Automatic Generation of UIs for Disabled Users using Context-aware Techniques and Reasoning

Lamia Zouhaier, Yousra Hlaoui Ben Daly and Leila Jemni Ben Ayed
Laboratory LaTICE, Higher School of Sciences and Technologies of Tunis, University of Tunis, Tunis, Tunisia

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Abstract: Today, users need to interact with the UIs of the computer systems at any time and in any place. In fact, users have to deal with diverse devices supporting diverse interfaces and used in diverse environments. Thus, research must to be devoted to adapting the content, presentation and also the navigation scheme of the user interface not only for people without disabilities but also to impaired users according to updated context of use. In fact, context is captured from the surrounding environment in which the user is interacting with the application, gathered from a variety of sources and changed dynamically over time. For that reason, we propose to include context awareness system as a solution for adaptation of user interface tailored to user with special needs. In this paper, we try to introduce our contribution in how to build a user interface which is aware and capable to adapt depending of context. Our contribution is demonstrated through the behaviour of task model.

1 INTRODUCTION

Due to the diversity in human society and the increasing numbers of user's profile (handicapped users, normal users, young/elderly people, etc), the interface of computational systems faces to be used by different users at same time but also in different environments. UI must to be flexible and autonomous in order to match the big numbers of users' needs (Lopez, 2003).

With the diversity of computing devices (mobile phones, PDAs, PC, interactive kiosks, etc.) increasingly present to support the daily activities of any individual, engineering of interactive systems is facing the challenge of not only produce quality systems but also systems which can be customized or adapted to any type of device with respect to the personal characteristics of user specially whose are with special needs.

These problems have motivated, recently, researches to define features for interface's adaptation according to the context change. The application must to be able to both detect the current state of context and the new context in the ambient environment and to determine what actions to take based on this contextual information.

In pervasive computing environments, context consists of any information that can be captured from the surrounding environment in which the user is interacting with the application, gathered from a variety of sources. Context-aware systems offer entirely new opportunities for application developers the possibility to gather context data and adapting systems behavior accordingly (Baldauf, 2007). Adaptation of user interface in mobile contexts is a topic that has recently stimulated various research contributions (Manco, 2013).

Existing work in the area of context awareness focused on all aspects of capture, interpretation, modeling, storage and dissemination of context but there are no generic and global solutions that include all steps of adaptation from context acquisition to generated final interface. Context aware application is a new computing paradigm. It gives the possibility to explore the dynamic context of use and to take advantage of contextual information in order to adapt to user needs. Many context-aware applications are built to demonstrate the utility of this new technology. The majority of existing frameworks of context sensitive use a layered architecture supporting the important aspects of sensor capture, context extraction and reasoning. Building context-aware applications is one of the

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solutions adopted but also still a complicated task due to the lack of an adequate and generic infrastructure that support in pervasive computing environments (Lopez, 2003).

The goal of this paper is to introduce an approach for the adaptation of UI to the context (user preferences, environment, terminal, etc). The populations that we target are people with disabilities. We try to give a plan of our contribution in how to build a UI which is aware and capable to adapt depending of context.

In section two, we list the related work in user interface adaptation. In section three, we introduce our approach. In section four, we discuss our context acquisition and management strategy. In section five, we show how the adaptation affects the behaviour of task model illustrating by Petri-nets diagram when the context varies.

2 RELATED WORK

This section is dedicated to existing works in accessible user interface adaptation. Little work has focused on identifying generic solutions able to adapt any user interface of applications to various combinations of context of use including disable people using context awareness mechanism.

In the early period, accessibility problems were primarily considered to concern only the field of Assistive Technology (AT), and consequently, accessibility entailed meeting prescribed requirements for the use of a product by people with disabilities (Stephandis and Savidis, 20001).

For some developments, it is necessary to apply also more specific guidelines such as a set of guidelines for specific application type (e-learning, tele-working), access device (mobile devices) or user type (elderly, children, blind, deaf) (Leonidis, 2011). Web developers and designers can leverage standards such as WCAG (Henry, 2012) to ensure the overall accessibility of a given Web application. This type of guidelines devises a set of conformance levels based on how loose or strict is a Web page's support on accessibility issues, independently from any particular disability (Calvary, 2002).

There are a wide variety of applications to which personalization can be applied and a wide variety of devices available on which to deliver the personalized information. Most personalization systems are based on some type of user profile, a data instance of a user model that is applied to adaptive interactive systems. Leonidis et al. (Leonidis, 2011) propose a toolkit for rapid prototyping in order to ease the design of adaptive widget-based interfaces.

Adaptive and adaptable interactions techniques are increasingly emerged in recent research. There are no generic solutions oriented towards accessibility of user interface, but different terminologies are employed as Universal Access (Stephanidis, 1998), User Interfaces for All (Akoumianakis, 1999), Design For All (Lopez, 2003) Unified User Interfaces (Minon, 2011) because of the range of the population which may gradually be confronted with accessibility problems extends beyond the population of disabled and elderly users to include all people (Stephandis & Savidis, 2001). Universal Access refers to the global requirement of coping with diversity in: (i) the characteristics of the target user population (including people with disabilities); (ii) the scope and nature of tasks; and (iii) the different contexts of use and the effects of their proliferation into business and social endeavors (Stephandis and Savidis, 20001).

Universal accessibility system should be accessible for all users, although the design is focused on people with special needs. But none of these projects resulted in any concrete solutions for users with special needs. The scope of User Interfaces for All, as a perspective on HCI, is necessarily broad and complex, involving challenges, which pertain to issues such as context oriented design, diverse user requirements and adaptable and adaptive interactive behaviors. This diversity of needs is generally ignored at the present time. Occasionally, it is addressed in one of several ways: manual redesign of the interface, limited customization support, or by supplying an external assistive technology.

AVANTI (Stephanidis, 1998) is the first project to employ adaptive techniques in order to ensure accessibility and high quality of interaction for all potential users. It put forward a conceptual framework for the construction of systems that support adaptability and adaptivity at both the content and the user interface levels (Stephandis & Savidis, 20001). The distinctive characteristic of the AVANTI browser is its ability to dynamically tailor itself to the abilities, skills, requirements, and preferences of the end-users, to the different contexts of use, and to the changing characteristics of users as they interact with the system.

EGOKI (Abascal, 2011) is a system that generates accessible mobile user interfaces adapted for people with disabilities in order to grant them access to ubiquitous services. These interfaces are intended to provide access to ubiquitous services in intelligent environments. EGOKI dynamically creates an instance of the interface running on the user device. To adapt the interface to the user characteristics, it is necessary to take into account what the most suitable communication modalities are for each user, mapping them to the appropriate media.

Plasticity (Calvary, 2001) is a recent and emerged technique of adaptation which is the capacity of an interactive system to withstand to context variations while preserving usability. In order to support the end-user preferences, adaptations rules can be changed according to user's order (Thevenin, 2001); (Calvary, 2002). It results from a *Situation→Reaction* process where the situation denotes a context change that needs a reaction, and reaction denotes the procedures that the system and/or the user executes to preserve usability.

In literature, few works deal with adaptation of the content, presentation or the navigation scheme of the user interface to users with special needs (Minon, 2011). Ubiquitous services are usually provided by means of generic interfaces that may contain barriers for people with disabilities (Gajos, 2011). To overcome this problem, the use of adaptable or adaptive user interfaces is recommended (Ay, 2007).

3 OUR APPROACH FOR ADAPTATION

Based on context awareness systems architecture, it is easy to deal with context from capture to management steps. That is why, we propose to use some of existing infrastructures that support context-awareness to adapt user interface accordingly to disabled people profile, preferences and surrounding environment.

Our contribution is to propose a novel approach of user interface adaptation targeted to impaired people. This approach must to be aware of user context, plateform context and environment context. Consequently, we need to follow these objectives:

- Provide a generic and scalable architecture for adapting applications to new context of use.
- Provide an overall adaptation strategy (features, data and presentation) of an application to new contexts of use.
- Ensure scalability of available adaptive mechanisms that we can apply to an application.

To ensure these described objectives, we propose to include recent techniques employed by context-aware systems for context acquisition and management for, afterwards, enabling the application of adaptation rules in order to generate the final interface using model-based technique following the approach Model Driven Architecture MDA. Three principal steps that characterize our approach and scheduled as depicted in figure 1:

- First: Context acquisition and Management
- Second: Application of adaptation rules
- Finally: Generation of final interface based on model based development using the paradigm Model Driven Architecture (MDA).

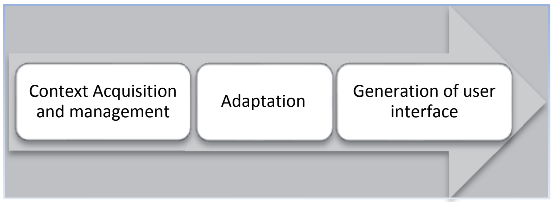

Figure 1: A global overview of our strategy.

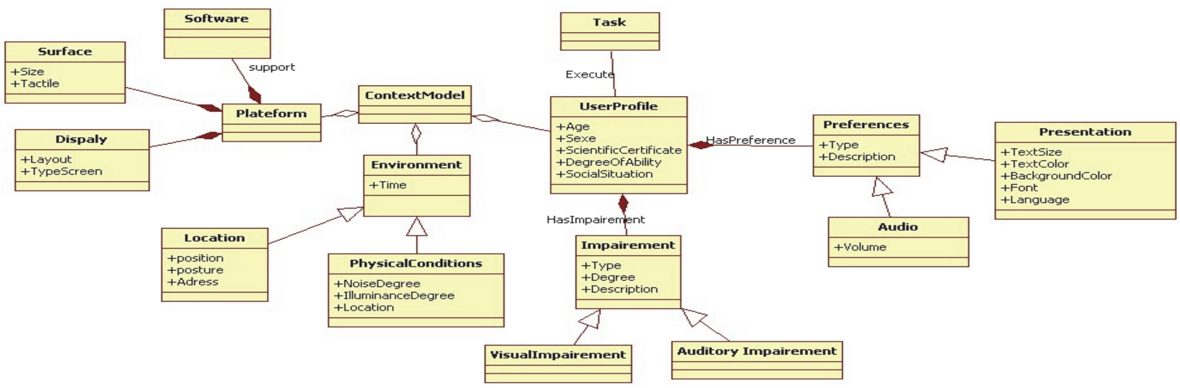

Figure 2: Class diagram of our context model.

4 CONTEXT ACQUISITION AND MANAGEMENT

Architectures presented in existing work to ensure sensitivity context (context-aware architectures) accord considerable importance to the management of context without showing how to modify the behavior of the application to fit the context.

Context modeling includes a variety of context information types, their relationships, different situations (e.g. abstractions of context information facts, etc), histories of context information, and uncertainty of context information (Bettini, 2010).

The different entities must have a common structure for representing information. Each context expression must contain at least *Context type* and *Context value*:

- *Context type:* Each context must belong to a category (Sound, time, temperature, etc.). These types will be used in a context subscription or query. Context type concepts form a tree structure.
- *Context value* refers to the semantic or absolute “value” of context type and is usually used together with *context type*, forming a verbal description. In some cases, *context value* might contain an absolute numerical value or feature describing context.
- *Attributes* specify the context expression and might contain any additional details not included in the other properties e.g Timestamp describing the date/time when context was sensed, Source containing how information was gathered, etc.

Existing approaches of context modeling differ in the ease with which real world concepts can be captured by software engineers, in the expressive power of the context information model (see figure 2), in the support they can provide for reasoning about context information, and in the computational performance of the reasoning (Bettini, 2010).
Context management layer as depicted in figure 3 is highly dependent on the two principal’s layers: Context Provider (CP) and Context Interpreter (CI).

a. Context Provider: is responsible of collecting context from sources and managing it.

b. Context Interpreter which translate the low level context into high level representation.

The context Manager is the middleware between the application and the context management layer. It carries only pertinent data to application.

Context repository maintain only context which is non-volatile, its value survive different execution sessions as user profile, but dynamic context (time, location, temperature, noise, etc) that rapidly changes will be maintained in internal data structures.

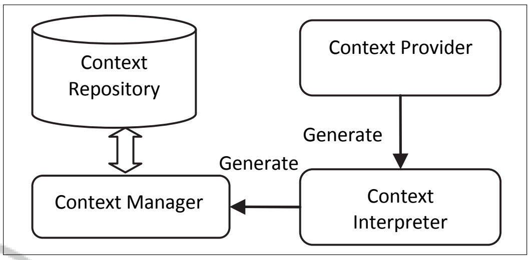

Figure 3: Context acquisition and management.

In the remainder of this paper, we demonstrate the impact of context on the task model task.

5 TASK MODELLING WITH CONTEXT CHANGE

We demonstrate our approach based on task model behavior at the arrival of context event.

In (Nathalie, 2002), authors provide a formal notation of task model in order to support the variation of conditions depending on multiple contexts of use. We will use the same formulation.

If we consider that a context is a triplet of three components user model, platform model and environment model, we can represent each component as a set of variables.

Let‘s U, a user Model described by a set of finite parameters, $\{u_1, u_2,..., u_n\}$, u_i represents a specific profile of a given user. A concrete User context is represented by identity, preference, activity, location, disability, etc.

$P= \{p_1, p_2,..., p_n\}$ is a finite set of plateform, p_i represents any property of the computing plateform such as a screen resolution, screen size, processor speed, location, operating system, network bandwidth, etc.

$E= \{e_1, e_2,.., e_n\}$ is a finite set of environment attribute, e_i represents a specific configuration of physical conditions (light or pressure), location, social and organizational environment (stress level or social interactions) in which a task is carried out.

So, a given Context C_i is a triplet $< u_i , p_i , e_i >$. A context variation appears when at least one element is modified. So, we consider C a matrix that contains all the different contexts of use.

$$[C]=\begin{pmatrix} c_1 \\ c_2 \\ \vdots \\ c_n \end{pmatrix}=\begin{pmatrix} u_1 & p_1 & e_1 \\ u_2 & p_2 & e_2 \\ \vdots & \vdots & \vdots \\ u_n & p_n & e_n \end{pmatrix}$$

With the multiplicity of contexts, the highest level of a user interface which is the task model must to support the variation of conditions. It is needed in order to create a boundary between two different set of tasks; those dependent and those which do not depend on context. According to (Nathalie, 2002), we will consider in our work (see figure 1):

- Task model Independent of Context which is a set of task that carried out in all different context of use.
- Task model dependent of Context which is a set of tasks that are valid in a subset of considered context of use.

We have used a formal technique which is Petri Nets (Elkoutbi, 2000). Petri nets are a basic model to describe state changes in a system with transitions. Based on this formalism, we consider that transitions represent the tasks that will be carried out by the user in interaction with the system, could be dependent or independent of context, noted:

$$\text{TASK}= \{\text{Task}_i\}_{i=1\ldots n} = \{\text{Task}_{dep}\} \cup \{\text{Task}_{Indep}\}$$

Places are the set of context attributes $C= \{C_j\}_{j=1..m}$

Based on (Calvary, 2002) triggers, we will use the following statements (1) and (2) in order to demonstrate the behaviour infection of Task Model:

If ContextEntering (C_j) Then perform ($Task_{Dep}$) (1)

If ContextLeaving (C_j) Then perform ($Task_{Indep}$) (2)

The Task Model (Limbourg, 2002) behaviour can be infected due to the change of context. With the Petri net, we want to show how the execution of some task depends on the new context that recently has entered. In this case, the transition from $task_i$ to $task_{i+2}$ ($task_i$, $task_{i+1}$ and $taski_{+2}$ are ordered using temporal operators in Concur Task Tree (CTT) (Limbourg, 2002)) is verified if and only if the two $Task_{dep}$ and $Task_{Indep}$ are successful executed and the condition "leaving context" is verified.

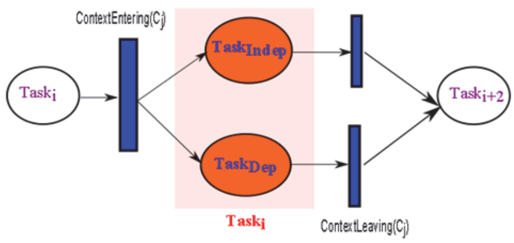

Figure 4: Petri Nets of Task Model behaviour when context change.

6 CONCLUSIONS AND FUTURE WORK

This work will allow us to frame the issues for user interface using context-awareness and open research perspectives related to the adaptation of interfaces. Using the history of the context to predict the task of the user interface and adapt accordingly is a field to explore. In fact, using this new paradigm of context-sensitive, UI can be aware of any change in the context of use. Thus, the user interface must to cover a huge number of context configuration and satisfying the user requirement in the adaptation process.

Ontology provide a uniform way for specifying the model's concepts, subconcepts, relations, properties and facts, altogether providing the means for the sharing of contextual knowledge and information reuse. The contextual knowledge is interpreted and evaluated by use of ontology reasoning (Rios, 2004). A reasonner can use ontology to deduce conclusion about context in order to make decision on content adaptation

Further work, we propose an approach that interprets the context based on the type of user (visual handicapped, deaf user, etc.), his location and on physical environment's properties like the degree of luminosity (Low, Medium, High) and the noise (Quiet or Noisy).

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