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A Context-aware Approach for Personalized Mobile Self-Assessment

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Abstract: With the increasing development of mobile technologies, the learning environment is currently undergoing a major shift. Access to contextual information in a mobile learning environment aims to meet the needs of learning and assessment personalization according to various learners' profiles and a range of learning contexts. Semantic Web technologies have been applied in recent years with different purposes in education. But, their applications for generating useful personalized mobile assessment resources have not been researched enough so far. In this paper, an approach making use of semantic Web technologies to support personalized self-assessment in mobile environments is described. Assessment techniques are formalized with First Order Logic rules which allow to personalize assessment activities. We also propose an algorithm for semantic assessment resources retrieval. Finally, a Mobile Semantic Web Assessment Personalization system is presented. The qualitative and quantitative evaluation of the proposed system is also provided.

Keywords: Personalized self-assessment, semantic Web, Ontologies, Mobile environment, Web Services
Categories: L.0, L.1.4, L.3.6, L.7

1 Introduction

Over the last decade, the advancement of computer and mobile technologies has encouraged researchers to develop more effective learning environments [Hwang et Chang, 11] [Hwang, Wu et Ke, 11] [Hsu, Hwang et Chang, 13]. Educators have pointed out their interest in adaptive and personalized learning by providing many researches works in Technology Enhanced Learning (TEL) [Brusilovsky et Millán, 07] [Mulwa et al., 10]. This has led to transform the traditional one-size-fits-all traditional learning approaches to adaptive and personalized learning [Šimko et al., 10] [Brusilovsky et Henze, 07]. Applying these approaches, learners are provided with adaptive and personalized learning experiences that are tailored to their particular educational needs and personal characteristics towards maximizing their satisfaction and learning effectiveness [Sampson et Zervas, 13].

On the other hand, the advancement and popularity of mobile technologies have encouraged researchers to adopt laptops and mobile devices in conducting learning activities [Young et Hung, 14] [Rogers et Price, 09]. Handling mobile devices in education have emerged new forms of learning and assessing systems [Bogdanović et al., 14] [Santos et al., 15]. Situated in mobile learning environments, learners could receive the learning materials provided by system according to where they are when learning [Zurita et al., 14] [Herrington et al., 14] [Baran, 14]. The design of assessment systems in mobile environment needs an effective personalization approaches. Indeed, personalization is becoming an important concern since the information derived from both assessment functionalities and learners' interaction can enable a better selection and generation of assessment resources [Dolog et Henze, 03] [Aroyo et al., 06] [Sitthisak, Gilbert et Davis, 07]. For an assessment process, assessment items generation must be carefully proceed looking for personalization efficiency. Extremely, providing learners with personalized mobile assessment test may be considered as an important issue. Thus, it requires the development of new methodologies for supporting such a process.

Furthermore, the notion of context had attracted significant attention in mobile environments [Dey, 01] [Economides, 08]. Context-aware applications require well-designed models to represent context dimensions. Reviewing literature, context modeling was classified into six approaches [Strang et Linnhoff-Popien, 04]. One of these approaches is ontology based models [Wang et al., 04] [Chen et al., 04] [Hong et Cho, 09]. Ontology can be seen as a semantic model comprising concepts, properties, relationships between concepts and constraints [Kiryakov et al., 04]. Semantic web offers tools and infrastructures for semantic representation by means of ontologies. It provides a common framework allowing data to be shared and reused across applications, enterprises, and communities [Berners-Lee, Hendler et Lassila, 01]. In the last years, the relevance of semantic Web technologies for developing e-learning systems was supported by several research efforts [Bittencourt, Costa, Silva et Soares, 09] [Devedzic, 06] [Bittencourt et al., 08].

The objective of this study is to describe an approach based on semantic Web technologies to support personalized self-assessment in mobile environments. Indeed, a flexible logic-based assessment framework for personalized mobile assessment is proposed. In this framework, information is described based on first order logic (FOL) predicates. We have also developed a Mobile Semantic Web Assessment Personalization (MobiSWAP) system that implements our approach and that has been used and validated by learners registred in a course in our university.

The rest of this paper is organized as follows; in Section 2, we present some related works. In Section 3, we detail the personalized mobile assessment approach by providing ontological models describing the Personalized Mobile Assessment Framework (PMAF), detailing the framework formal description and presenting the personalized mobile assessment resources retrieval algorithm. Section 4 details the architecture of our proposed framework and presents its different implementation stages. The results of the application of our approach in real course are shown in Section 5. At last, we present conclusions and our future work in Section 6.

2 Related Work

Assessment has always been a very important step in the learning process. The use of mobile devices for assessment makes possible the creation of new types of assessment activities.

In this work, an approach for supporting personalized self-assessment in mobile environment combining semantic Web technologies is presented. We explain how assessment has been addressed in mobile environments in recent years. Alternatively, the use of semantic Web technologies in mobile learning will be discussed.

2.1 Assessment in Mobile Learning

Mobile assessment is a new delivery mode of assessment that offers ubiquitous access to testing material “anytime and anyplace”. Due to its mobile features, it has the potential to complement and enhance other assessment delivery modes [Nikou et Economides, 14]. The provision of assessment system in mobile environment has been an area of research in the last decade. In [Romero, Ventura et De Bra, 09] authors have presented the AHA! Test system that can be used to develop and execute adaptive and adaptable tests in both web-based and mobile devices. The system resolved the problem of authoring assessments only one single time for delivery on very different platforms. In another research work [Santos et al., 11], an approach called “Assessment in situ activities” has been proposed. In this work questions are to be answered in front of a real space. The QuesTInSitu system has been also developed. The software includes both an editor and a player based on the IMS/QTI specification and GoogleMaps. Henke et al. [Henke et al., 14] have described the Test, Examination and Assessment System called TEASE. TEASE can be used via Internet and is therefore suitable for both local and remote examination preparation as well as for examination within lab courses or during lectures. In the study work [Isabwe et al., 12], students participated in iterative design processes of a mobile tablet based peer-to-peer assessment system (P2PASS) for mathematics. P2PASS exhibited several challenges related to the process itself, especially concerning the objectivity in assessment. Referring to [Lin et al., 13], a test-based assessment system running on top of the mobile devices has been detailed. Both pad and phone devices were supported. Proposed system allowed students taking tests on mobile devices.

In the majority of the presented research work above, context is not considered. Therefore, they are not suitable for personalized mobile assessment test generation using context dimensions. Besides, such systems require specific web services based architecture. For this reason, they cannot be easily reused in different fields and for different assessment contexts. The propose scheme encapsulates context dimension reuse and provides personalization of assessment in mobile learning environments. Also, it enables automatic assessment tests’ generation. Context-awareness is one of the drivers of the mobile learning environment. Whereas, a well-designed model is crucial in any context-aware system. Indeed, context modeling and reasoning are essential to consider in ambient intelligence study. In this alternative, authors in [Ranganathan et Campbell, 03] have proposed a first order predicate calculus context model. Based on this model, an infrastructure to enable context-awareness in ubiquitous computing environment has been developed. Another approach [Moore et al., 09] introduced a revised context reasoning ontology and context processing rules.

In order to make full use of context, a model for semantic knowledge retrieval based on context has been also proposed in [Wu et Wang, 08].

To ensure context reasoning, we present in this article a logic based framework formal description. Formal description is based on ontologies and the FOL language. Assessment techniques are formalized with FOL rules which allow to personalize assessment activities.

2.2 Semantic Web Technologies and Mobile Learning

Recently, semantic Web technologies have been increasingly used as a tool for generating, organizing and personalizing e-learning content, including e-assessment [Cubric et Tosic, 11]. The use of ontologies for context modeling in many research works explores the relationship between semantic Web technologies and context modeling. In practical settings, ontologies have become widely used for mobile context modeling since they are reusable and sharable [Wang et al, 04] [Chen et al., 04] [Siadaty et al., 08]. In [Yu et al., 08], a context-aware ubiquitous learning infrastructure called Semantic Learning Space has been proposed. The infrastructure leveraged semantic Web technologies to support explicit knowledge representation, flexible context reasoning, and adaptive content recommendation. Semantic web technologies especially ontologies has been also used as an efficient modeling approach to propose an exhaustive learner model called “learner context” [Laroussi, 12]. In this work the context has been defined as a set of evaluative elements appropriate for the interaction between learner and learning application. In the meantime, a context-aware ruled-based recommender system for the automatic redirection of incoming communications based on semantic Web has been presented [Lemos et al., 12]. The system allowed users to receive any kind of communication through the best channel available depending on his/her context and personal preferences.

However, the use of semantic web technologies to personalize assessment in mobile environments still rarely studied. The role of ontologies in designing assessment resources has been less evoked and only recently, are techniques for ontology-based assessment design strategies starting to emerge [Harchay, Cheniti-Belcadhi et Braham, 12a] [Harchay, Cheniti-Belcadhi et Braham, 12b].

In this research work, an attempt is made to deal with some of the imposed challenges. In fact, most educational systems incorporate solutions for assessment based on unified questions delivered to learners independent of their profiles and competences. Nevertheless, there is clear need for approaches considering the use of personalization approaches in mobile environments for assessment resources generation. The assessment-based approach is built on top of ontologies and semantic annotations.

3 The Personalized Mobile Assessment Approach

The personalized mobile assessment approach presented in this work includes the following steps: (1) Ontological Models Describing the PMAF; (2) Personalized Mobile Assessment Formal Description; and (3) Personalized Assessment Resources

Retrieval Algorithm. The three phases of the approach are described in the following sub sections.

3.1 Ontological Models Describing the PMAF

A survey of the current literature concerning context-aware computing indicates that context dimensions can be summarized in features illustrated in table 1[Verbert et al., 12] [Lonsdale et al., 04] [Gasparini et al., 10].

Context dimension	**Description**
Location	Location captures human-readable and geometric information of objects, including persons and devices, and relationships between objects.
Computing	Computing characteristics can be classified in three areas: network, hardware and software.
Time	Time context includes date and time information.
Physical conditions	Physical context describes the environmental conditions where the system or user is situated.
Activity	Activity context reflects the tasks, objectives or actions of the user.
Resources	Resource context captures relevant characteristics of physical or virtual resources.
User	User context refers to learner modeling. It includes among other: basic personal information, knowledge/performance, learning goals, learning and cognitive styles, etc.
Social relations	Social relations describe social associations, connections, or affiliations between two or more persons.

Table 1: Context dimensions

Modeling the context leads to the design of systems that deliver more appropriate learning content and services to satisfy students' requirements and to be aware of situation changes by automatically adapting themselves to such changes [Bouzeghoub, Do et Lecocq, 07]. Our starting point in modeling context is to identify the purpose of the context we are interested in. For our approach, the purpose is assessment, especially self-assessment in mobile environments. The mobile assessment context refers to dimensions allowing learners to be described in Mobile Assessment Situation [Harchay, Cheniti-Belcadhi et Braham, 12a]. Mobile Assessment Situation (MAS) refers to a set of contextual information defined in a specific period of time:

MAS = {Mobile Assessment Context, Initial time, Final time}; with:

- *Mobile Assessment Context* = {Learner information, assessment resources information, spatial dimension, temporal dimension, mobile device information}.
- *Initial time:* start time of MAS.
- *Final time:* finish time of MAS.

We propose using ontologies to model context. Therefore, to implement the semantic of the proposed PMAF, we propose a set of ontologies: Mobile Assessment

Context (MAC), Mobile Assessment Object (MAO), Mobile Assessment Learner (MAL), and Mobile Assessment Portfolio (MAP). The following sub sections will concentrate on a detailed description of each ontology.

3.1.1 Mobile Assessment Context Ontology

The MAC ontology provides information allowing learner to be described in MAS (Figure 1).

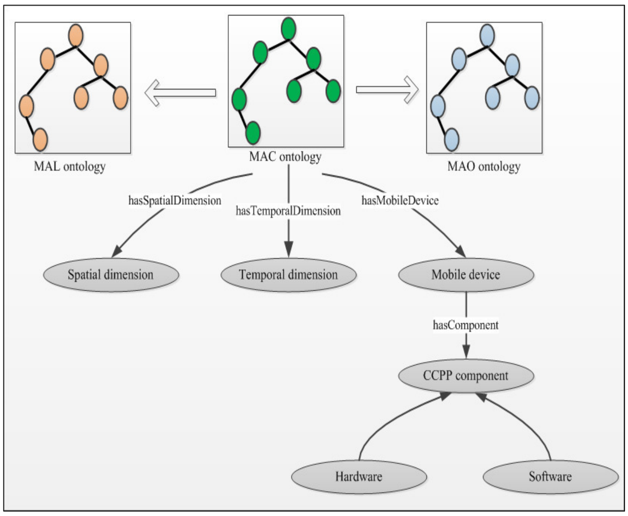

Figure 1: Mobile Assessment Context ontology

As presented in the figure above, mobile assessment context is characterized by five dimensions:

- Spatial dimension to identify the assessment activity location,
- Temporal dimension to specify the start and the finish times.
- Mobile device to describe used device to achieve assessment. The W3C's CC/PP specification [CC/PP, 04] is used to model the device.
- MAO to identify generated questions. A MAO is described using ontology.
- MAL to characterize learner in mobile environment. Learner is also described using ontology. To provide personalization in mobile environments, we need to save all learner interaction. Besides, a MAP is also provided to save learner's interactions.

We present a description of the mobile assessment context ontology:

MAC = {MAO, MAL, Temporal Dimension, Spatial Dimension, Mobile Devices}

MAO = {identifier, MAO_Level, MAO_state, MAO_prerequisites, MAO_objectives, MAO_Interaction, MAO_AccordedTime, body, MAO_Score, correctResponse, feedback}

MAO_Level = {Hard|Medium|easy}

MAO_state = {NotVisited|SolvedCorrect|SolvedIncorrect|VisitedNotSolved}

interactionType = {MCQ|MRQ|T/F|fill in blanks}

body= {MAO_test, MAO_context, MAO_content}

MAO_content = {audio|video|image|text}
MAL = {identification, LearnerAccount, MAL_prerequisites, MAL_Level}
identification = {name, forname, address, contactInfo, demographics, agent}
contactInfo = {email, mobile, telephone, web page}
demographics = {gender, birthdate, place of birth, uid}
agent = {agentid, agentDomain}
MAL_Level = {Beginner|Intermediate|Advanced}
TemporalDimension = {StartTime, FinishTime}
SpatialDimension = {LocalType, Local_description}
LocalType={Private|PublicNoisy|PublicQuiet}
MobileDevices = {components (hardware, software)}

3.1.2 Mobile Assessment Object Ontology

The MAO ontology represents the metadata ontology (Figure 2). It provides the common structure of metadata to index the content of a MAO. MAO ontology does inspire from the IMS/QTI specification. Also, it refers to the ALCoM-Core ontology to model MAO's content [ALOCoM-Core, 10]. The MAL ontology is used to describe learner. A MAO is described using some IMS/QTI attributes: Identifier, URI, MAO_Score, MAO_Interaction, MAO_Level, and Feedback. To these attributes, some others properties are added so as to make a MAO more distinguishable in a mobile environment.

- MAO_DeviceDependency: presents device's type on which a MAO is displayed.
- MAO_LocalDependency: details local's type where a MAO could be presented.
- MAO_AccordedTime: specifies duration to solve a MAO.

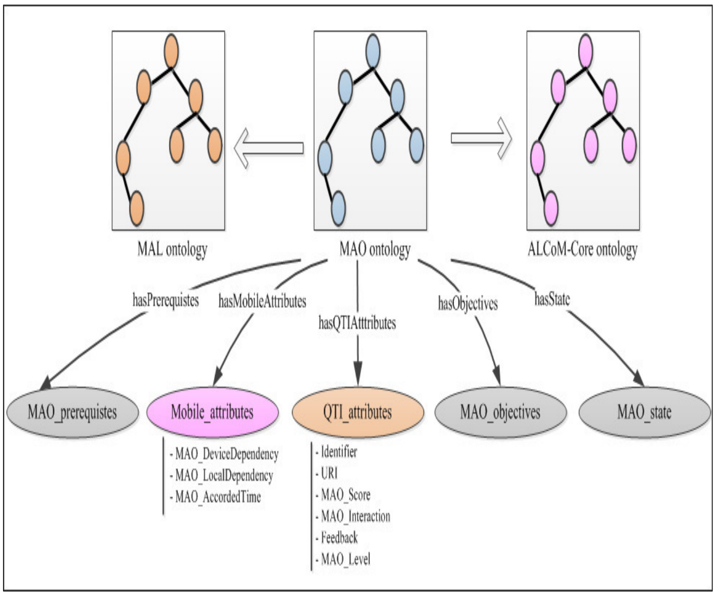

Figure 2: Mobile Assessment Object ontology

3.1.3 Mobile Assessment Learner Ontology

The MAL ontology is used to model learner in mobile environments (Figure 3). It is based on the use of the IMS/LIP specification. Also, it deploys the FOAF and the SIOC ontologies to model learners' social dimensions.

A MAL can be described through: (1) Identification: personal and professional information characterizing a learner, (2) Learner prerequisites and level. The assessment personalization takes into account the competency level to provide assessment content according to the leaner behaviour and competence.

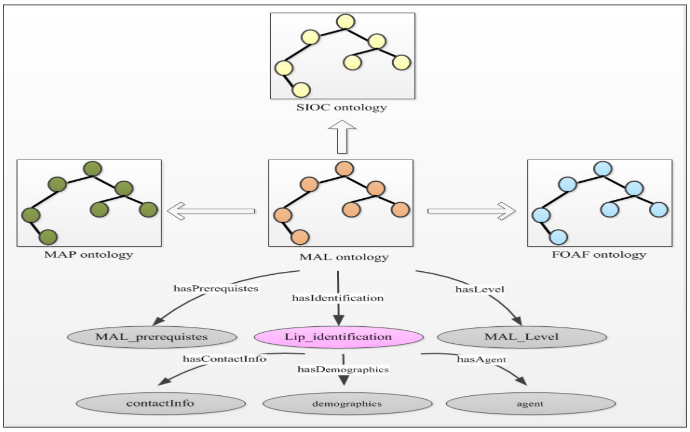

Figure 3: Mobile Assessment Learner ontology

3.1.4 Mobile Assessment Portfolio Ontology

The MAP ontology contains information allowing to characterize the assessment activities history and to save all learners' interactions. As shown in Figure 4, the portfolio is typically created and managed by the learner. The MAP ontology models the following information: identifier, URI, MAO_state, and MAO_Score.

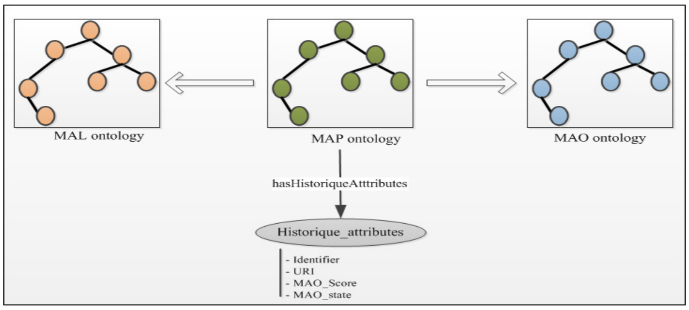

Figure 4: Mobile Assessment Portfolio ontology

3.2 Personalized Mobile Assessment Framework Formal Description

This section provides a logical description of a personalized mobile self-assessment framework. The framework is described with series of FOL rules which can be applied to achieve self-assessment personalization in mobile environments. A system which proposes personalized assessment should manage various types of information to be able to personalize assessment resources according to ontologies described in the previous section. In doing so, it should be able to draw the needs of the learners from observations about their previous interaction behaviors, and dynamically personalize assessment on basis of these observations. Such a system should, therefore, include a personalization component that uses gathered assessment objects fitting to the learner's knowledge and registered performances. Concretely, a mobile assessment framework that performs a personalization self-assessment task needs to represent different types of information [Harchay, Cheniti-Belcadhi et Braham, 12b]: MAL information, MAO information, MAC information, MAP information, and PC (Personalization Component). We define a PMAF as follows:

PMAF = (MAL, MAO, MAC, MAP, PC)

Subsequent, we give details of each of the framwork components.

3.2.1 Mobile Assessment Object Information

MAO information is a finite set of FOL sentences containing atoms and predicates describing assessment resources. We present some predicates used to establish FOL rules.

- *MAO_Score (MAO, val)*; *val* presents the value accorded to a MAO following the learner interaction. *val* can take different value :
  - $val \geq 10$: item correctly resolved.
  - $val < 10$: failure to resolve the item.
  - $val = -1$: the learner has interacted with the item but he/she has not completed all resolution stages.
- *MAO_Interaction (MAO, InterType)*; each MAO is characterized by an interaction with *InterType* = {MCQ, MRQ, True/False, etc.}.
- *MAO_Level (MAO, MAO_Level, LearnerLevel)*; with *MAO_Level* = {Easy | Medium | Hard} and *LearnerLevel*= {Beginner | Intermediate | Advanced}.
- *MAO_DeviceDependency (MAO, Device)*; Device presents the type of device on which a question can be displayed.
- *MAO_Objectives (MAO, Concepts)*; *Concepts* detail MAO's objectives.
- *MAO_Prerequisites (MAO, Concepts)*; *Concepts* form MAO's prerequisites.

3.2.2 Mobile Assessment Learner Information

MAL information is defined through a finite set of FOL sentences containing atoms describing learners. We define the following MAL predicates:

- *MAL_Prerequistes (MAL, Concepts)*; *Concepts* form learner's prerequisites.
- *MAL_Level (Concepts, Level)*, with *Level* = {Beginner | Intermediate | Advanced} and Concepts describe learner's prerequisites.

3.2.3 Mobile Assessment Context Information

To make reasoning on context, the following predicates are used:
- *Compatibility (device, InteractionType)*; *InteractionType* is the item's type that can be displayed on device.
- *LocalType (Local, type)*; *Local* details the assessment location and type = {Private| Public Quiet| Public Noisy}.
- *StartTime*, *FinishTime* are two constants specifying start and finish time of an assessment activity.

3.2.4 Mobile Assessment Portfolio Information

MAP information allows saving the direct learner's interaction with the framework. A MAO can have one of the following states:
- ***Visited***: consists to check whether a learner has visited a MAO. The negation of this state ***NotVisited*** is also used to check if a learner has not interacted with a MAO.
- ***SolvedCorrect***: describe a visited and correctly resolved MAO. The negation of this state ***SolvedIncorrect*** checks if a MAO is visited and resolved incorrectly.
- ***VisitedNotSolved***: specifies a visited and unresolved MAO. The learner has interacted with the item but he/she has not followed all resolution steps.

Initially, MAO is considered as **NotVisited**. Once the learner interacts with, state changes to **Visited**. Thereafter, it may take a particular state (**SolvedCorrect**, **SolvedIncorrect**, **VisitedNotSolved**) according to the **Score** value.
MAP_state (MAO, MAL, visited), presents a MAP predicate specifying that a learner has interact with a MAO.

The interaction generates a score according to the following rule:

MAP_state(MAO, MAL, visited) → MAP_AccordedScore (MAO, value).

According to the score value, the MAO's state changes to:
- *(∀MAL L,∀MAO O (MAP_state (O, L, visited) → (MAP_AccordedScore (O, val)= -1)) → MAP_state (O, L, **VisitedNotSolved**)).*
- *(∀MAL L, ∀MAO O (MAP_state (O, L, visited) → (MAP_AccordedScore (O, val) < 10)) → MAP_state (O, L, **SolvedIncorrect**)).*
- *(∀MAL L, ∀MAO O (MAP_state (O, L, visited) → (MAP_AccordedScore (O, val) >= 10)) → MAP_state (O, L, **SolvedCorrect**)).*

3.2.5 Personalization Component

PC is a finite set of FOL sentences describing personalization functionalities in mobile environments. The PC component is composed of constants and rules. Constants represent mobile assessment resources states. Consequently, we define the constant **Selected** specifying a selected and personalized MAO. This constant and its negation (**NotSelected**) appear in rules. In the following, we present some logical rules:
- A MAO is recommended to be selected if all its prerequisites are acquired by the learner:

(∀concepts C, ∀MAO O, ∀MAL L (MAO_prerequisites (O, C) ∩ MAL_prerequisites (L, C) → PC (O, L, Selected))).

- A MAO having the state ***NotVisited***, ***VisitedNotSolved*** or ***SolvedIncorrect*** can be selected:

(∀MAO O, ∀MAL L (MAP_state (O, L, NotVisited) ∪ MAP_state (O, L, VisitedNotSolved) ∪ MAP_state (O, L, SolvedIncorrect)) → PC (O, L, Selected)).

- A MAO is selected if at least one of its objectives is a keyword specified by the learner:

(∃Concepts C, ∀MAO O, ∀MAL L (MAO_objective (O, C) ∩ keywords (C)) → PC (O, L, Selected)).

The above FOL rules and others are used to personalize assessment activity in mobile environments. However, several logical rules can be activated simultaneously. To effectively exploit MAO, test generation is provided following an assessment resources retrieval algorithm.

3.3 Personalized Assessment Resources Retrieval Algorithm

In the previous section we have presented a component based description of personalized assessment functionalities using FOL. As we have mentioned, several MAO can be selected both. We present an algorithm allowing determining most relevant MAO to be retrieved. A set of meta-reasoning rules are applied to extract assessment objects.

In the following subsections, we will first present the reasoning rules, then the matching method and finally the personalized algorithm.

3.3.1 Reasoning Rules

To generate personalized tests in mobile environment, we assume that MAO are managed by a set of reasoning rules [Harchay, Cheniti-Belcadhi et Braham, 13] containing information distributed in the following components: MAO_DeviceDependency, MAO_AccordedTime, MAO_LocalDependency, MAO_Topic, MAO_objectives, MAO_State, MAO_prerequistes, MAO_interaction, and MAO_Level. Reasoning rules are classified in two categories: filtering rules, and personalization rules.

Filtering Rules

Filtering rules exclude a number of assessment resources from the global assessment resources set. If some ontological model' concepts (context, domain, learner, and portfolio) do not meet assessment features then resources are filtered and are not exhibited to learner.

Personalization Rules

Personalization rules depend mainly on the learner profile. Specially, personalization rules allow to personalize an assessment activity according learner profile and prerequisites.

Occasionally, some rules can be selected both which cause conflicts during reasoning process. Hence, it is necessary to define an order among reasoning rules:

1. Filtering rules have the highest priority because they have the unique ability to exclude all assessment resources do not match assessment activity criteria.
2. Personalization rules have the following ability.

3.3.2 Matching Method

Matching method occurs according three steps that can lead subsequent to generated an assessment test personalized to learner profile and adapted to assessment context.

Step 1: Filtering Rules

The first step consists to filter the initial assessment resources list by excluding resources inadequate to the assessment context. The filter is done following: the mobile assessment activity topic, the MAO_objectives, the MAO_DeviceDependency, the MAO_LocalDependency and the MAO_AccordedTime. This step is followed respecting several constraints.

Step 1 Constraints:
MAO_objectives: a MAO is selected if at least one of these objectives corresponds to an objective specified by the learner.
MAO_AccordedTime: a MAO is selected if the MAO_AccordedTime is less than or equal to the mobile assessment activity accorded time.
MAO_LocalDependency: if the assessment local has the type **Public noisy** or **Private**, then all assessment resources are generated. Else, only assessment resources that do not contain audio content are generated.

Step 2: Personalization Rules

The second step consists to personalize assessment resources according the learner profile. It occurs following two parameters: learner prerequisites and MAO state. Personalization step respects the following constraints.

Step 2 Constraints:
MAO_Prerequisite: a MAO is removed if one of these prerequisites is not acquired.
MAP_State: a MAO whose state is *SolvedCorrect* can't be generated for further assessment activity.

Step 3: Optimization Process

The retrieval algorithm first and second steps result is a list of MAO personalized to learner profile and adapted to assessment context. Mobile assessment objects are not presented in an order that meets maximum assessment activity's objectives. The optimization process step consists to allocate weights to some parameters. Weights help to determine the MAO requisites to be generated first. We assign (w = 5) as maximum weight value.

Parameters involved in assigning weights are: *MAO_Objectives, learner's level* and *MAO's state*. The optimization process respects several constraints.
Step 3 Constraints:

MAO_objectives: Consider the following variables: Nb_choice, Nb_mat, and Nb_ob such as:

- Nb_choice represents the MAO's objectives.
- Nb_ob represents learner assessment objectives.
- Nb_mat represents the number of matches between Nb_choice and Nb_ob.

if (Nb_mat/Nb_ob = 1 and Nb_choice = Nb_mat) then $w \leftarrow 5$
if (Nb_mat/Nb_ob = 1 and Nb_choice ≠ Nb_mat) then $w \leftarrow 4$
if ($0.5 \leq$ Nb_mat/Nb_ob < 1) then $w \leftarrow 3$
if (Nb_mat/Nb_ob < 0.5) then $w \leftarrow 2$

Figure 5 shows an example of objectives weight affectation. The learner specifies three objectives (Class, Objects, and Heritage) representing the Nb_ob variable. 4 mobile assessment objects respecting the retrieval algorithm step 1 and step 2 are generated. For each of MAO, we determine Nb_choice and Nb_mat variables. The quotient (Nb_mat/Nb_ob) is calculated to determine MAO weight.

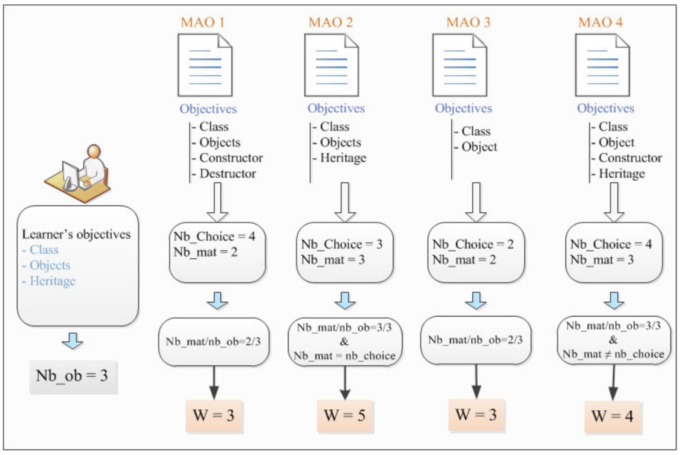

Figure 5: MAO weights affectation

Status: mobile assessment objects never resolved have the highest priority.

if (MAP_state = NotVisited) then w ← 5
if (MAP_state = VisitedNotSolved) then w ← 2.5
if (MAP_state = VisitedSolvedIncorrect) then w ← 1

Learner level: in case of conflict, mobile assessment objects are stored by ascending difficulty order.

3.3.3 Personalization Algorithm in Mobile Assessment Environment

Algorithm requires to follow three distinct steps:

- *Step1:* Filter assessment resources depending assessment context dimensions.
- *Step2:* Personalize assessment resources result's step1 according learner profile.
- *Step3:* Use assessment resources result's step 2 to assign priorities to display mobile assessment objects according weights.

Assume that the initial number of assessment resources, filtering rules, personalization rules, optimization rules, MAO accorded weight are n, F, P, OP, and w respectively. Flowchart shown in Figure 6 presents the personalization algorithm steps.

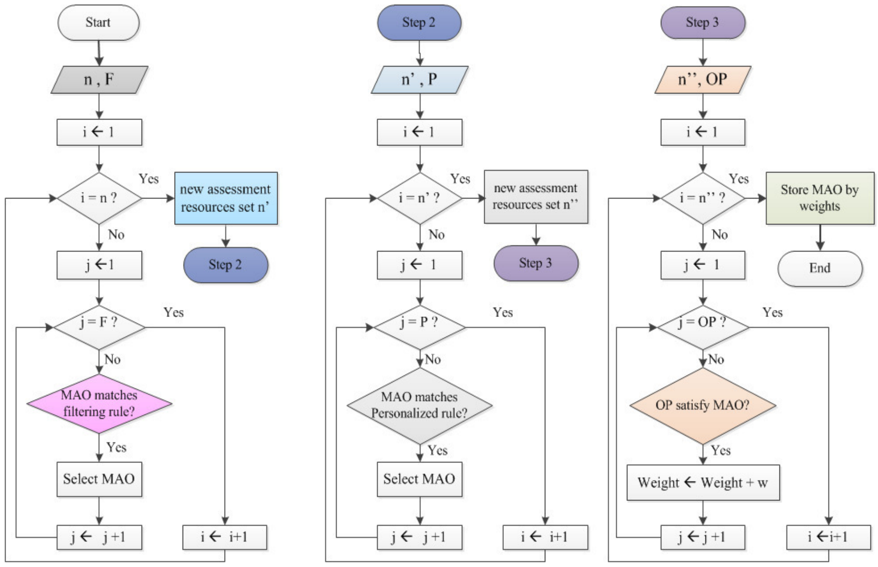

Figure 6: Personalization Algorithm in Mobile Assessment Environment

4 Development of a MobiSWAP System

The MobiSWAP includes basic and ultimate functions that provide learners with appropriate assessment resources considering contextual information. The system is based on Web services and semantic Web technologies. Figure 7 exhibits a global view of the system composed of 3 layers: (1) Assessment Context layer, (2) Semantic layer, and (3) Assessment Resource layer.

The Assessment Context layer manages information data related to learner profile, used device and accessed GLI (Graphical Learner Interface). The GLI forms a knowledge portal illustrated as an interactive assessing tool specifying learner's needs in a mobile assessment situation. The Responsive Web Design is used as an approach that allows web applications to provide an optimal viewing experience across a wide range of devices.

The Semantic layer consists mainly of reasoning components which uses an adaptive engine. It uses Apache Tomcat server to provide the necessary environment to run JSP scripts. The Spring framework is used as an open source application framework and inversion of control container for the Java platform. The Semantic layer provides three distinct features:

1. Mobile Assessment Context Acquisition: represents the first level of our personalization engine allowing detecting context dimensions: local type,

assessment activity accorded time, used device and so on. The system must retrieve the type of used operating system to specify used device (PC, mobile phone, PDA).

2. Mobile Assessment Reasoning: represents the reasoning process that finds out the learner's situation by surrounding information provided by learner or other sensors. It uses the personalized assessment resources retrieval algorithm applying a set of reasoning logical rules.
3. MAO test generation: represents the last step allowing assessment resources generation. It is responsible for displaying resources required by learner.

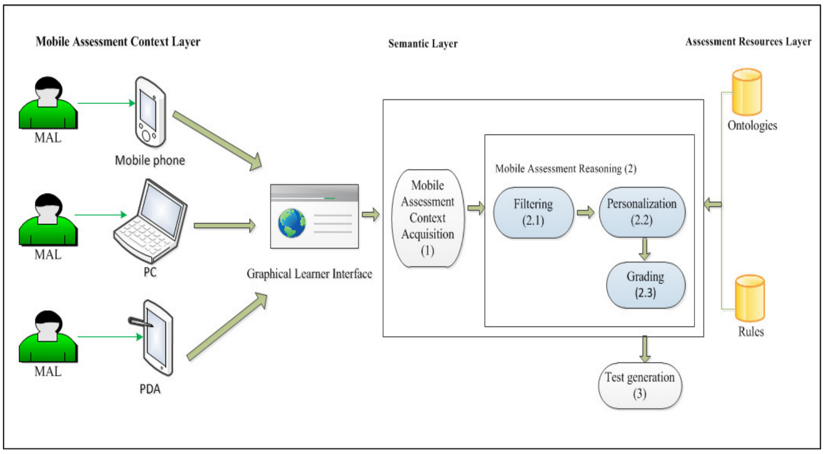

Figure 7: MobiSWAP's Three Level Architecture

The Assessment Resource layer contains used ontologies and logical rules. This layer communicates with the semantic layer to deliver personalized mobile assessment tests.

The MobiSWAP employs the Model View Controller Architecture: for the model, RDF files are used where context information can be managed; for the view, JSP is used; and for the controller, Java and Web services are employed. The system is based on the use of the REST (REpresentational State Transfer) Web Services architecture. Web Services are available to search for lightweight MAO from RDF document. It is worth to note that our objective is to build a system using semantic Web technologies to enable interoperability and reusability of data. It is therefore necessary to choose a semantic Web query language, which enables to query RDF resources. SPARQL is designed to query data conforming RDF data model. It is able to retrieve and manipulate data stored in RDF format. To validate SPARQL queries, the Java API for RDF Jena is integrated. Jena is used to create and manipulate RDF graphs and to construct semantic Web applications.

The system collects context information. It queries the MAO ontology, the MAL ontology, and the MAP ontology. Then, it applies the personalized assessment resources retrieval algorithm. Finally, a personalized mobile assessment test related is generated. Figure 8 illustrates a mobile assessment test in a mobile phone. Learner access the system using a personal account (first interface of figure 8). Then, he/she specifies assessment information: assessment topic, assessment keywords and assessment local type (second interface of figure 8). Based on specified information, a personalized mobile self-assessment test is generated (third interface of figure 8). Finally, learner interacts with the test and the final score in shown (fourth interface of figure 8).

When specifying the assessment topic, the MobiSWAP uses a domain ontology bringing concepts related to object oriented programing courses. Concepts are presented as assessment keywords.

Figure 8: Personalized Mobile Assessment Test Generation in mobile phone

Our MobiSWAP has some personalization features to allow self-assessment tests generation:

- Learner must create a personal account when he/she uses the system for the first time. He/she may determine his learning prerequisites. The generated self-assessment test is personalized for each learner following its prerequisites and pervious system' interactions (using the MAP information).
- When learners start the application they have to identify themselves by introducing their login and password.
- If a learner executes an assessment test, then the elapsed time for each question is shown on the screen.

Also, it provides some adaptable features:

- The mobile assessment test is adapted to the local type. In a public quiet local, questions having audio or video content cannot be generated.
- The mobile assessment test depends also on the used device. Some questions can only be displayed on large screen.

5 Experimental Results

The objective of this evaluation is to find results that help us to validate the following statement: "Personalized and adaptable assessment activities that facilitate student's learning in mobility can be achieved with the MobiSWAP". We have carried out experiments with university students. Our objective is to evaluate student's results and satisfactions when they take various scenarios tests evidencing the value and the performance of the system.

5.1 Description of the Experiment

We have used two different platforms: PC (students own laptops) and mobile phones (students own cell phones). The main differences between the two platforms are inputs (methods used: full keyboards and mouse versus touch screen) and output (the size of the screen). We select 40 computer sciences students at the Higher Institute of Computer Science and Management of Kairouan, in Tunisia.

Before preceding the experiment, students have made a pre-test to determine their levels in object-oriented programming (OOP) course. The pre-test was composed of 20 multiple-choice items giving a score of 100. Table 2 shows the pre-test results. The Cronbach's α value [Tavakol et Dennick, 11] of the per-test was 0.92. This value shows the high reliability of the test.

n	min score	max score	mean score	median score	SD score	score > = 50 (n')	score < 50 (n'')
40	0	100	59,625	70	32,456	27	13

Table 2: Pre-test's results

Pre-test's results divide students in two groups:

- Intermediate level is assigned if the score value > = 50 (n'=27).
- Beginner level is assigned otherwise (n''=13).

After the pre-test, students follow three scenarios verifying personalization and adaptable features of the system. Scenario 1 consists to test the MobiSWAP functionalities as part of a formal educational scenario based on the use of the Web. The experimentation local is a computer lab and the used devices are PC. Scenario 2 consists to test the system as part of a formal educational scenario based on the use of mobile devices. The local is a computer lab and the used devices are mobiles phones. Scenario 3 aims to test the MobiSWAP as part of an informal educational scenario. The local type is the university yard and the used devices are PC and mobiles phones.

The MobiSWAP is composed of 80 multiple choice OOP questions (assessment items) with three possible answers of which 1 or 2 are correct. Items have two different levels: easy and medium.

5.2 Research Question and Objectives

The experimentation was realized to with the objective of answering the following main research question: "Can the MobiSWAP support personalized and adaptable assessment activities by facilitating learning in mobile environments?". In order to satisfactory answer this question the results obtained after the evaluation of the experimentation must demonstrate that the MobiSWAP accomplishes the following features. It must be able to:

- generate self-assessment tests depending students' levels. Students have to be able of answering questions regarding their knowledge levels. Besides, students follow the ***[test 1]*** and compare generated tests (with the same assessment parameters) for two student's level (beginner versus intermediate students).
- allow to take inti account the assessment activities achievements and history when generating self-assessment tests. The students have to be able of personalizing question's generation with their system's interactions. To verify this functionality, students track the ***[test 2]*** by comparing generated tests when they use the MobiSWAP for many times (first system's interaction versus others interactions).
- consider assessment parameters when generating self-assessment tests. Students are invited to follow the ***[test 3]*** and to compare tests when they change the assessment parameters (objectives, keywords and accorded time).
- generate self-assessment tests depending on the used platform. The test has to be adapted to the used device. Students must compare generated tests when they change platforms (PC versus mobiles phones) and follow the ***[test 4]***.
- consider the local type when generating tests. Students have to compare by following the ***[test 5]*** tests when they change the local type (public quiet versus public noisy).

Test 1, test 2 and test 3 allow to verify the personalization features of the MobiSWAP while test 4 and test 5 verify the adaptable ones.

5.3 Methodology and Gathering Techniques

The aim of this experiment is to identify the personalization and adaptable features of the system. To this end, the mixed evaluation method proposed par Martinez et al. [Martinez et al., 03] has been selected due to the characteristics of the educational context. The mixed method combines quantitative techniques and sources, such as closed questions or event log files generated automatically by the system, with qualitative techniques, such as open-ended questions and first-hand observations [Pérez-Sanagustín et al., 12].

To evaluate the case study according to the mixed method, students' perceptions about the experiment were collected in a paper-based questionnaire delivered immediately after the experiment. Questionnaire allows evaluating personalization and adaptable system' aspects. It permits also to determinate student's satisfactions evidencing the MobiSWAP's performances. This data is also combined with noted observations gathered by the examiner that followed the students during the experiment. To justify obtained results we have analyzed students' interactions stored in the Mobile Assessment Portfolios (log files) as described in section 3.1.4.

5.4 Performance of the Students

To perceive the personalization and adaptation system’s aspects, five tests were executed. At the beginning, students execute PC test and phone test in a public quiet local (computer lab). Then, they change to a public noisy local (university's yard).

Table 3 shows the percentage of students who have observed the personalization aspect of the MobiSWAP after the execution of ***[Test 1]***, ***[Test 2]*** and ***[Test 3]***. Students were even asked to assign a score to evaluate each test. All items were measured on a seven point Likert-type scale with 1 corresponding to "strongly disagree" and 7 to "strongly agree".

	[Test 1]	**[Test 2]**	**[Test 3]**	**Total**	**min score**	**max score**	**mean score**
Beginner	76.92% (n = 10)	38.46% (n=5)	53.85% (n=7)	53.85% (n=7)	1	7	3,54
Intermediate	88.89% (n=24)	77.77% (n=21)	77.77% (n=21)	92.60% (n=25)	2	7	5,86

Table 3: Results testing the MobiSWAP personalization feature

We can see in table 3 that the intermediate students have increasingly observed the MobiSWAP personalization feature then beginners ones analysis (92.60% through 53.85%). Similarly, intermediate students have better noted the feature (5.86 through 3.54).This result is mainly justified by the analyze of the mobile assessment portfolio file and the comparison of the number of items answered correctly, the number of items answered incorrectly, and the number of unanswered items for each student’s level (see Table 4). In fact, beginners students faced more difficulties when they use the system. This result is mainly due to the difficulty of OOP course content. Indeed, most of them believe that the generated tests are more difficult than their levels.

	Correct	**Incorrect**	**Without answer**
Beginner	35.35%	64.65%	00.00%
Intermediate	69.90%	30.08%	00.00%

Table 4: Students tests execution results: correct, incorrect and unanswered items

To verify the adaptation feature, students execute the Test 4 (change platform) and the Test 5 (change local type). Table 5 highlights that the adaptation feature was clearly appreciated by both groups. The two groups emphasize the MobiSWAP adaptation feature with an affirmation of 69.23% for the beginner group against an affirmation of 88.88% for the intermediate group.

	[Test 4]	[Test 5]	Total	min score	max score	mean score
Beginner	69.23% (n = 9)	84.62% (n=11)	69.23% (n=9)	1	7	5,08
Intermediate	92.59 (n=25)	88,88% (n=24)	88,88% (n=24)	1	7	5,41

Table 5: Results testing the MobiSWAP adaptation feature

5.5 Students' Opinions and Personal Comments

We have also carried out a survey among all the students in order to determine their satisfaction and opinion regarding the MobiSWAP performances. The questionnaire was designed to gather information on student's attitudes towards aspects of the self-assessment in mobile environment as well as towards some more specific aspects of the system. The questionnaire was composed of 4 questions:

1. How much do you prefer to use the system for mobile assessment?
2. How useful is the system for self-assessment in mobile environment?
3. How much do you like the navigation process and the user interface?
4. How much do you like the assessment process (question generation, instant correction, and score affectation)?

Students use a Likert-type scale (7 points). In table 6, we show the mean value of the rating on: preference, usefulness, rate of acceptance of the user interface and the navigation method, and the assessment process.

	Preference	Useful	Interface and navigation	Assessment process
PC	5.94	5.74	6.21	6.12
Mobile phone	5.69	5.89	5.4	5.3

Table 6: Student's opinion about the MobiSWAP performances

The analysis of the table 6 shows that the first question (preference) and second (useful) have no significant differences between the two platforms unlike other questions. We believe that this may be due to the fact that the two questions are relate to more subjective and abstract concepts and are therefore more difficult to evaluate. PC test receives the most favorable evaluation in almost all the questions (see table 6). Students prefer to take assessment tests on a PC. They consider that they have a better input method, a more readable interface and an easier navigation method. However, they consider that the assessment tests are more useful on mobile phone as on PC.

Students can also write reviews with the questionnaire where they indicate the main advantages and disadvantages of using the system. Among the benefits we identified:

- Practice in the free time: students think that the system will perform assessment activities in their free time (while traveling, waiting for public transport, etc.). They can take personalized self-assessment tests especially when they cannot use PC.
- Utility in classroom: students feel that the generation of the system for others assessment formats (diagnostic, formative, and summative) can be very helpful for assessment activities when the number of students in classrooms is greater than the number of available PC. They can use their own mobile phones for assessment.

Given these advantages, learners feel that the main disadvantages of the MobiSWAP are due to:
- Tiny buttons and small screens on mobile phones: Some students believe that the mobile phone input methods cause problems. Most of them believe that the small screens degrade their concentration especially to answer programming questions.

The obtained results justify student's motivations to use the MobiSWAP as an effective tool for personalized self-assessment tests in mobile situations limited by a specific time. Results affirm also that the system presents a useful tool for preparing exams despite students prefer to take tests on large screens. This is interpreted by the student's habits to use small screens for entertainment activities such as: Facebook, email, online games, etc.

6 Conclusions

Mobile assessment is a fundamental task in the educational context, because it allows learners to get information anywhere, anytime, and any device. In this paper, we have presented an approach based on semantic Web technologies to support personalized self-assessment in mobile environments. Our assessment method is built on the top of ontologies, semantic annotations, and a personalized algorithm allowing assessment resources retrieval. The algorithm operates based on constraints and logical rules for automatic assessment resources generation.

To validate our approach, the MobiSWAP is developed. The system combines and implements a composition of Web Services based on REST architecture. Web Services generate assessment resources according to the set of specified ontologies. The system deals with a set of ontologies and specifications to promote interoperability. It is also considered to be conformed to the IMS/QTI specification in order to ensure exchange of assessment resources. Indeed, the annotation of resources, aligned with the eLearning standards, assists personalization and reuse of resources for different learners. The MobiSWAP can be used and adjusted for different application domains. This is accomplished via a coherent approach in which various independent components are assembled and each one serves for a specific need. The system provides an open and modular architecture able to exchange information and share components with standards and protocols with different scenarios and implementations.

The efficiently of the system is also provided. Preliminary results are encouraging. In particular, they denote the respect of the two aspects of personalization and adaptation. In addition, they confirm that the system can be used by a large community of students as soon as the tool is hosted and generated for several domains.

In the future, we will focus on the evaluation of the system with students with different background and profile (such as medicine, mathematic or physics students). Finally, we hope to add more types of assessment items (such as matching pairs questions, ordering questions and others) and to use the system with others academic courses (such as mathematics, physic or chemistry).

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