Instantaneous*: contextual element is acquired only once at the beginning of the interaction (e.g., date) *Continuous*: contextual element is acquired continuously during an M-learning session (e.g., noise level).
Relevance	*Active* : contextual element relevant to the interaction between learner and the system (e.g., if learning type is a Visio-conference, noise level is an active element) *Passive*: isn't relevant to a given interaction between learner and the system (e.g., if the learner's task consists of reading a text, the name of learner is a passive element).
Evolution	*Dynamic*: contextual element change during the interaction (e.g., noise level) *Static*: contextual element does not change during interaction (e.g., season)
Adaptation	*Adaptable* *Not adaptable*
Frequency of updating	This feature ensures the newness of contextual elements

C. ContextModel

Activity Context in a Mobile and collaborative Learning

According to [18], Activity theory, as a social and cultural psychological theory, can be used as a framework for describing the components of an activity system for the design of a context-aware mobile learning application**.**

In order to define elements of a Collaborative learning activity model we have developed an approach inspired from activity theory. There are two main reasons for using activity theory. First, it provides a simple standard form for describing human activity. Secondly, it takes into account the concepts of tool, community, rules and division of labour that are important in a collaborative learning environment.

Activity Theory Background

Activity Theory is a philosophical framework used to conceptualize human activities. In 1987 Engeström proposed the triangular structure of human activity as shown in Figure 2 [9].

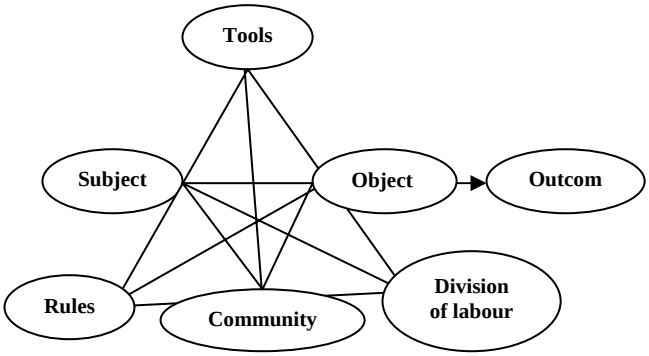


Figure 2. Activity theory model

Activity Theory describes and relates key elements that influence human activity. Activity Theory considers that any two elements in the model are mediated by another element. For example, the relationship between subject and community is based on rules and at the same time the tools have influence on how the subject meets the object.

In a mobile and collaborative learning the main components of this activity theory model can be transformed as follows:

Subject: Learner
Tools: Available tools that help learners to accomplish their tasks.
Community: collaborative teamwork work.
Division of labour: The division of tasks between teamwork's members/roles.
Rules: Explicit or implicit regulations, norms and conventions that constrain action or interaction.
Object: Target of the collaborative learning activity.

Integrated Model of Context in a Mobile and collaborative Learning

In order to give a better presentation of the possible adaptation scenarios between learning activity and context in the following step, we have, in a first step, suggested a

model based on the integration of both the Collaborative learning activity model and the context model as shown in Figure3. This model shows that in a given context, the learner accomplishes an activities sequence.

The elements in this model can be described as follows: in one session of M-learning, there is only one context. A context is composed of many contextual elements acquired from various sources. Each context is characterized by its name, nature, evolution, relevance, acquisition type, acquisition mode, value or set of values and its adaptation. Many of contextual elements are updated or adapted during a session of M-learning.

Each collaborative activity has a type and requires role types of learners, resources and tools to be well performed in order to reach its objectives and didactic goals. A teamwork is composed of many learners who play many roles according to the activities that they perform. An activity can be composed of many sub-activities and can have relationships with other activities.

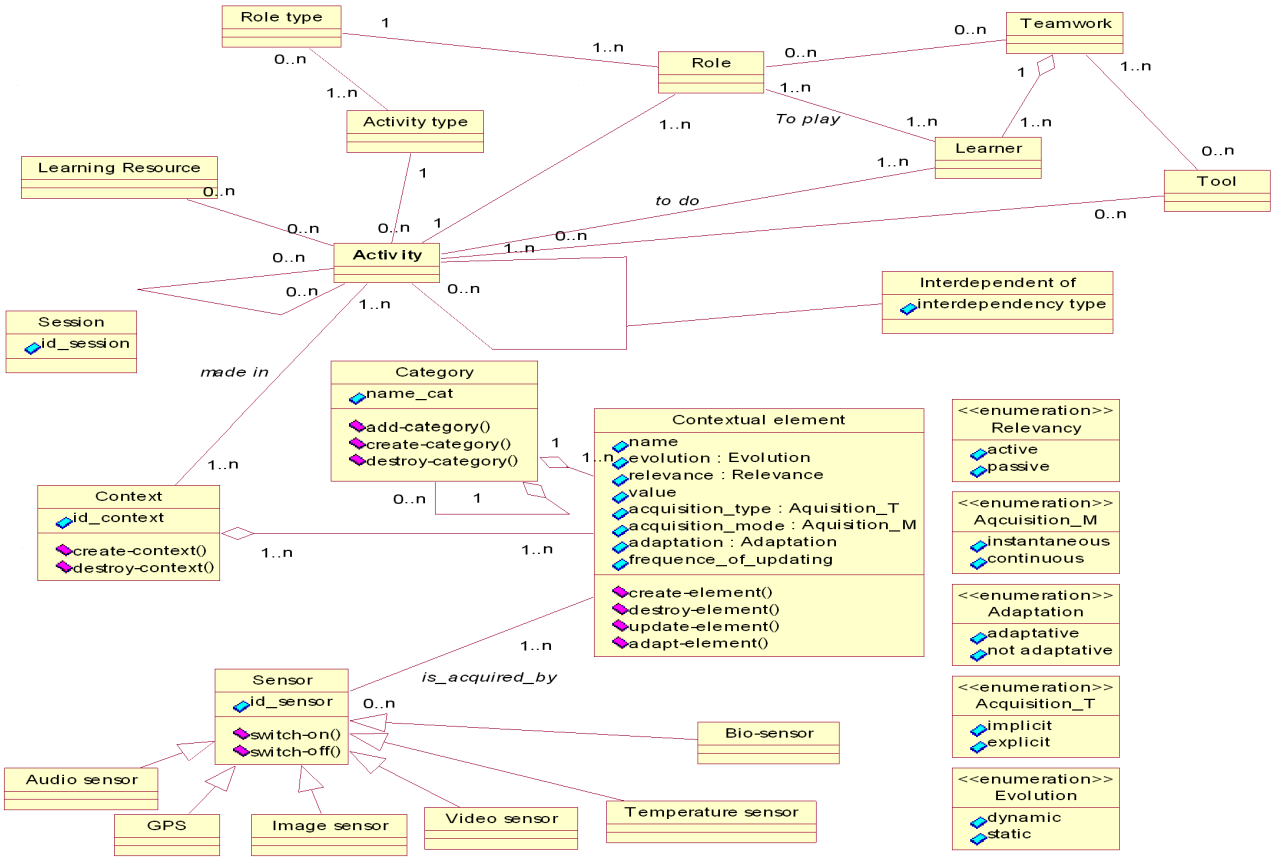


Figure 3. Integrated Model of Activity and Context

IV. A MULTI-LAYER PERVASIVE MIDDLEWARE

Based on conceptual elements described in section 3, we are able to design a multi-layer conceptual framework for building contextaware mobile learning systems [19].

A. *Conceptual View of the Middleware*

This middleware aims to manage, store, reason and adapt contextual elements to the learning activities needs.

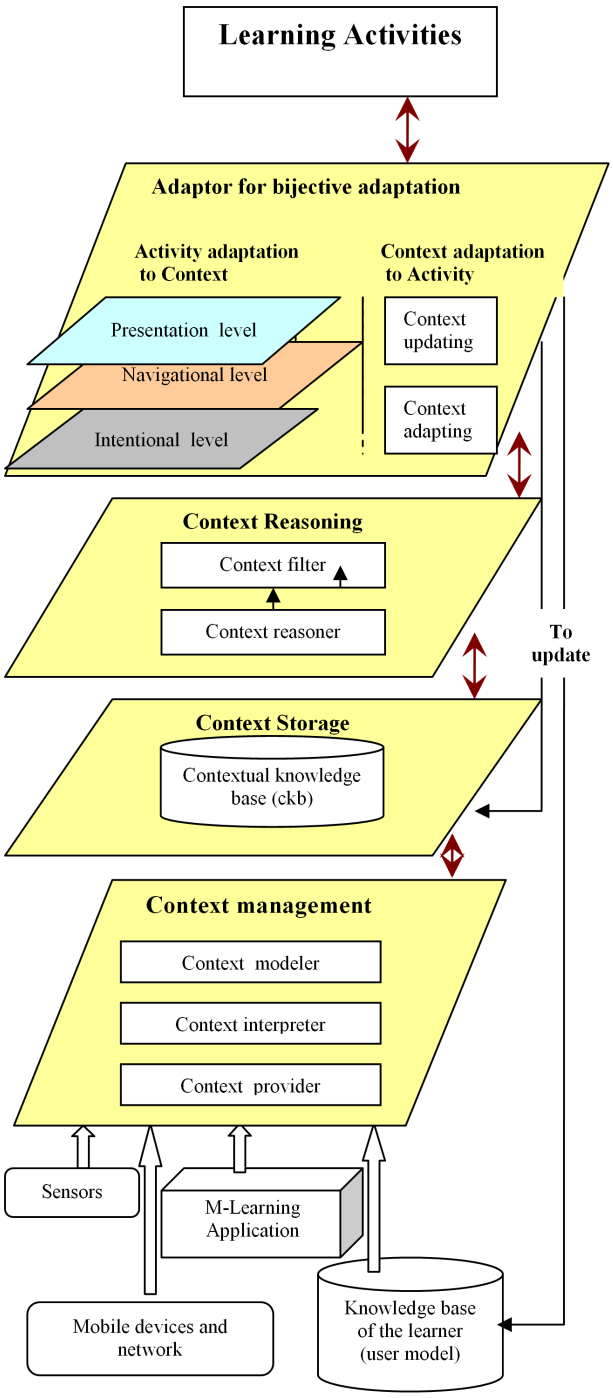


Figure 4. Conceptual View of the Ubiquitous Middleware

B. *Specification of the Middleware Functionalities*

According to figure 4, our middleware includes four layers: Context management, Context Storage, Context reasoning and adaptor for bijective adaptation.

Context management: includes three modules:

Context provider: realize the context acquisition from different sources:

- Sensors: light sensors, Gps, bio-sensor, audio sensor, temperature sensor, camera...
- Knowledge base of the learner (User model)
- M-learning application (contextual element about the activity which would be made by the learner)
- Mobile devices and network (contextual elements are about Mobile devices and network characteristics)

Context interpreter: the middleware interprets the acquired contextual elements in order to obtain high level contextual elements. For example, it's possible to transform GPS coordinates to a complete address because it's more significant than GPS coordinates.

Context modeler: the middleware models the contextual elements by representing them in the form of high level description. The basic concept of our context model is based on ontology which provides a vocabulary for representing and sharing context knowledge in a pervasive computing domain, including machine-interpretable definitions of basic concepts in the domain and relations among them. An ontology-based model for context information allows us to describe contexts semantically in a way which is independent of programming language, underlying operating system or middleware; enables formal analysis of domain knowledge (context modeling is out of the scope of this paper but it concerns another related work).

Context Storage: a Contextual knowledge base (CBK) stores contextual elements values in order to build a contextual history.

Context reasoning: includes two modules:

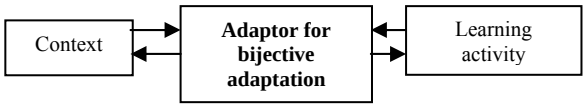
Context reasoner: the middleware provides deduced contextual elements or implicit contextual elements based on explicit context

Context filter: first, the middleware distinguishes between passive contextual elements and active ones. Second, it retains only those which can be adapted.

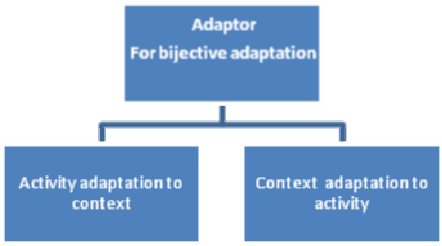
Context adaptor: defines two classes of functionalities: context adaptation to activity and activity adaptation to context. The functionalities of this layer will be detailed in the following section.

V. ADAPTOR FOR BIJECTIVE ADAPTION

The main aim of our work is to use context awareness to improve usability for ubiquitous learning users who have to perform multiple activities. For this purpose, we have developed an adaptor that has potential of being a framework for implementing context aware systems. This adaptor models all possible interactions between context and learning activity because context and learning activities influence each others in learning processes.



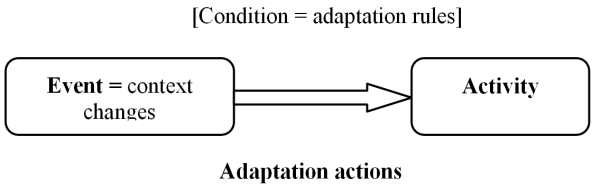
This adaptor provides developers with all the possible adaptation actions that should be taken into account through a bijective adaptation process.



A. Activity Adaptation to Context

An activity is adapted or conducted with some variations depending on some values of contextual elements attributes. So, only relevant context changes are modeled and taken into account for the triggering of the activity adaptation process.

When **event** (or relevant context changes) occurs, **conditions** (or adaptation rules) are checked and then Activity adaptation process **actions** are triggered.



Three levels are differentiated within an activity adaptation process:

- **Presentation level:** for example: if the physical environment is characterized by a high noise level and the learning activity includes a sound, then adaptation action compels the inhibition of this sound if it's not necessary for performing the activity.
- **Navigational level:** to model the navigational schema of learning activity, we propose to use UML activity diagram as shown in figure 5. Adaptation actions at this level will consist of the selection of the appropriate learning sub-activity according to the current context.

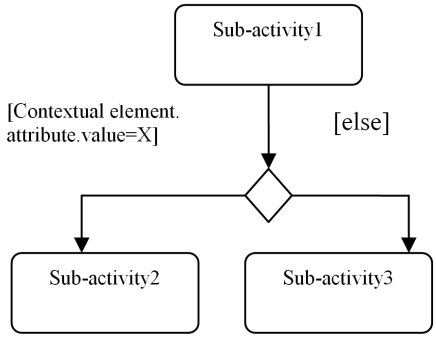
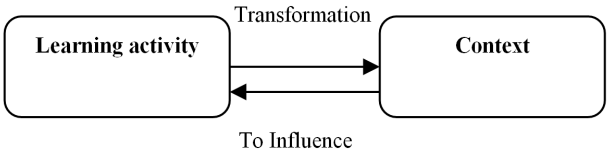


Figure 5. Navigational schema of learning activity

For example, the number of connected learners of the teamwork is used as selection criteria which outlays the nature of the adequate sub-activity.

- **Intentional level**:The intentional level doesn't have the same role as the other levels of adaptation. This level guarantees that learning activities objectives are preserved and not modified by the adaptation whatever the latter is; presentation or navigational level.

In addition to those three adaptation levels, the activity can be transformed into contextual element that influences and affects the future of the activity.

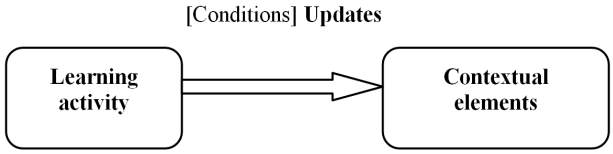


Therefore we can speak about **reflexive activity** because it affects itself.

B. Context Adaptation to Activity

Activity updates context

The values of some contextual elements attributes are updated when an activity is completed, but some conditions must be checked before the update (when activity's goals are achieved).



For example, passing an exam updates the user model in a way that extends the learner's knowledge in that relative area.

Activity adapts context

Some contextual elements can be adapted to the activity needs. So context adaptation process consists of controlling the context parameters in order to adapt them to the activity needs. This adaptation aims to create an adequate learning environment which helps learners concentrate better on their learning activity.

For example, the volume of the tape recorder stereo will be adjusted automatically according to the type of activity performed by the learner and the degree of needed concentration.

VI. USING LEARNER CONTEXT TO PERONALIZE M-LEARNING ENVIRONMENTS: CASE STUDY

The prototype's target is to show the interest of our proposed ubiquitous middleware and especially the top most layers: Adaptor for bijective adaptation. In fact, we suggest a scenario to explain our motivations to conduct this study on how and why to guarantee bijective adaptations between context and activities in mobile and collaborative learning.

A. *Context aware mobile learning Scenario*

We propose, in this context, a scenario highlights and demonstrates the bijective adaptation between context and mobile learning activities for context aware learning applications. The retained implementation environment is a computer science engineering school. The laboratory of research of this school is composed of many rooms equipped with interconnected computers and a presence detection system that localize mobile learners and teachers in different rooms through bracelets that they wear.

This system can be used by learners to manage their learning material and research work. Teachers use the system to create, manage and dispatch their learning material to learners.

In the beginning of each course session, learning material will put at the disposal of learners and displayed at each present learner mobile device (PDA …).

The attendance list will be filled in automatically during each course and the cumulated absences for each learner will be communicated through SMS.

During the course session, the mobile device of learner displays appropriate slides and he/she can follow up his/her course. The latter is adapted automatically to the display capacity of the mobile device.

In all cases, learners can annotate their course and publish their annotations in order to share them among others learners to enrich the course.

Outside the courses timeframe, in different rooms of the laboratory (indoor locations), learners continue their learning activities individually or collaboratively.

In this context, we distinguish two types of indoor environments:

- 1st type: shared indoor environment in which learners work together in the same room (course rooms or laboratories).
- 2nd type: personal indoor environment (offices) in which the learner or teacher is in an individual room. The bijective adaptation between context and learning activity will be more evident in this type of indoor environments because contextual elements can be adapted to the user's and activity's needs. For example, the user's favorite radio channel will be switched on and the volume will be adjusted automatically according to the type of the activity performed by the user and the degree of concentration needed.

In the case of collaborative work and in case of need, learners can help each other and work together in teamwork thanks to the presence of the aforementioned detection system. Then, present learners can:

- *Communicate* through messaging system in order to make their work more fruitful.
- *Produce* documents
- *Coordinate* and plan

B. *Scenario Modeling*

Figure 6 illustrates that in every physical school room (office rooms, course rooms or laboratories) and in every virtual space of the prototype (study space, shared space and personal space), the learning activities (which are accomplished by mobile users) and the contextual elements influence each others in learning processes.

A collaborative or individual activity can be composed of many sub-activities. Contextual elements are acquired from various sources and some of them can be acquired by sensors (audio sensors, presence sensors…).

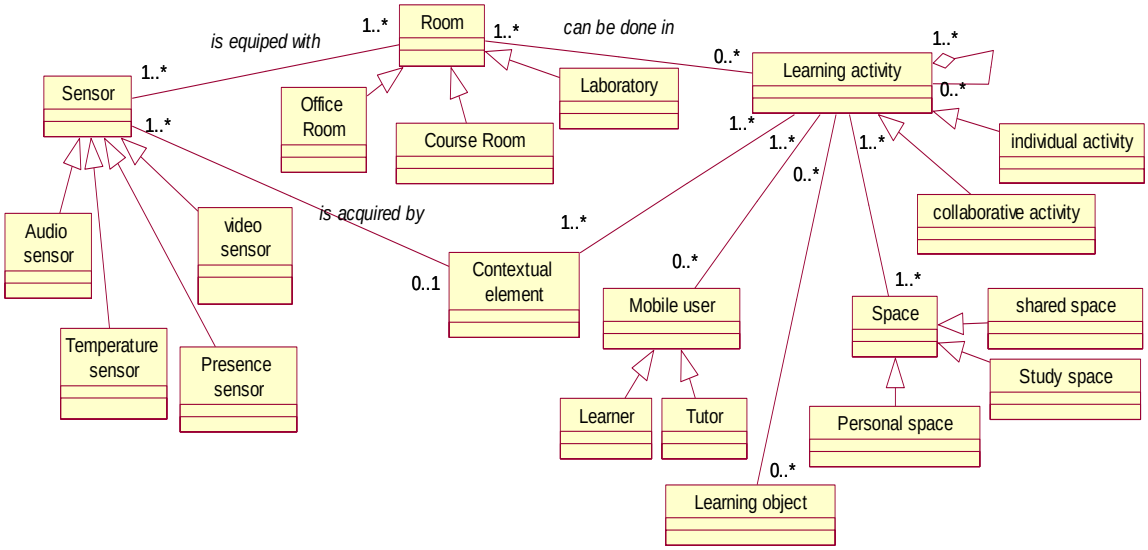


Figure 6. Scenario modeling

C. *Prototype functionalities*

The prototype's target is to illustrate the interest of our proposed adaptor for bijective adaptation between context and learning activities within mobile and collaborative learning. This prototype, based on contextaware and mobile learning scenario, makes possible the interaction of learning applications with context (or environment) in such a way that they can detect the contextual elements changes in order to:

1) Adapt learning activities to provide services more appropriate to new values of the environment.
2) Adapt and update contextual elements to the needs of learning activities and preferences of the mobile user to create more favorable learning environment.

Figure 7 depicts two mobile users (learners and tutors) and three virtual spaces of the proposed prototype: study space, personal space and shared space. All those spaces use functionalities of bijective adaptation package, which ensures both the adaptation of the activity to context and the adaptation of context to activity.

Through the *study space,* mobile learner can consult and annotate his/her learning objects and consult his/her cumulated absences. Through this space, the tutor can manage learning objects and check the attendance list, which is filled in automatically thanks to the presence detection system.

Through the *shared space*, mobile learners can work and collaborate together. This collaboration should be communication, production of documents or projects or coordination between teamwork's members.

Through the *personal space,* mobile learner can consult learning objects and perform learning activities and can be aided by a competent learner or a tutor and this thanks to the presence detection system, which can localize mobile learners or tutors.

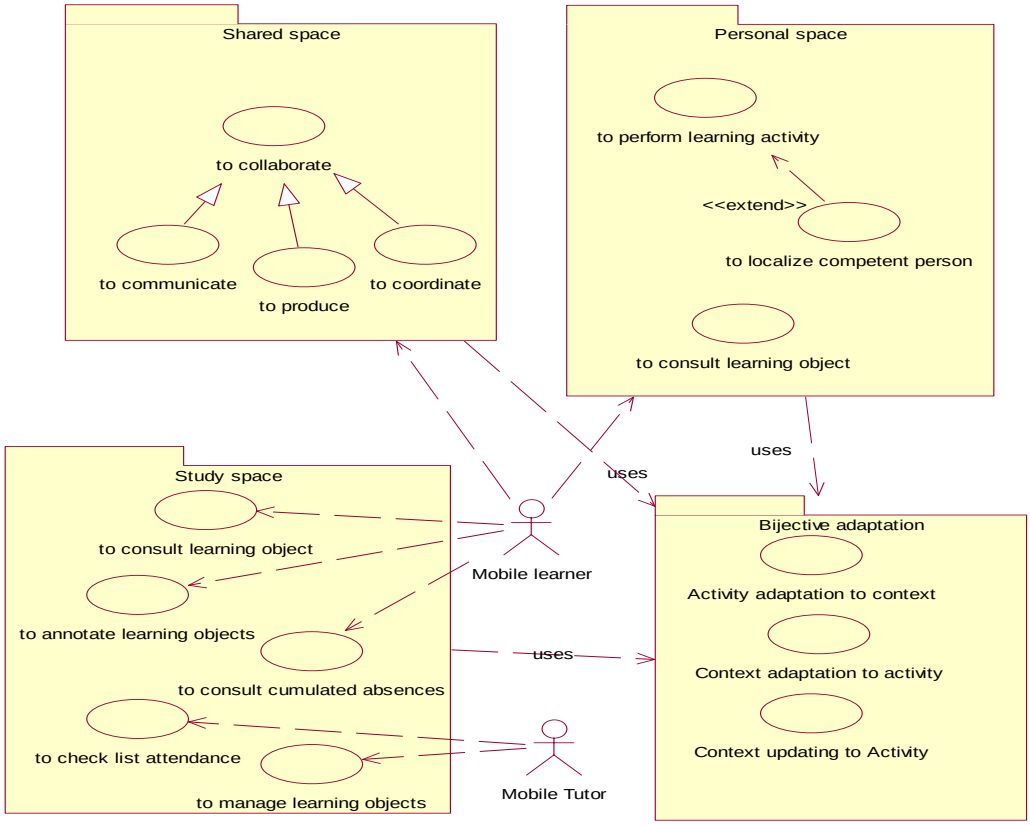


Figure 7. Context aware prototype functionalities

VII. SIMULATOR IMPLEMENTATION

The previous section dealt with the modeling of the simulator that highlights and demonstrates the usefulness of bijective adaptations between context and mobile learning activities for mobile and collaborative learning systems. This section focuses on how the simulator ensures those adaptations by describing some relevant interfaces.

The simulator is implemented using JAVA and XML.

In each space of the simulator (study space, personal space or shared space), the learner can perform many activities. Each chosen activity is loaded with its relevant contextual elements.

In this section, we will describe the bijective adaptations between only two activities and their contexts.

A. *The Activity "sending Learning material to present learners"*

In the beginning of each course session, when Sensors detect the presence of a learner, the learning material will be sent automatically to him and displayed at its mobile device (PDA …) in the study space. This learning material is adapted automatically to the display capacity of the mobile device (cf. Figure 8).

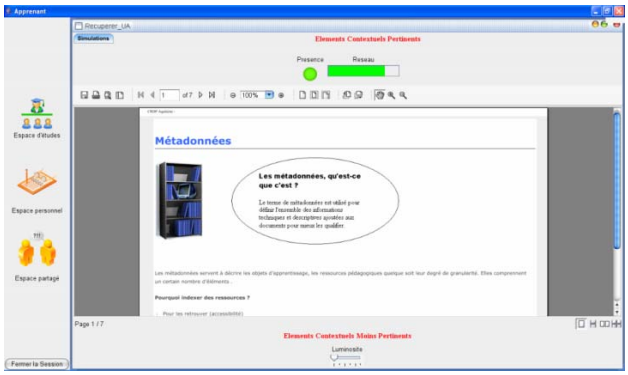
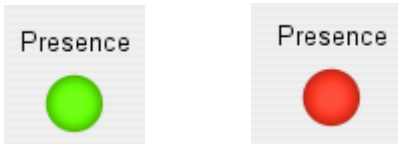


Figure 8. Interface relative to the activity "sending Learning material to present learners"

As shown in Figure 8, the contextual elements relevant to this activity are:

The Contextual Elemnt: Presence

If sensor detects the presence of a learner, the indicator of presence is set to green.



Learner is present Learner is absent

.

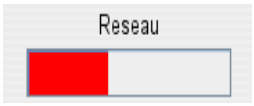
The Contextual Element: Light

If the lighting condition is too bright for viewing the learning material, this contextual element will be adapted, so the room lights will be dimmed. The influence of the adaptation of context "light" is simulated by this change of the brightness of the screen (cf. figure 9).

Figure 9. Adaptation of the light condition

The Contextual Element : Fluency of the Network

If the network is fluent, the indicator of the fluency of the network is set to green. Otherwise, it's set to red.



Network is not fluent

Network is fluent

If the network is not fluent and the learning material contains many images then the system will send another version (alternative) of the same learning material. This version will not contain images as shown in Figure 10.

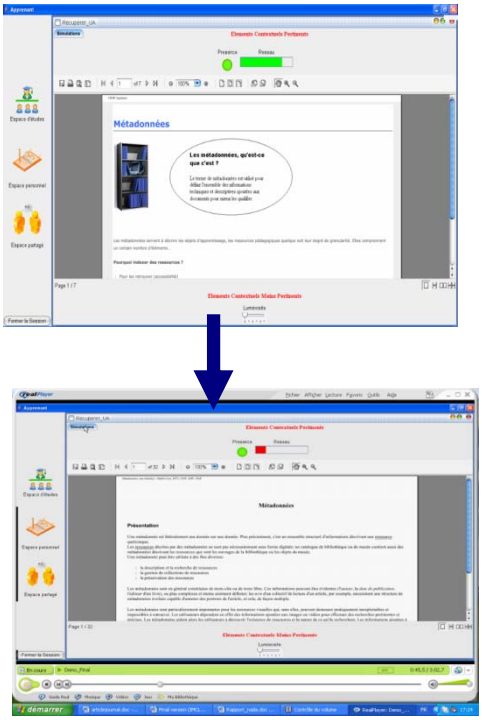


Figure 10. Network is not fluent: Learning Material not contain images

A. Activity "To Consult Learning Material"

Through the Personal Space, the learner can consult his/her Learning material. Especially, in personal indoor environment (offices) in which the learner or tutor is in an individual room. The bijective adaptation between context and learning activity will be more evident because contextual elements can be adapted to the user's and activity's needs (cf.figure11).

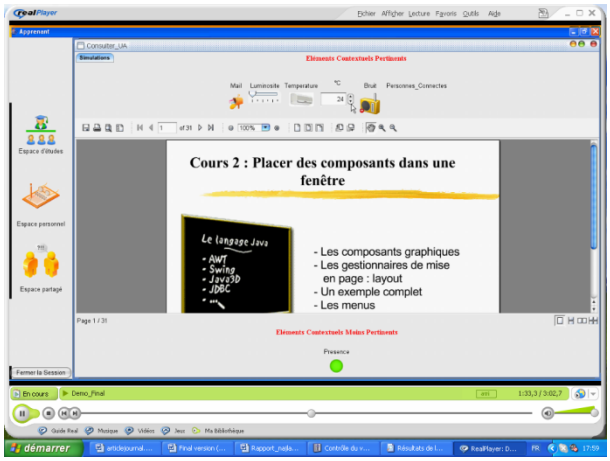


Figure 11. Interface "To Consult Learning Material"

The Contextual Element : Temperature

To make the learning environment more favorable, when the temperature inside the study space is below a certain threshold, the heating system is automatically triggered. On the opposite, if temperature increases, the air conditionning becomes functional. Whenever there is a change in temperature, an animated image is displayed to simulate the functionning of the heater or the air conditioner.

Air conditioner is ON

Heater is ON

The Contextual Element : Noise Level

If the Activity "to consult Learning Material" requires a high level of concentration, then the stereo recorder is automatically switched off. so, we can say that the contextual element "noise level" is adapted to the activity's needs.

Stereo recorder is on

Stereo recorder is off

The Contextual element: connected persons

Once a user is connected, the system informs the tutor that a new user had connected.

The contextual element: Competence

To perform learning activities and the learner can be aided by a competent learner or a tutor and this thanks to the presence detection system, which can localize mobile learners or tutors. So, in case of need, the system displays a list of competent learners or tutors in the same domain of study (cf.Figure 12).

Figure 12. To localize and communicate with competent persons

VIII. CONCLUSIONS AND FUTURE WORK

In this paper, we presented a new approach for bijective adaptation between context and learning activities within a mobile and collaborative learning.

First, we have proposed a classification of contextual elements into two categories: individual context and shared context. Then, we have identified contextual elements features.

We have also proposed a multi-layer ubiquitous middleware that supports tasks including: acquiring, interpreting, modeling, storing, reasoning, updating and adapting context. In this paper we focused on the top-most layer of the middleware which is an adaptor that defines two classes of functionalities: the adaptation of learning activity to context and the adaptation of context to learning activity. This adaptor makes possible the visualization and automatic execution of all adaptations needed to model relationships between context model and learning activity model within a mobile and collaborative learning. After we have presented a simulator that implements this adaptor. Through this simulator we tried to demonstrate how the bijective adaptation can facilitate the learner's and the tutor's life and create adequate learning environment, which helps them concentrate better on their learning activities.

The development of this simulator has required the proposition of a contextaware mobile learning scenario that highlights and shows the bijective adaptation between context and learning activities.

As future work, we mention:

- The completion of the implementation of the middleware;
- The inclusion of the mechanism of proactive adaptativity in order to anticipate the changes of contextual elements values.

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