# Ontology Traceability for the Adaptation of Services in Pervasive Environment

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***Abstract*—Recently, interaction with computer applications in a pervasive environment benefit increasingly from mobile technologies. These technologies generally attribute to these environments of physical and social properties. Therefore, the adoption of these technologies ensures more flexibility and creates new forms of use. The consideration of the context of use in pervasive interactive applications is a field of research known as *Sensitivity to context* or *context-awareness*. A sensitive application context must be able to manage the context information in order to provide adequate services. The inclusion of these two components is made the object of our contribution. Indeed, to achieve the context management, we adopt the concept of ontology through basic universal descriptions of domain context awareness. Presenting the context of management models based on ontology it's very important to adapt the context sensitivity application. This paper presents a formal Context-awareness model based an ontology traceability to provides adaptive services in order to accomplish a specific goal at any moment and any place. The proposed ontology traceability will be integrated into our context platform adaptation platform. In addition, this kind of traceability allows the supervision and management of what is happening at the environment and, in consequence, to improve the service of information visualization offered to users.**


## I. Introduction

The pervasive interactive system has particular characteristics which perform a complex problem due to their context-awareness. For the satisfaction of focus user to his tasks, applications must be able to operate in very dynamic environments. The huge numbers of users evolving in these ambient systems are themselves a source of dynamic. Their requirements, their preferences and consequently their behaviors are able to evolve. Pervasive systems are aimed at making information available anywhere, anytime. These systems must be used in different contexts depending on the user environment, its profile and the terminal being used. In pervasive environment, the application must be aware of the context of the devices, human services and entities that are presented in this ubiquitous computing environment to adapt any changes and to be sensitive to the context of use.

In this paper, we present a formal context-awareness model based on ontology (OWL) integrated a Virtual Contextual Card (VConC) to support various tasks in user pervasive application. It supports semantic context representation by defining the key dimensions of context elements to describe context information in a general manner (upper level) and provide a set of low-level ontology's that will be applied to the area of context awareness. It models the contexte by the basic concepts of person (his activity, his task and his role), location, environement, and device, by describing the properties and relationships between these concepts. Our context model captures various contexts by generating a Virtual Contextual Card: it captures the relationships between the different context information related to current contextual situation and associate the connection parametrs to the property associated with a specified context class. Next, it provide the use of a context reasoning engines to reason about various contexts for the building and rapid prototyping of context-aware services in pervasive environments. This paper is organized as follows. Section 2 explores the discussion and related work. In section3 we describe our ontology model contribution to adapting context in pervasive environment using OWL. Our proposal is to integrate formal model contex-tawareness based ontology traceability and Virtual Contextual Card to adapt the pervasive contexte. Section4 introduce a prototype for adapting context. Finally, we conclude and give an outlook toward future work in section6.

## II. Previous Work: Classifications of Existing Context-Awareness Modeling Approaches

The idea to use the context of user comes from the domain of CSCW and the HMI (Humun-Machine Interaction)[1][2]. Indeed with the advent of ambient informatics as a new potential type of context information, an adaptation to a terminal type and to user type has to be assured in order to guaranties a comfortable use of applications in these new environments. To adopt taking into account context in the ambient interactive applications is a necessity, that does a new research is known sensitivity of context. In literature,[3] is the first who defines the context awareness, it as an emotional state of user, its attention interests, its orientation, the date and the time where it evolves the objects and the persons that exist in its environment. Much research has been done in the area of context-awareness computing in the past few years. Many authors have defined a context modelling approaches. In this section, we supply a classification of the existing context models in two namely family: Model-based context approach and the Ontology-based context approach. Then, we review and discuss the more important context modeling approach.

*Model-based context approach:* A large number of existing context-awareness approach use a relational database to represent context and managed it [4]. Represent the context by these models is only generally made for specific applications which also have a special treatment. These models are exploratory, lack formality and expressiveness.

*Ontology-based context approach:* In literature, the representation of context-awareness of interactive system is the structuring of information of this context according to a given model. In [5][6], the Composite Capability / Preference Profiles: CC /PP) is a recommendation of W3C that enables to create profiles describing the final capacities of a terminal and the preferences of user through a multi-level structure according to formalize RDF. However, CSCP does not allow describing the relations between the information of modulated profile which evokes a problem at the adaptation level.

[7] proposed CONON (context ontology) OWL-based context ontology in order to modulate and represent the context in an ambient environment. Then CONON defines an ontology of high level with general basic concepts to define a context .For the adaptation, the reasoning on the context in based on mechanisms of interpretation and logic reasoning which is done to verify the coherence of context for the aim to deduce an implicit context of high level from an exploit context of low level. In CONON, a mobile phone for example could be adapted to the context of a call phone of User. For example if the user is sleeping in his room or is taking a shower in the bathroom, the coming calls will transfer to the phone mail box.

An extension at the ontology based context interpretation level appears with COBRA ONTO (context Broker Architecture) [8], this approach enables not only to modulate the context but also to think about the described data through intelligent agents. For a detailed context modeling, the ontology CoBra-ONTO focuses on context modeling and offers to the system the possibility of reasoning about collected information through a multi-agent system. In using CoBra-ONTO, the adaptation to context of interactive applications produces through the creation of activities among agents. Or, each sensor (considered an agent) describes the data which the collected. Consequently, these data are shared among the agents of each application. This share of data enables multi-agent CoBra-ONTO system to reason on the information of context and to perform as result an adaptation at the level of the use in interactive applications. The major advantage of CoBra-ONTO is the use of ontology which by definition enables the share of data and the reasoning on its context-awareness in the intelligent ambient environments.

The SOCAM project[9][10] offers a distributed middleware for context awareness in ambient environments. It wants to convert the diverse physical spaces (captured context) to a semantic space where the context may be shared and give to context-aware services.

For its contextual modeling, SOCAM uses the ontology pervasive which describes the information characterizing the environment of execution and the application in its globality. The architecture SOCAM understand a specific ontology in the domain of application as well as other different components figured in the following: - A context providers: It captures the contextual information of different heterogeneous sources of the user's environments and the application. The nest stage enables the conversion in representation OWL i order to share and reuse of the context; - A context interpreter: It enables to provide logical reasoning services based on the representation OWL of context in applying chains of interpretation rules; - A Database context: It enables to store the different elements of the ontology specific to the application domain describing the user environments.

In PIVON, [11] proposed a generic and adaptable context model based ontology. He focused at a user-centered classification compounded by the own user, environment, devices and services, It seeks a more general classification. The user's situation is modeled including the dynamic and circumstantial issues of the user, for example the accompanists, the user location, and the current task and goals designed for asking three basic questions: What are the user characteristics? What the user want to do? And What is the user doing?. The answers to these questions belong to the three main parts of the user model. First, the static characteristics of users have adaptation. To adapt, Hervas use the OWL context model based on description logics in order to endow the context-aware architecture with inference capabilities.

Extending PIVON [12] exploited the semantic to apply context adaptation, particularly for services in a user centered smart environment at the COIVA (context-aware and ontology-powered information). The management of Context-sensitive services need to implement mechanisms to support all dynamic behavior of the users and their surroundings, including techniques to adapt the model to their future needs. The formal semantics allow used to apply decidable reasoning, a powerful mechanism to infer new context information. The Web Semantic Languages, in particular OWL-DL, are syntactic versions of the semantic logics and, as such, they have sufficient knowledge representation capabilities and efficient inference mechanisms for our purposes. In COIVA, anticipation of this requirement, we decided to refractor the mechanism to monitor the reasoning rules by dynamic context-event handlers, which are in charge of developing a reaction to a context change. Next, in [13] a new application of modeling context allows patient monitoring through Biometrics and mobile devices for chronic diseases. It added new diseases to this application based on the ontology's defined in this research.

We present the results of a performance study which was arranged to evaluate the feasibility of modeling context-awareness in pervasive computing environments (cf figure 1). Of the above two categories, the application-oriented approach lacks the formal basis and does not support knowledge sharing across different systems. Though the ontology-oriented approach focuses on context ontology and explores the potential capability of context reasoning based on Semantic

Web technologies.

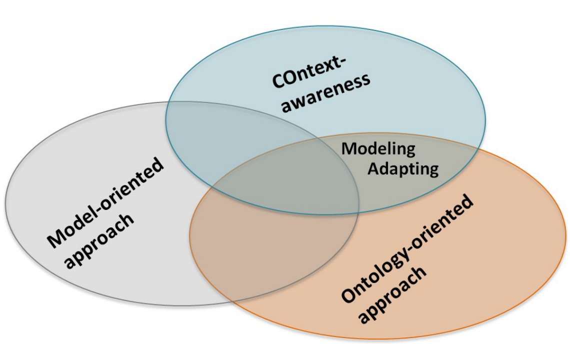


Figure 1. The Ontology-Oriented Approach Vs Athers Models

## III. Ontology Model Contribution to Adapting Context in Pervasive Environment

In[9], authors agrees that ontology-based approaches offer more opportunities to give a descriptive universal model on user context information with consederation in making changes to such information with the change of their contextual situations. it can satisfy their needs through this modeling regireuse context information. In this study, we use ontologies to specify the context information and relationships between contexts because ontologies provide rich expressiveness and support evolutionary aspect of the context modeling. ontologies to specify the parameters and links between the various entities of context. In addition, the use of ontologies for context modeling is particularly suitable to represent knowledge. Progress on semantic modeling allow people and machines to share information describing the semantics of concepts. The basic concept of our context semantic model is based on ontology which provides a vocabulary for representing knowledge about a domain and for describing specific situations in a domain. Indeed, ontologies aaprouvent information being explored as a vocabulary characterized by a variety of situations of the context to be treated. In representation of knowledge in our field of sensitivity to context, a module consisting of a specific vocabulary used to describe a model of the real world vocabulary with which a set of assumptions (assertions) about the meaning that must be attached the elements of the knowledge base. Ontologies provide a common vocabulary field and define the meaning of terms and relations between them.

### *A. Context Model Contrubition of Contextual Traceability*

In [11], the authors are content to defend the representation models based ontology. Ontology-based approaches provide more capacity to meet the information needs at the levels of service expected. In this study, we use ontology's to specify context information and the relationships among contexts because ontology's offer rich expressiveness context modelling by achieving levels of description of the context and the representations that will with.Advances on Semantic modeling enable people and machines to share information, describing the semantics of concepts. The basic concept of our context semantic model is based on ontology which provides a vocabulary for representing knowledge about a domain and for describing specific situations in a domain. It also enables reuse of domain knowledge, building a large ontology by integrating several ontology describing portions of the large domain.

Most importantly, it enables formal analysis of domain knowledge, for example, context reasoning becomes possible by explicitly defining context ontology. Considering the work of Hervas, we take as our reference work given the importance of the model based on ontology that he proposed. Indeed, in [11], although the context is a broad concept, vague and not defined, it proposed an adaptable and generic context model based on premises ontological elements for modeling context. Then will be described through the OWL language and it is part of a general context-model. We can summarize the principal taxonomical elements involved in it (cf figure 2):

- User ontology: It describes the static characteristics of the users in their profile, their situation, their role and their task and daily activity.
- Device ontology: It describes the relevant devices and their characteristics.
- Environment ontology: It describes the space distribution.
- Service ontology: Service ontology: It is an ontology that specifies the context model to the particular applications and adapted services to be offered to users using traceability of context. Specifically, service ontology for this proposal includes the traceability data needed about physical parameter of context connection of elements into the user interface. These data of traceability are instances of the following classes:
  - Agent class: defines the entity's connection parameters (It assembles the human and the device actor) according to their profiles, in Contextual current situation;
  - Location class: defines the parameters of localizations coordinates entity's in pervasive environment for a Contextual current situation;
  - Feature class: defines the parameters of adaptation relted to activity requested by the user through its task. A Virtual Contextual Card (VConC) will be generated to store the parameters of context, we use an XML representation that will be converted after at RDFs file (cf figure 4). This card can contain a set of facets include all of context parameters entity's for a current contextual situation in a pervasive environment. These parameters can represent with hierarchical structures.

Our ontology defines the basic concepts of person, location, environment, service ontology, when we integrated the contextual traceability class's (cf figure 2).

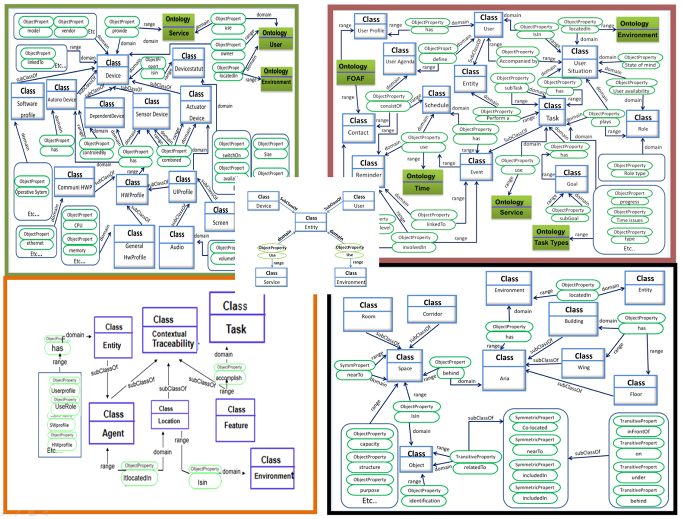

Figure 2. Context Model based Ontology Traceability Overview

### *B. Integration of the Ontology Traceability into our COntext Adaptation pLAtform: COALA*

In the interactive applications which are adaptive to context, the notion of context is indispensable. The objective of our study leads to the conception of an adapted system capable to render in real time a context-aware into pervasive environment. As we show it in the previous sections, an adapted interactive application has to integrate a well structured data model which modelizes well the contextual sensitivity, and possess a mechanism of reasoning and interpretation allows providing a proactive behavior according to the different contextual situation. Our platform COALA (COntext Adaptation pLAtform, (cf figure 3))consists to sensitizing and adapting the interactive applications in the ambient, COALA constituted of three main levels which are: the user level which presents the lower level of the platform, the application level is considered as the functional core of COALA and the level of adopted interaction which situated on top of the platform. COALA consists also to visualisation services it does can be enabled to offer personalized information pro-activity. To adapting the interactive services in the ambient, COALA allows through of three main levels and several information points were installed in the environment to give user the opportunity of access their profile and relevant personal documents, to find relevant places, offer personalization activities and events at the right time.

In this level context-awareness is defined through the four compensatory dimensions, which will be represented in our work according to ontology of domain, to know the user profile, the technical device the task of user and environment of user in order to adopt the interactive system to context of use. In this stadium, COALA describes the user context by a quintuplet.

<User (Role, Task), Device, Environment, Service>

In COALA, Ci is defined as following:

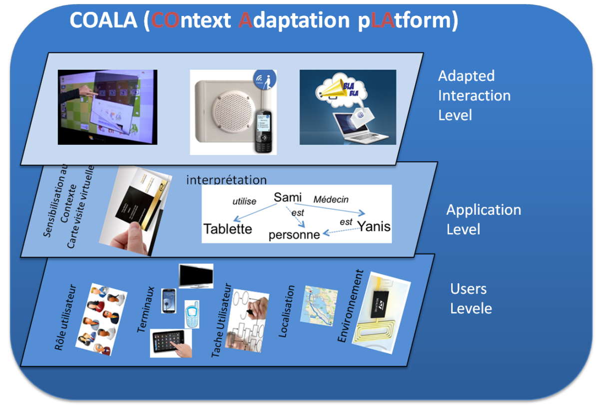


Figure 3. A Platform COALA: COntext Adaptation Platform

Ci= <(R, TUi), Di, Ei, Si>

Each of these dimensions in the ontology has its importance in COALA since it allows defining the context of user in a complete manner. In our platform, the context model of user is situated at lower level of architecture as it is the basic of COALA. Then, the application level is stuated in mid of platform. It present the Context-awareness part where a VConC will be defined and other adaptation system allows interpreting and reasoning on the trailed contextual information. For this VConC, we propose to use XML representations for storing and exchanging parameter values for a given contextual situation. As we have defined a set of axes to the context model (location, environment, terminal, dots), we defined for each axis an XML element used to retrieve the current settings. These parameters constituting each element are defined according to their structures. This VConV will be integrated later into the platform for adaptation. Indeed, this card will be integrated and used to adapt services to the current context. the data stream based on this card will be between ontology service and the rest of context model (ontology User, Device ontology, dots). Finaly, the adapt level, who is stuated at the high level of platform, allows the adaptation of interface taken a very important dimension mainly in cases where we want to add context–awareness to applications. In COALA, we try to sender the interactive application where the data's were adapted dynamically to use current context characteristics.

## IV. A Prototype for Ontology Traceability for Adapting Context

This section describe the generic architecture that we have designed to generate context-aware and adapt applications in a general, reusable and applicable way. We will describe our adapt context platform in pervasive environments,to illustrate the function of the prototype. Our platform constitutes three main levels which are: the user level which presents the lower level of the platform, the user model has been designed for asking all basic questions: What user's characteristics? What does the user want to do? What is he doing? Which terminal will be used? in what environment? The answers to these questions should be defined in the user model. The application level is considered the functional core of our platform. It consists of the contextual administrator of this level, and the level of adopted interaction which situated on top. The construction flow of Adaptation COntext in our platform consists of the following components as show in (cf figure 4)

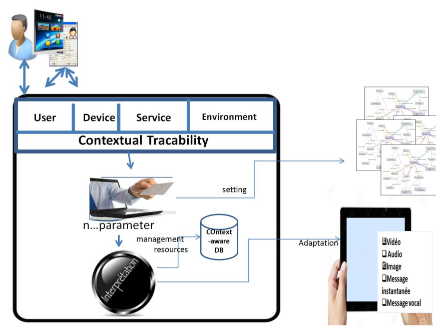


Figure 4. Construction Flows of Adaptation Context using Ontology Traceability

To illustrate the function of this prototype, we chose the application that can be the tele-surgery of the brain tumor. The hospital center consists of a staff as the following: doctors (professor, resident, internal, emergency,...), supervising agent (nurse, healthcare aid,...), trainers and patients. This proposal follows a generic perspective and can be applied to multiple scenarios. In this step we describe some particular prototypes to illustrate the contributions of our work. Indeed the medical environment for this case is a critical environment which touches the lives of human beings. We focus on a scenario with the following study case: "I returned from vacation early because I had different headaches than usual. I immediately went to my doctor. It was he who asked for the first scan, on which he saw that there was something. He then ask to the neurological hospital for further tests. " Josiane, 54. Automatically, this patient will be hosted by a hospital staff. "Even if one sees only one doctor it is reassuring to know that decisions are not taken by one person but by many specialists. We saw only one doctor, but we knew that behind it there was a whole team."Josiane.

As the decisions on the patient's state are not taken by only one entity (person according his/her role in the work staff), the different tools of communication and interaction using a technology of the ambient mobile environment. So, a collaboration that can lead to optimal accepted attitude for all the staff will be more beneficial to the patient. The staff can inform from their posts, their office, anf from their mobile terminals (Smartphone's, laptop,...) moving an the different places of the hospital (the office, corridor, surgery room,...). We consider that the doctor will exert of stimulate andanalyse the brain area of patient through his application. his contextual situation is defined as follow:
User Role⇒ neurosurgery doctor, his Task⇒ stimulate and analyze the area of patient brain, his Location⇒ his office, his Terminal⇒ personnel computer with a WAN network type, his Environment⇒ room temperature 27C. Once connected to his application, a context traceability file will be generate to describe the user current situation that will be transformed into a source of contextual knowledge(XML file) for the adaptation phase that comes after (cf figure 5). In this stage: -a new contextual situation is detected; -a number of parameters related to the context of use are defined in full as a result of a connection to the system of adaptataion;-a communation between ontologies will be realized after to reason about the current context data and allows to adapt it. Our work consists to implements the principles contextuel parametrs defined and includes all necessary mechanisms to provide context-awareness. We will transformer firstly information based XML to RDF, to transform it next into OWL instances to craete our contextual traceability ontology.

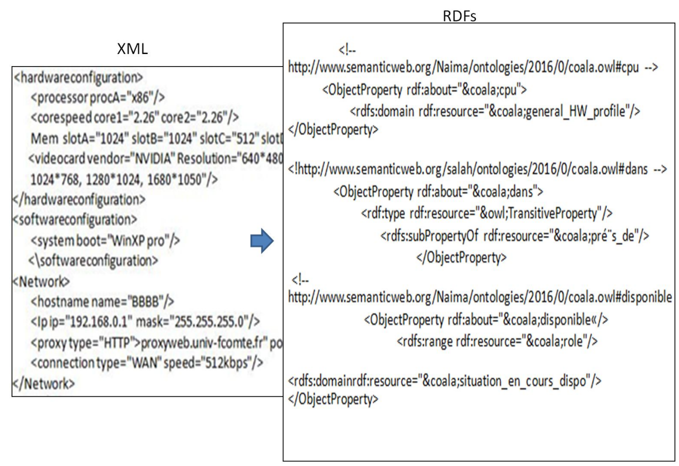


Figure 5. XML and RDFs Representation of Parametrs Associated to User Contextual Current Situation

Next, to describe the user profile information in our ontology using OWL, we use the profile of hospitaller staff(doctors, nurses, ...) (cf figure 6).

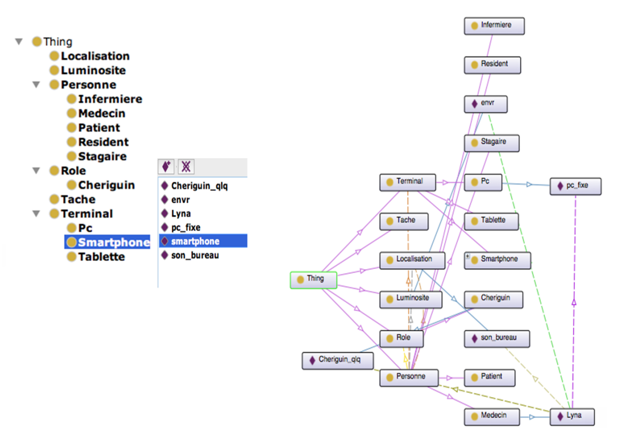


Figure 6. Extract of Class Hierarchy of The Ontology

Additionally, our architecture maintains a representation of users situation and their surroundings (context model).it is possible to determine which parametrs will be shown depending on the user needs. So, the using of The Context Reasoning Engines provide the context reasoning services. The context Knowledge base provides the service that other components can manipulate context knowledge stored in the Context Database (cf figure 4). The decision for the resource appropriate to the current context generate by tbe traceability classes and according to Current Contextual Situation use a several methods defined in the class"adaptercontext", among them, we quote the "selectressource" which is defined in the following figure. This method implements the algorithm of interpretation on the information of the context. Consequently, basing on the parameters of the information of context generated (location, characteristic of terminal, user role,. . . ) the interactive application can decide on the appropriate shared resources.

As it's mentioned in the following figure (cf figure 7), the used algorithm by the interpretation server on the contextual situation of user in progress, the audio resource, video, and instantaneity message will be affected to this user (the neurosurgical doctor).

```
Publicvoid selectressource( boolean cnnx, string loc ){
If (cnnx==false){
Activateselectressource ("msg-vocal")
        else if (loc==" Outside office")
activateselctedressource("audio")
Else (activiteselectedressource("vidéo")
            activiteselectedressource("audio")
                                activiteselectedressource("msg-instantané")
                                        activiteselectedressource("notif-email")
                                        }
                              }
                  }
      }
```

Figure 7. Activation of Interaction Ressources According by Contextual Traceability


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## V. CONCLUSION AND PERSPECTIVE

Following the study of literature works and to the proposition of the classification of existing platforms, this proposal describe an infrastructure to support adaptative retrieval information using an ontological traceability for context-awareness. For adaptation, information retrieved to users can be personalized to their current situation and needs. Apart from adaptive information, our proposal architecture implements general and reusable mechanisms. The platform offers adaptation interface easy to manipulate and intuitive for user. Then, we try to render our generic prototype to adapt to different scenarios. We will so continue our work on building a prototype system in a smart surgical operating room and implemented more reasoning mechanisms.

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