Traveler Information in ITS: A Model-Driven Engineering Approach to its Personalization

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Abstract—Today, the problem of a traveller is to obtain the right information at the right time. To do that, many solutions have been proposed, the main one being the personalization of Traveler Information. But, they are often limited to specific types of applications and/or deal with only a part of the theoretical potential offered by personalization. In addition, tools and methods that have been proposed often focus only on the technical aspects of personalization, making it difficult to integrate them into a Model-Driven Engineering (MDE) approach that would allow personalized interactive applications to be modeled. To remedy these deficiencies, we have developed the PERCOMOM method, whose objective is to allow business experts to autonomously create personalized interactive applications by assembling pre-existing models. The case study concerns traveler information in ITS.

Keywords—Traveler information; traveler information system; ITS; Personalization; Model Driven Engineering (MDE); Human-Computer Interaction (HCI); PERCOMOM; Conceptual Modeling

I. INTRODUCTION

The widespread use of data-processing tools and the increase of the quantity of information available have led to new needs. Thus, the problem is not to provide information to travelers, but to provide the right information at the right time on the right support. This is even truer as all travelers have different needs and different goals [1]. Generally, personalize is defined as “individualizing the relationship between the user and the application”. In public transportation, personalizing has become a determining factor in making it possible to solve, partially, the many technical and methodological problems that arise when the applications are made available to a large audience [2] [3]. However, individualizing the user-application relationship tends to create other technical and methodological problems [4].

Model Driven Engineering (MDE) has become a determining factor in software development, and is becoming a new paradigm for building data-processing applications [5] [6] still limited by the existing tools [7]. Its objective is to create applications by defining, exploiting and assembling conceptual models. Each model deals with one or more well-defined problems, making it possible to achieve operational goals. To do so, MDE is based on a Model-Driven Architecture (MDA) [8], whose first level is the application's conceptual model which is independent of the development techniques and data-processing tools. We will show how our method is able to resolve problems related to content personalization in the field of public transportation within the conceptual models.

II. STATE OF THE ART ABOUT PERSONALIZATION

A. Basic principles

Currently, there is no standard definition of personalization. Placing ourselves in the context of conceptual modeling of applications, we have adopted two complementary definitions:

“Content Personalization is the ability to provide content and services that are tailored to individuals based on knowledge about their preferences and behavior” [9]

“Personalization is the capacity to customize customer communication based on knowledge of preferences and behaviors at the time of interaction.” [10]

So, personalization is the capacity to provide travelers with content and services adapted to their requirements and their expectations. This could be done on three levels:

- **On the user interface** The interface is adapted according to user needs and the context. For example, an interface for a visually-challenged or a sighted person will be different. Such an adaptation can be done either implicitly, as a system adaptivity [11] or explicitly (i.e., based on user's choices), as a system adaptability [12].
- **In the business processes associated with the applications** These processes can be different depending on the user. For example, the transport document will be different for an identified user than for an occasional user. The adaptation can be done implicitly or explicitly [13].
- **Through the content** In the Viatic.Mobilité project (http://www.eltis.org/PDF/case_studies/study_1903_en.pdf), personalization concerns are either information given to the user or the number and nature of the functional services available. As in SUGGEST [14], it could be done implicitly or explicitly in the Google online search tool.

In the rest of this article, we limit the scope to the solutions of content personalization in order to meet the needs, in public transportation, identified within the Viatic.Mobilité project. The other levels will be addressed in future research.

Though personalization can be done on several levels, external factors influence personalization [4]:

1) **User/Group:**...
This category contains all the factors that specifically relate to the users (e.g., centers of interest); 2) **Information**: This category contains all the factors that relate to the content; 3) **Context**: This category contains all the factors that relate to the technical and external environment; 4) **Retrieval approach**: This category contains all the factors that relate to the choice of the method and the tools used to effect personalization.

This presentation highlights the fact that the concept of personalization itself is a wide field of research, in which technical solutions alone were not able to solve the problems.

### B. Existing tools and methods for the conceptual modeling of applications

Although MDA has been around for several years [15], it is relatively seldom used to create applications. When used, it is frequently incompletely in spite of the abundant research showing the advantages of using it [16], particularly in HCI [17]. Its use is limited today partially due to the lack of tools and methods for modeling applications [8].

Today, the Unified Modeling Language (UML) is the most used language for modeling applications. However, it is too close to the Object-Oriented Programming paradigm to be a good candidate for modeling applications at the conceptual level. In addition, UML is not always easily readable by the various stakeholders, particularly non-computer scientists [18].

Otherwise, one of the most advanced HCI tools is probably, USIXML, the XML-based markup language for defining user interfaces [19], developed on the framework CAMELEON [20]. This framework allows user tasks to be handled, but also contains an entire set of additional concepts that allow the users or the environment to be modeled [21]. Other approaches have also been proposed in the HCI literature [22] but they are less advanced than UsiXML.

In the field of public transportation, the various approaches all have limitations that make it impossible to manage the complexity of the field. For example, they are unable to take into account the problems related to content personalization.

### C. Conclusion of the State Of The Art

This State of the Art shows that personalization and Model-Driven Engineering are rich complex domains.

Unfortunately, though many tools and methods exist for personalizing information, they frequently take only certain aspects of personalization into account and are almost never integrated into the modeling of interactive applications. In addition, very few modeling tools and methods allow applications to be created from real conceptual models as these tools and methods are very often linked to the techniques through which the applications are modeled at the CIM level.

The following section presents the PERCOMOM method that was developed and tested during our research. PERCOMOM makes it possible to reconcile the conceptual modeling of the applications, MDE and personalization.

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**III. THE PERCOMOM METHOD (PERSONALIZATION AND CONCEPTUAL MODELING METHOD)**

### A. Introduction

The aim of our research to develop a platform that, in the context of information and services distribution for public transportation, will allow interactive personalized data-processing applications to be generated semi-automatically (i.e., with limited human intervention) based on conceptual models. For the moment, our method manages only interactive WIMP (Window, Icon, Menu, Pointing device) interfaces, but we intend to extend it to other types of user interfaces. In order to provide a solution that can be easily used with the existing tools and methods, we developed an MDA method.

We use the term **method** with an eye to industrializing data-processing development. For this reason, PERCOMOM is more a manufacturing process than a theoretical approach to modeling data-processing applications.

### B. The conceptual modeling of applications in PERCOMOM

A data-processing application could be seen only from a technical point of view, but this would be very restrictive since an application is always defined for a given use context. To avoid this restriction, we chose to use a systemic approach to model the applications. This systemic approach allowed us to define a set of conceptual models, which in turn allowed us to apprehend the complexity of the applications (see figure 1).

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![Fig. 1. The set of conceptual models in PERCOMOM](image)
The business process model is based on a formalism called Business Process Modeling Notation [25]. BPMN allows the tasks that need to be accomplished to achieve a business goal to be represented. This formalism allows to indicate the links between the tasks and to specify the conditions for passing from one task to another. In PERCOMOM, this formalism was enriched to allow: 1) HCI to be taken into account; 2) the consideration of the functional and technical services. The static interaction model uses a formalism derived from BPMN in which the concept of task has been replaced by the concept of interaction element and the concept of transition between tasks has been eliminated. The dynamic interaction model uses the same formalism limited to the interaction elements of the static model. To allow the greatest degree of reusability, each model of our approach, except the application model, is designed to be independent of the application that uses it.

In PERCOMOM, each type of conceptual model is designed to deal with only one aspect of the application modeling so as to allow its use by the person the most capable designed to deal with only one aspect of the application designed to be independent of the application that uses it. The static interaction model of our approach, except the application model, is the same formalism limited to the interaction elements of the static model. To allow the greatest degree of reusability, each model of our approach, except the application model, is designed to be independent of the application that uses it.

In the next section, we describe how PERCOMOM moves from the conceptual models to the concrete applications.

C. The PERCOMOM technical architecture and the concept of functional service

To pass from the CIM level to a final application that can be exploited by the end-user, PERCOMOM has a three-level MDA-based architecture, as shown in Figure 2.

![Fig. 2. Schematic representation of PERCOMOM's technical architecture](image)

The first level contains all the conceptual models used to model an application (corresponds to the CIM level of MDA).

The second level corresponds to the PIM level of MDA and, unlike other MDA approaches, contains a framework with functional and technical services that can be used at the CIM level. These services contain the functions needed for a business process to operate correctly, but they are not specific to this business process. In other words, the business processes use these services; they do not define them. The services of PERCOMOM's PIM level can be explicit or implicit. The explicit services can be called directly at the CIM level. For example, the content personalization service is called directly in this way. The implicit services, defined by rules, are automatically called by the applications. For example, the user session and data access services are managed in this way.

From a business process perspective, a functional service is a set of processes that make it possible to execute a specific operation on the element to which it is attached. It can be attached to any interaction element. One functional service that can be used on the CIM level is the linguistic information management which concerns the adaptation of the interfaces to the user's language. The person in charge of modeling doesn't need to know how this adaptation is done but just needs to indicate whether or not this type of personalization should be used in a given business process.

In PERCOMOM, the contents and the business operation done by the functional and technical services are defined by the business experts themselves. Since these services are found on the PIM level, their technical orientation implies a traditional modeling and development approach by data processing specialists. This means using a UML model at the PIM level, which is transformed into a usable model at the PSM level. In order to allow the homogeneous development of these services, a development guide was written, listing all the rules that must be respected when developing and defining a functional service. The actual guide contains only a certain number of simple technical rules, and thus will have to be extended in the future in order to insure that the functional services developed 1) can be easily integrated into our architecture at the CIM level, 2) don't interact with the other already developed functional services, and especially 3) respect quality standards both from a business and a technical point of view.

The third level corresponds to the PSM level in MDA. It contains two sub-levels:

Sub-level 1 – On this level, the rules and the general layout information are defined for a family of interaction platforms (e.g., all PDA). The rules are used to specify the way that the HCI elements defined at the CIM level will be translated into concrete HCI elements for a specific family of interaction platforms. For example, the rules could be used to indicate how many elements must be in a list of values before it needs to be presented as a drop-down list of elements (like with ListBox) or as a selection box (like with ComboBox).

Sub-level 2 – On this level, the rules and layout information are defined for a specific platform (e.g., a cPDA). At this level, the different frameworks are used to specialize the framework of services defined at the PIM level but also to define the elements that allow the HCI elements defined at the CIM level to be taken into account physically. For example, the colors used to present an element will be different on a color PDA than on a monochromatic PDA. The specification and definition done at the second PSM sub-level allow the optimal use of the individual capacities of each platform.

In this article, we do not explain how the CIM models are transformed into concrete applications; indeed this description is available in [26] [27]. Illustrations in ITS domain are provided in the next section.
IV. CASE STUDY IN ITS DOMAIN

A. Definition and use of a functional service in the domain of content personalization

In PERCOMOM, content personalization is a functional service at the PIM level because personalization is not a part of the business processes associated with the application unless the user asks for it.

In order to meet the needs for the business experts, it is possible to act on the personalization function by defining parameters. These parameters are not designed to define the method of personalization used but to indicate, from a business perspective, the external factors that can be taken into account when personalizing content. Thus, by defining a parameter, it is possible to indicate that the personalization function will not take the user's geographical location into account, but will consider the user's preferences.

In the PERCOMOM conceptual models, personalization could be used in various models: 1) In the application model, in which default values can be assigned to each personalization parameter; 2) In the business rules models (BM3), in which a rule can define a test on the value of a current personalization parameter; 3) In the action models (BM1), in which actions can be defined to modify a parameter's value; 4) In the business process models (IM1), in which business rules could be used to influence the course of the business process through the use of personalization parameters; 5) In the static interaction models (IM2), in which a personalization artefact, defining the values of each personalization parameter, can be directly associated to each type of interaction element.

To show how a call to the functional personalization service can be integrated into a CIM model, we use the example of a static interaction model (IM2) defining a logical group of interaction elements. This model, called ViewResult, displays the result of a search request for the most appropriate means of transport for a trip (Fig. 3). To this logical group of interaction elements, an association was associated, via a Personalization_Service artifact, a functional personalization service which uses the user's geographical localization and preferences.

![Fig. 3. Example, in PERCOMOM, of an association of a personalization service to an UIUnit interaction element, which allows the display of a search result, in a static interaction model (IM2)](image)

B. Functional services at PIM level

Defining at the PIM level the personalization service as a functional service for applications in the field of transportation

- Allows ITS expert to use personalization services, at the CIM level, without defining them at the technical level.
- Simplifies the conceptual models, since the personalization service is called explicitly via an artifact for which only a few parameters need to be defined.
- Adapts the personalization service to the functional needs at the level of the conceptual models by using parameters.
- Makes the content personalization operation coherent for all ITS applications.
- Allows greater flexibility in the maintenance of the personalization service (done centrally for all ITS applications)
- Increases the reliability of the ITS applications because the functional personalization service must be validated before its use in the CIM models is authorized

These advantages could be attained for other types of PIM-level services. Only the type of call (explicit or implicit) and the properties are specific to each service.

The use of functional services in PERCOMOM constitutes a new approach. By simplifying the conceptual models and by requiring the definition and the management of the functional services on the PIM level, PERCOMOM makes it possible to create conceptual models that focus on the business problems.

Unlike other modeling methods, PERCOMOM permits the business models and the functional services to evolve separately, making it possible (under certain conditions) to set up a new personalization service without modifying the business models that use the service and vice versa. This separation of the business models and the functional services allows the role of each participant in an application development project to be tailored to their competencies, with the business experts in charge of the modeling at the CIM level and the "data processing specialists" in charge of the design and the evolution of the services at the PIM level. This maximizes the role of the business experts in the design of Traveler Information Systems.

C. An example of the handling of user-related factors

User characteristics are stored in the user profile model. The list of the characteristics, their possible contents and their organization are defined in the conceptual model of the user profile (called SM1, see Fig. 1). The user's centers of interest and preferences are defined in the user profile based on the business domain ontology, making it possible to assign a semantic to each center of interest and each preference. The social groups to which users belong are defined via the semantic to each center of interest and each preference. The social groups to which users belong are defined via the social model defines the access security to the applications through the use of social groups specific to one or more social groups.

In the context of content personalization, this user information can be used in three different ways: 1) As a filter in the conceptual models, to indicate the list of the personalization properties to be used (see Fig. 4); 2) In the business process models at the conceptual level, to influence the task sequencing of these processes (see Fig. 5); 3) In the functional personalization service at the PIM level, to allow, for example, user preferences to be taken into account.

Fig. 4 represents an example of a static interaction model (IM2) in which a set of interaction elements, “ViewNextDepartures”, displays the next departures in a station using a personalization method different depending on the user's social group. The filter is defined by defining a validation business rule (BM3) that can only return two values: true or false. This rule allows the user's social
membership in the “Customer” group to be evaluated (users identified as having a subscription). In the model, the business rule is associated to the link connecting the interaction element to the artifact “Personalization Service”. The name that follows the keyword “Rule:” indicates the name of the rule that should be used for the evaluation (Fig. 4.a). If the user is a customer, the content is adapted to user’s language (Fig. 4.b) whereas the content use the default language of the application which, in our example, is french (Fig. 4.c).

Fig. 4. Example of the use of a social filter for defining the personalization parameters in a static interaction model (IM2) for showing next departures in a station (a) with the corresponding result for an English spoken customer (b) and for a non customer with french as the default language (c).

Fig. 5 provides an example of the use of a business rule in a business process model, which makes it possible to personalize the application's business process according to the user's social membership group. In this figure, which is a part of a business process (IM1) associated to an application used to show the next departures in a station, the next departures screen will be show directly to the customer. For non customer users, they will have to pass through an information screen, informing them about the benefits of becoming a customer, before accessing to the next departures screen.

The advantage of using an MDE approach to manage content personalization at different levels lies in the possibility of refining the personalization of each application at the conceptual (CIM) as well as technical (PIM) level. This makes it possible to avoid all links with specific personalization methods or specific personalization tools at the conceptual level, while allowing the chosen method or tool to be very tightly controlled at the technical level.

To personalize content, PERCOMOM is able to handle all the external factors related to personalization:

- Users (Travelers), by managing their profiles, centers of interest, preferences and navigational histories, but also by tracking their psychological state throughout their trips.
- Contents / Information, by managing structured and unstructured data.
- Context, by managing time and space.
- Personalization approach (method), by taking the concept of functional personalization service into account.

TABLE 1. PERCOMOM's management of the external factors related to personalization

<table>
<thead>
<tr>
<th>MDA level</th>
<th>User-related factors</th>
<th>Content-related factors</th>
<th>Context-related factors</th>
<th>Personalization method related factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>CIM</td>
<td>Use of selection criteria linked to the social membership groups, user profiles and/or user preferences in the business processes. Use of restrictions when defining the properties associated with the functional personalization service</td>
<td>Association of structured data to the domain ontology. Transformation, if possible, of unstructured data into structured data using metadata.</td>
<td>Use of selection criteria linked to the applicative, geographical and temporal context of the business processes. Use of restrictions when defining the properties associated with the functional personalization service</td>
<td>N/A (Modeling methods are NOT taken into account at the CIM level)</td>
</tr>
<tr>
<td>PIM</td>
<td>Definition of the way that user history is handled in the functional personalization service</td>
<td>Definition of the way that unstructured data is handled in the functional personalization service</td>
<td>Taking into account of the concept of data filtering (principle of using restrictions for data)</td>
<td>Definition of the rules governing the choice of the personalization method used</td>
</tr>
<tr>
<td>PSM</td>
<td>Definition of a user identification system</td>
<td>N/A (Content is NOT taken into account at the PSM level)</td>
<td>Definition of the geographical and temporal sensors that permit the system to be sensitive to the context</td>
<td>Adaptation of the functional personalization service to the platform</td>
</tr>
</tbody>
</table>

By distributing the personalization over the three levels of a MDA architecture, PERCOMOM also: 1) Handles the concept of personalization conceptually in the CIM models; 2) Makes the application models independent of the personalization methods and tools used; 3) Manages all the
types of personalization, including the contextual personalization carried out by the platform user.

PERCOMOM represents a promising advance in the field of modeling personalized interactive applications. To our knowledge, no other method handles personalization to such an extent. Our method was validated for the Viatic.Mobilité project in the field of public transportation.

V. CONCLUSION AND PERSPECTIVES

In today's ever changing economic environment, many interactive applications must be developed in less and less time and with more and more important functional requirements. To deal with this situation, new tools and methods have appeared. One of most promising is Model-Driven Engineering (MDE), whose objective is to allow the creation of new applications by assembling existing application models. But, today, it lacks tools capable of defining the conceptual models and handling them in order to use an authentic MDE approach.

To provide a preliminary response for the field of public transportation, we propose the PERCOMOM method, designed to allow the semi-automatic generation of custom applications derived from conceptual models based on a business approach. For the moment, PERCOMOM takes only content personalization into account but not the personalization of interfaces or business processes, which limits its usefulness. Research about these particular types of personalization must now be undertaken. The various external factors influencing personalization are managed only partially in PERCOMOM. In fact, each factor is, in and of itself, a direction for research.

PERCOMOM open many perspectives for new research, which should allow, in the relative long term, the creation of data-processing application factories using MDE, in turn making it possible for ITS experts to create their own applications by simply assembling existing models.

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