A Model Driven Approach for Improving the Generation of Accessible User Interfaces

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Abstract: In a ubiquitous computing, disable users are required to accommodate their particular needs using interactive systems. Thus, ensuring accessibility into applications' user interfaces is highly recommended. Hence, it is crucial to elaborate a generic solution which is compliant to handicapped user requirements. Therefore, this paper is addressed to define a model driven approach for generating adapted interface according to accessibility context. This approach benefits from Model Driven Engineering methodologies. In addition, it is characterized by the integration of a multimodal solution which selects the suitable modality of interaction into the adaptation process. This will improve the degree of user interface flexibility. This approach is based on different model transformations' belonging to different abstraction levels of the adapted user interface development according to the captured accessibility context attributes.

1 INTRODUCTION

Technological change delivers products and services requiring particular skills and abilities of the users. Traditional user interface engineering doesn't address disable users requirement when developing interactive systems. This implies the indispensability of pushing this type of interface from traditional to modern adaptive user interface. Hence, interactive systems must to be flexible and autonomous in order to match the big numbers of users' requirements and preferences (Lopez, 2003) but also the diversity of computing devices (mobile phones, PDAs, PC, interactive kiosks, etc.). Unfortunately, users with special needs (hearing disabilities, sight disabilities, physical disabilities, cognitive disabilities, etc.) are confronted to a big numbers of access barriers when interacting with user interfaces using emerged devices. It is indispensable to define a generic solution for this category of users that guarantees an equal access and an a good quality of life.

In this paper, we propose to address this problem by a generic solution for developing accessible user interfaces applications based on Model Driven Engineering. Model Driven development approach has benefits in developing multiple variants of a UI for multiple target platforms, devices, users, or situations developed from the same abstract UI models. It has the advantage of transforming high level specifications into executable code. An Abstract UI (AUI) is transformed into a Concrete UI (CUI), followed by the Final UI.

This approach aims to provide an infrastructure of automatic adaptation and generation of user interfaces based on user interface model and accessibility context. It allows the specification of the interaction modality by constructing and manipulating the abstract components of PIM model according to user disability.
Therefore, our approach is based on three levels:

- In the first level, we proceed by modelling the application interfaces, and the captured accessibility context. The provided models are platform independent (PIM) specified accordingly to a metamodel that we have already defined. This metamodel describes our UML profile language specific to define user interface.
- In the second level, we apply the adaptation process by means of different transformations. Once the PIM is adapted, its transformed to specific platform model accordingly to the defined technical and environment contexts
- In the third level, the provided PSM will be transformed to concrete model relative to the targeted device.

This approach improves the system's capacity to manage the accessibility context inside the adaptation

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process at the runtime and to generate the adapted interface model using multimodal interaction.

Model based approach is a feasible solution for addressing accessibility into applications. In fact, it identifies useful abstractions highlighting the main aspects that should be considered when designing accessible application.

Model Driven engineering MDE is a development approach which puts emphasis on models. It provide a good practices of UI generation. The approach define UI models of high abstraction from which UI models of lower abstraction are obtained successively through model to model transformations and model to code transformation (Aquino, 2010). These transformations are made automatically. Using Model Driven Engineering, we guarantee the efficiency and consistency when developing multiple variants of a UIs from the same abstract models.

Based on a parameterized MDA-transformation, we propose an adaptation approach dependent on accessibility context presented in a previous work (Zouhaier, 2013). The approach extends and generalizes the process in (Zouhaier, 2014).

This paper is addressed to propose a generic solution for developing accessible user interfaces applications based on MDA paradigm (OMG, 2001). The proposed solution includes a set of parameters that is based on:

- Accessibility context-aware process followed by a context modelling to define disabled user profile, its suitable modality and the device mean characteristics.
- A set of assistive technologies that must accomplish the User Interfaces design as Speech Recognition and Synthesizer in the case of vocal User Interface.
- A set of accessibility guidelines to generate rules for user interface adaptation process,
- A set of parameterized model transformations to generate automatically adapted and specific user interface models.

In fact, the proposed approach has to be characterized by its capacity of context-awareness. It must to be able to capture and manage all contextual information related to user, platform, and environment, location and time. Therefore, based on the given disabled user context model, it has to perform the adaptation at runtime depending on different situations. Thus, it selects the best adaptation rules for the suitable interaction modalities according to the disable user. This will improve the degree of user interface flexibility.

The remainder of this paper is as follows: in section 2, we present some relevant work in relation with our problematic. The section 3 details our approach by presenting their steps, and user interface models. Finally, section 4 concludes the paper and presents our future research.

2 RELATED WORK

This section is related to existing relevant works related to different proposed approaches devoted to: accessibility approach, Adaptive UI approach, Model based UI approach.

The development of accessible applications must meet specific guidelines for accessibility. We note that multiple standards and guidelines have been emerged recently such as WCAG 2.0 (ISO, 2012), (Henry, 2012) and ISO9241-171 (ISO, 2008). However, fulfilling such guidelines is not sufficient, it still a little solution for accessibility problems.

Regarding accessibility, many works had considered primarily only the field of Assistive Technology (AT) (Stephandis, 1998). Example, when navigating via screen reader, the user perceives page content in a very different way from its rendering on the screen.

Therefore, the accessibility is considered as prescribed requirements for the use of a product by people with disabilities (Stephandis, 2001) (Arrue, 2007).

Few works have been focused on identifying generic solutions adapting user interfaces to various combinations of contexts of use (Thevenin, 1999) (Calvary, 2002) (Bacha, 2011) (Bontagartz, 2012) (Minon, 2013). Specially, adaptations which are based on context-awareness mechanisms specifying disabled people (Stephanidis, 1998) (Akoumianakis, 1999) (Lopez, 2003) (Abscal, 2011) (Peißner, 2012) (Manca, 2013). Many focus on context capture (Dey, 2000) and adaptation (Calvary, 2002) (Thevenin, 1999) by the use of legacy architectures and others artifacts to input context into application logic (Vale, 2008).

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Some other works (Bouchelliga, 2010) (Brossard, 2011), (Bacha, 2011) (Oliveira, 2013) propose solutions based on model based approach. They use MDA as a standard on context-aware development and adaptation of a UI.

Bouchelliga et al., (Bouchelliga, 2010) have proposed a MDE approach for plastic HCI. UI

adaptation considers various aspects of context and it is based on parameterized transformation. The authors provide the meta-models of the different contexts used in the approach to adapt the interface. Adaptation is made during the design and treats as aspects of the dimension of presentation with container and not the contents.

However, none of these studies have considered accessibility context into adaptation process using model based development basically the MDA approach.

Sottet et al., (Sottet, 2005) have joined his work to the Model Driven Engineering and the domain of Human Computer Interaction (HCI). His approach makes it possible to show that the concepts of the MDE could be successfully applied to the UI engineering. Sottet et al. proposes meta-models and models transformations to generate adaptable UI, and defines a general context meta-model based on CAMELEON platform (Calvary, 2003). In fact, he has been based on CAMELEON languages to describe his models. Unfortunately, the CAMELEON do not allow adaptation based on the description of accessibility context. There is why we are brought by defining our UML profile languages specific to define user interface models accordingly to accessibility context.

Based on this state of the art, we are able to approve our main objective which is basically ensuring accessibility of user interfaces for people with disabilities. We can say that there are few research proposals that have considered accessibility context into conceptual design of UI in adaptation process at runtime. But also, few works are based on a model-based method using the Model Driven Engineering (MDE) (OMG, 2001) approach for adaptation according to accessibility context.

3 OUR PROPOSAL MODEL DRIVEN APPROACH

Model based approach is a feasible solution for addressing accessibility into applications. In fact, it identifies useful abstractions highlighting the main aspects that should be considered when designing accessible application. Based on a parameterized MDA-transformation, we propose an adaptation approach dependent on accessibility context as presented in another work (Zouhaier, 2013). We follows the CAMELEON Framework (Calvary, 2003) to provide an overview of the mapping from actual context to a specific accessibility context. As described in the figure 1, the approach is basically a series of transformations from application model to final adapted application. As indicated, a reverse PIM. Secondly a transition in the abstract level from PIM A to PIM B in order to generate an adapted Abstract User Interface specific to the accessibility context. Finally, an parameterized MDA transformations is applied to generate final interface.

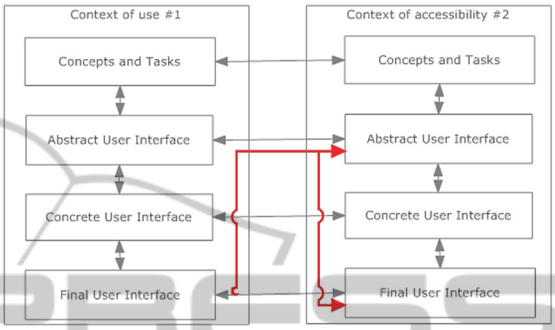

Figure 1: The mapping from actual context of user to target accessibility context using the CAMELEON Framework (Calvary et al., 2003).

This approach aims to provide an infrastructure of automatic adaptation and generation of user interfaces based on application's user interface model and model accessibility context development. Figure 2 illustrates the approach steps:

1. **Step 1:** first, we provide an abstract view of the user interface using our UML profile specific to describe user interface models. UI model is in conjunction with two others model which are Data Model and the External Functions Model. These models describes the The abstract view represents a non adapted Platform Independent Model (PIM A). Then, we collect all information relative to the accessibility context to build actual accessibility context model. We use an ontology model in order to manage high-level context properties acquired from sensors related to environment, platform and user.

2. **Step 2:** the adaptation process transforms the interface model (PIM A), provided by the first step to an adapted interface model (PIM B). This process is based on the ontology model provided by the first step of the approach and adaptation rules depicted from the WCAG2.0 and ISO 9241-171 guidelines.

3. **Step 3:** using the adapted model, which represents the output of the adaptation process, we generate the Platform Specific Model of the adapted UI (PSM) and then the relative code, depending of application platform, using simultaneously PIM2PSM and PSM2Code transformations.

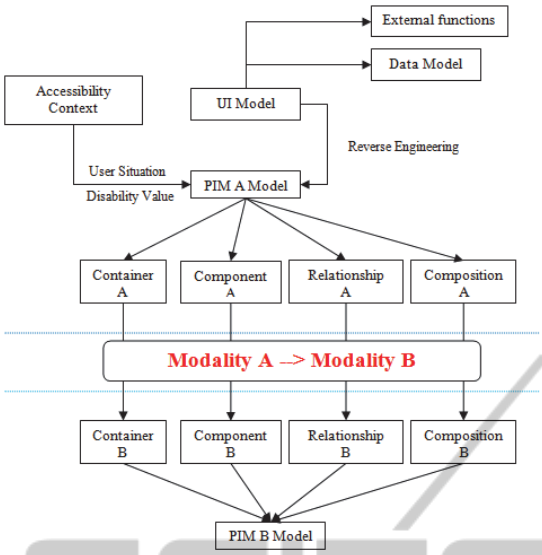

Figure 2: The proposed Approach with the incorporation of multimodality solution.

According to user disability, different interaction modalities are required. Therefore, we propose a multimodal approach by incorporation of the modality of interaction into adaptation process. It permits to the system to provide the best modality for accessibility context according to user's disability. Incorporating flexibility to choose desirable modality into user interface systems is indispensable for people with disabilities, since most computing applications use graphical modality into user interfaces useful only to sighted users.

This approach must enable to trigger the best from several alternative interaction modalities to fit the best adapted model.

Based on a work given by (Aquino, 2010) where the authors describe a framework of different type of transformations coping with the development of UIs for single and multiple contexts of use, we propose according to the two proposed viewpoints on UI systems:

- Platform-independent viewpoint contains a viewpoint that is (1) independent of the computing platform for which the system will be implemented and (2) dependent of a particular modality.
- An implementation viewpoint is a viewpoint containing a coded UI i.e., any UI running on a particular platform.

3.1 PIM Metamodel/Abstract User Interface Description

Abstract User Interface Model or Platform Independent Model is an independent model of any interaction modality and computing platform. It doesn't give any abstract specification how the interface will be concretized: graphical, vocal or multimodal. In literature, it is described by different manners. In literature, we find that different definition was given with different annotations. But, they differs by the designation used to refer each element of the user interface model.

In our approach, we have described the user interface model by an association between different components that are related to the modality used. Hence, the transformation from PIM2PIM to adapted PIM is a remodelling of the user interface model using the disability parameter by switching the actual interaction modality into the suitable modality. At this level, the PIM will take into account the new modality and make the best transformation at layout and presentation units. This transformation of UI structure is dependent of the value of disability. In some case, some abstract components must be placed into separate containers.

In our approach, we define the PIM model as a composite of a set of an abstract user interface element (AUI Element) that are clustered into a set of an abstract containers (Container Element) connected by UI relationships (Relationship Connection). AUI Element represent the elementary component of the interface which can be Input Element, Output Element, Control Element, Navigation Element. Container Element which regroups a set of UI Element, is described by it type and the corresponding layout. Each PIM corresponds to one or many modalities of interaction.

4 CONCLUSION AND FUTURE WORK

In this paper, we have proposed a model driven approach for adapting application's user interface to the context of accessibility. This approach proposes different transformations at different levels of abstraction to generate adapted user interface. We have focused on PIM 2PIM transformation which presents the core of the adaptation process.

Actually, we are working on developing a tool supporting our approach by implementing different transformation processes. The PIM 2PSM transformation is implemented using the ATL transformation, language (Eclipse, 2014).

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