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TOWARD AN ONTOLOGY-BASED APPROACH OF CONTEXT-AWARE

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Abstract- The context-aware mobile learning environment can dynamically load a variety of information's from its external environment of execution, and that information's called a context. The mobile learning environment adapts dynamically its execution according to this context. The main challenge in context-aware M-learning system is context ontologies, it represents the most part for context modeling. In this paper, we propose an ontology-based approach for modeling context-aware in an adaptive mobile learning environment.
Keywords- Mobile learning, Adaptive learning, Ontology engineering, Context Awareness, software engineering.

1. INTRODUCTION

With the rapid progress of mobile computing technology and network connections, mobile learning has gained significant potential in the field of e-learning and the new teaching approaches[1],Learners are in the center of the learning process and they are provided with adaptive learning experience related to their personal characteristics and educational objectives. In general, adaptation can be done based on the learner profile, learning content, in this paper, we explore anadaptation approach that can be done on the learning environment. In order to provide adapted services for the learner, applications and services should be aware of their contexts and automatically adapt to their changing context-known as context awareness. Context is any information that can be used to characterize the situation of an entity. An entity is a person, place, or object that is considered relevant to the interaction between a learner and an application, including location, time, activities, and the preferences of each entity[2]. Context awareness is increasingly taking applicability in pervasive mobile computing, this paradigm refers to the idea that the context-aware mobile learning system should be able to capture, analyze and manage every state of the learner, his external environment and adapt its reactions to the current situation needs[3].

Using ontology to model the context-aware in the mobile learning environment has already been proposed in many approaches, but most only offer a weak support for adaptation services, knowledge sharing, context reasoning, and context information presenting. Ontology modeling has proved an effective way to deal with context awareness in the ubiquitous learning environment for the following reasons[4]. 1. Ontologies are a powerful tool to deal with knowledge sharing and information reuse. 2. Ontologies enable context-reasoning and interoperability in a pervasive computing system. 3. Ontologies play a major role in semantic description modeling of information. The ontology represents a description of concepts and their relationship; these models are very promising for modeling contextual information due to their high and formal expressiveness and possibilities for applying ontology reasoning technics[5]. Ontologies in education can be used in the various field, they include domain modeling[6], context modeling and reasoning[7], learning object creation[8] and semantic context-aware reasoning[9].

In this study, we propose an ontology-based approach for modeling learner contextual information in order to provide learners with appropriate content related to their context of learning. This paper is structured as follows: In section II we explore the notion of context awareness and his relation with adaptability; in section III we introduce our context-aware modeling based on ontology and semantic web and we conclude in the last section.

2. RELATED WORK

The most relevant approaches presented in the literature for modeling a context-aware are [10],[11],[12]:

2.1 Key value models

In this model context information is presented as a key-value link process, the key presents the information identity and value present the current value of this information (e.g. Set location=room_1). The advantage of this model is the facility of implementation however it presents an inconvenient of information expressiveness for more sophisticated structuring purpose.

2.2 Graphic model

This model uses a unified modeling language (UML) to model the context. In particular this model is useful for structuring context information, but usually not used on the instance level.

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2.3 Markup scheme model

This model is an XML based model, it uses markup query language method to retrieve context information and is defined as an extension of composite capabilities (preference-profile)[13], user agent profile(UA Prof) encoded in RDF.

2.4 Object-oriented model

The main intention behind object orientation model is encapsulation and reusability that offer oriented object programming.

2.5 Logic-based model

This model provides a high level of formality, the context in this model is defined as facts, expression, and rules, however, it presents an inconvenient such as dealing with uncertain or conflicting information.

2.6 Ontology-based model

Ontologies are very powerful tools for modeling context in a mobile environment; the context is modeled as concept and fact based on reasoning methods for retrieving context information. It presents a formal model of context that can be shared, reused, extended and combined. As an example; SOCAM [14] (Service Oriented Context-Aware Middleware), COBRA[15] (Context Broken Architecture) are context-aware middleware's that provide specifications and requirements to develop a context-aware system but all offer a weak support of general adaptation service. The advantage of ontologies resides in the semantic description of context information and reasoning technics engines. According to [16] context modeling should be satisfied with five requirements:

Distributed Composition (DC): Mobile learning systems are a distributed system, with no central instance responsible for the creation, deployment, and maintenance of information.

Partial Validation (PV): In a context modeling approach, it's highly recommended to partially validate contextual knowledge on the structure as well as on instance level (against a context model in use) because of the complexity of the contextual information relationship.

Richness and Quality of Information (RQI): The quality of contextual information captured by sensors varies over time, so, the context modeling should be aware of that and take advantage of it.

Incompleteness and Ambiguity (IA): The model should be aware of uncompleted information captured (e.g. Interpolated instance).

Applicability to Existing Environment (AEE): The context model should be implemented and deployed within an existing platform.

Context Adaptation (CA): The above-mentioned requirements are important to model a context in a ubiquitous environment such as M-learning; however, we find that another requirement should be added to this list in order to deal with learning adaptation.

The context-aware model should be aware of learner contextual information, and use them as input data to provide adapted output content.The Key value model validate one of the requirements, XML-model, graphics model, logic-based model validates more than one. Ontology and oriented object model validate all the requirements, only the ontology provides a better understanding of context information and a better validation of partial validation. We summary the entire requirements in the table as follow:

Context-aware requirements pattern using ontology [5] [17].

APPROACH	REQUIREMENTS					
	DC	PV	RQI	IA	AEE	CA
Key-Value Model	-	-	-	-	-	-
Markup scheme Models	+	++	-	-	+	-
Graphical Models	-	-	+	-	+	-
Oriented Object Models	++	+	+	+	+	-
Logic-based Models	++	-	-	-	++	-
Ontology-based Models	++	++	+	+	++	++

3. TOWARD AN ONTOLOGY-BASED APPROACH OF CONTEXT-AWARE

The future of technology and software engineering in education’s gradually converted from "software-centric" to "Learner-centric" named Learner experience. It's primarily important to provide learners with accurate, efficient and adapted information related to their context of use as context-aware which result in a great learner experience with the software.

Context is any information that can be used to characterize the situation of an entity, an entity can be a person, location, time, device or object that is relevant to the interaction between a learner and a software[2]. Adaptation through context play a major role in the process of the learning experience, it provides the appropriate content for learner based on his contextual information. In addition, applications and services should be aware of their context and automatically adapt their behaviors to the current detected context as context-awareness.

In mobile learning a context-aware can provide a significant adaptation of their services to the learners' needs, it should be able to detect, interpret and use context information such as location, time, and any information that can be used to improve an adapted learning process.
The learning context is a critical aspect in the field of mobile learning. In recent years a new focus has been formulated, the learning process is changing the way learners learn and progress, the new approach focuses on the creation of mobile learning environment that supports adaptive learning as well provide personalized learning scenario to learner profile based on his context of use. Context is one of the key issues for adaptive learning; in this paper, we propose a new approach for modeling a context-aware adaptive learning environment in order to meet learner needs. This approach is based on five elements as follow:

- Spatial Context-awareness
- Temporal Context-awareness
- Learner Context-awareness
- Device Context-awareness
- Vector Context-awareness

All elements are briefly detailed in the next section.

3.1 Spatial Context Awareness

We find that spatial location of learners is an important factor in order to provide content related to his location, we aim to propose a metadata that defines the Spatial Context, this metadata is based on the following attributes.

SpatialContext Meta-Data

Meta-Data	Description
_LocationName	It presents the location name (e.g. FST_LIM). FST: Faculty of Science and Technology.
_LocationType	It presents the location type (e.g. LIM is a laboratory of computer science in FST).
_LocationProperties	It presents the properties related to learner location, in some cases, the context-aware environment should be able to detect and manage the characteristics of the environment. (e.g. location with a high level of noise, the system should manage the volume level of the device).
_GeographicPosition (Latitude, Longitude):	We attempt to use the global spatial database (e.g. GeoNames server) to collect name, address and type of location in use (e.g. learner is located in LIM laboratory, so we provide him recent content related to computer science).
_ConceptInterrelationship	Ontology and semantic web provide a variety of semantic relationship to determine constraints between concepts presented above.

We present spatial context-awareness as a SpatialContext; the figure shows a brief taxonomy of concept and their semantics relationship.

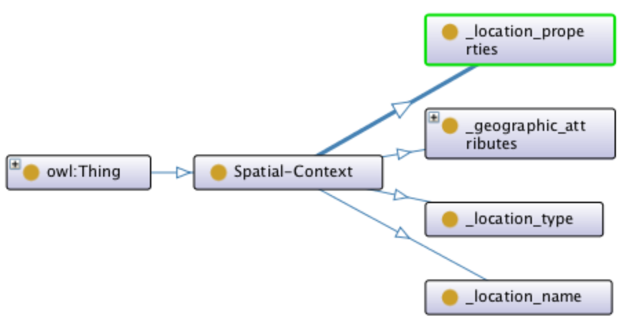

Fig 1 Spatial Context Ontology

3.2 Temporal Context Awareness

Also, we find the temporal context of learner an important factor in the adaptation mechanism. ISO 8601[17]provides a full standard way to write a date, time of day, UTC, Time, etc. In this case, not just we adapt learning content to learner location but also, we provide him options to select his appropriate learning timing. The recent OWL Time ontology provides a full representation of time[18].
We aim to propose a metadata that defines the temporal context; this metadata is based on the following attributes:

Temporal Context Awareness Meta Data

Meta Data	Description
_TimeOfDay	It presents periodic timing of learner (e.g. Night).
_DayOfWeek	It presents the day of the week (e.g. Sunday).

_MonthOfYear	It presents the month of the year (e.g. April).
_FreeTime	It presents the free time of the user.
_SeasonOfYear	it presents the season of the current year.
_Date-Time	It presents a description of date and time structured with separate values for the various elements of a calendar-clock system, the temporal reference system is fixed to Gregorian Calendar, and the range of year, month, day properties restricted to corresponding XML Schema type xsd: gYear, xsd:gMonth and xsd:gDay, respectively.
_Clock	It presents the current clock system e.g. learner start learning at 10:00 pm.
_TimeZone	A Time Zone specifies the amount by which the local time is offset from UTC. A time zone is usually denoted geographically (e.g. Australian Eastern Daylight Time), with a constant value in a given region. The region where it applies and the offset from UTC is specified by a locally recognized governing authority.
_TimePosition	A temporal position described using either a (nominal) value from an ordinal reference system or a (numeric) value in a temporal coordinate system.
_Laps	it presents the interval timing of learning related to the context of the learner (e.g. Learner in a bus has 30 min of the road then Laps =30min), we use relations provided by Allen and Ferguson[19] to represent laps of learning time. (E.g. StartTime indicate the start of the learning process).

We present Temporal Context awareness as Temporal Context; therefore, this context has been described into three categories: Abstract Time (Refer to concepts or events; they have no physical referents e.g. SeasonOfYear attribute), Concrete Time (Refer to concepts or events; they have a sense e.g. Laps) and Learning Time (Refer to concept; the learner has learning time affected to him and it will be calculated each month).

The semantic description in ontologies can be a powerful tool in order to connect the interrelationship between abstract, concrete and learning time as Los (Learning Objects); an example of that (has begun, has duration, has time, has end etc.), this semantic description is more significant in daily learner life.The figure shows a brief taxonomy of concept and their semantics relationship:

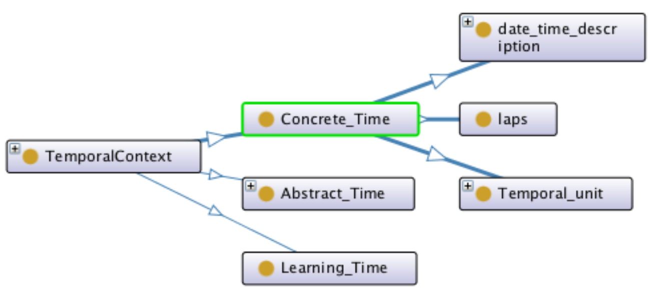

Fig 2 Temporal Context Ontology

3.3 Learner Context Awareness

Learner plays a major role as an actor in an adaptive learning environment, each learner is characterized by different attributes related to his profile. We aim to propose a metadata that describes learner profile as following:

Basic information: First name, Email, Tongue mother, etc.

Dynamic information: Company, Institution, Job title, Learning style, Interest, Heath, etc.

User Type: Learner, Author, Administrator, Etc.

The figure shows a brief taxonomy of concepts:

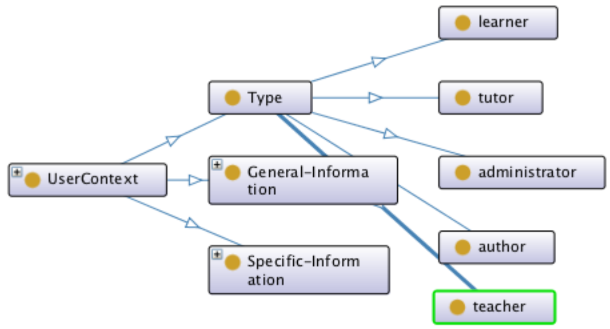

Fig 3 User Context Ontology

3.4 Device Context Awareness

In order to adapt learning content to mobile devices, it's necessary to know the physical properties of this device.Mobile device technology is characterized by Portability, Small Size, GPS, Wireless Communication, Battery Life, etc.

A remarkable study on device description ontology has been published such as WURF (XML file), composite capability/preference (CC/PP) (RDF use), W3C 2007, Fipa device ontology (OWL ontology), UAProf (User Agent Profile). Under the name Device Context, we propose our ontology based on three categories:

GeneralDeviceInformation: this category shows general information related to the device such as device name, device type, vendor.

HardwareDeviceInformation: this category collects hardware information about the device used by the learner such as CPU, Memory.

SoftwareDeviceInformation: this category collects software information such as OS version, web browser, apps installed.

All information collected is used with user permission and it's used for adaptation purpose, the figure shows a brief taxonomy of concept and their semantics relationship:

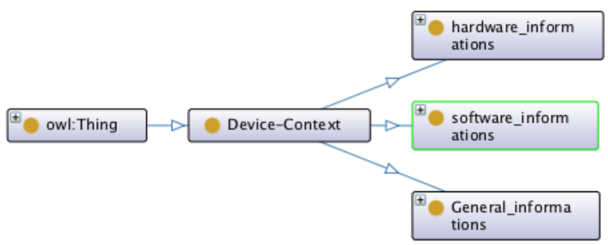

Fig 4 Device Context Ontology

3.5 Vector of Context Awareness

In order to model a learner context ontology, all model cited previously are grouped in a vector of context-aware,this vector presents all RDF objects.

Let's take C as learner context, a vector of context can be noted like, V(c) ={X(s), X (t), X (L), X (d)}, With X (S) as SpatialContext, X (T) as Temporal Context, X (L) as Learner Context and X (D) as Device Context.

V(c)= ((Bus, Public, Noisy, Tangier, Morocco), (2017-14-7,10:00pm, Monday,1H),(Level_1, English,27), (iPhone,4G, iOS8.0,Battery life, apps installed")).

The figure shows a brief taxonomy of models:

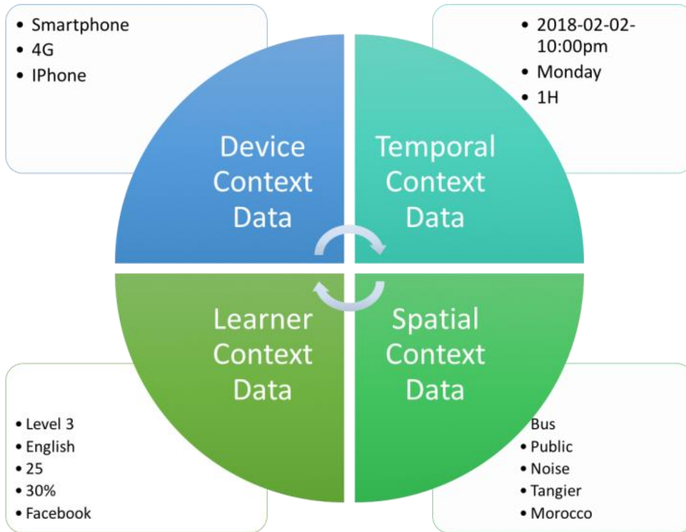

Fig 5 Vector Context Ontology

4. CONCLUSION

In this paper, we introduce an ontological approach for service adaptation in the context-aware mobile learning environment. therefore, we proposed, firstly, a context model which is generic and open to allow its extension to various changes based on learner needs. Then we perform a model execution in order to generate an OWL ontology that represents learner context aware. The generated OWL ontology is then used to extract high-level adaptations situations. also, we have proposed a semantic context-aware service, represented by extending OWL-S. This approach uses the power of ontologies and semantic web to represent and reason about context and perform service adaptation to learner needs according to their context.

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