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Personalisation of web information systems – A term rewriting approach

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Abstract

Personalisation of web information systems (WISs) means customisation of the presented data content to the needs of users, restricting the available functionality to the goals and preferences of users, and tailoring the web presentation according to used devices and style options. This paper primarily concentrates on the customisation of functionality by making all those operations available to a user that are needed to achieve a specified goal, and by organising them in an action scheme called plot that is in accordance with the behavioural preferences of the user.

Plots are formalised by algebraic expressions in Kleene algebras with tests (KATs). Then personalisation can be formalised as an optimisation problem with equational preference rules, for which a term rewriting approach is proposed. In a second step the approach is extended to conditional term rewriting thereby dispensing with the particular need to associate preference rules with user profiles. Finally, the approach is refined by taking content specifications via extended views and abstract programs on these views into account. This leads us to reformulating the personalisation problem in higher-order dynamic logic.

Keywords: Adaptivity; Dynamic logic; Kleene algebra; Personalisation; Term rewriting; Web information system

1. Introduction

A web information system (WIS) is a data-intensive system that is primarily accessed via the world-wide web. A particular characteristic of these systems that makes them different from standard (enterprise) information systems is that they are in principle open to any user, and that acceptance by a wide spectrum of users is usually considered a success criterium. As users are very diverse, this openness brings with it the need to customise the system to its users, so that each user can work with higher personal version of the system. This leads to the problem of *personalisation*.

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Personalisation of WISs means customisation of the presented data content to the needs of users, restricting the available functionality to the goals and preferences of users, and tailoring the web presentation according to used devices and style options. It is of course desirable that personalisation be performed by the system itself in form of an intelligent reasoning process instead of somehow blowing up a system specification by lots of variants for different user characteristics. This requires in the first place a formal model of the WIS including a model of its intended or anticipated users.

For the design of WISs several integrated methods such as the Co-Design approach [38], WSDM [10], WebML [7], OOHDM [33,39], ARANEUS [3], HERA [23], and OO-H [19] have been proposed. Each of these models could serve more or less for the provision of such a formal model. Though the authors of all these methods are aware of the personalisation problem, only Co-Design has taken an explicit formal and reasoning-oriented approach [34,36]. Furthermore, there are some approaches to adaptivity that restrict themselves to the level of pages, i.e. the starting point is a full implementation of a web information system by web pages. Then adaptation takes HTML as the format of its input. In the UWA framework [15,24,41] the adaptation is expressed by event-condition-action rules. Other page-level adaptation techniques are re-authoring [5], transcoding [4,22] and the functional-based object model [8]. Based on these techniques several commercial products and system prototypes have been implemented such as Mobiware [2], PowerBrowser [6] and WingMan [18]. None of these approaches support our aim to base personalisation on an intelligent reasoning process. We therefore continue the line of research of the Co-Design approach.

The co-design approach to WIS design uses five layers of abstraction [37], two of which are of eminent importance for personalisation. On a high-level of abstraction – the *business layer* – we may consider a WIS as a process called the *plot* or *action scheme*. The plot can be described by an expression in an assignment-free algebra and consequently gives rise to an algebraic expression in a Kleene algebra with tests (KATs) [28]. KATs share many simularities with process algebras as, e.g., in [16,17], though they originate from formal language theory. We will present this view on high-level WIS specification in Section 2.

On a lower level of abstraction – the *conceptual layer* – we may consider a WIS as a data-intensive dialogue system that can be specified by a collection of extended views called *media types* on some underlying database schema. Media types combine the specification of content and functionality. In particular, they refine the actions of the plot by operations associated with the media types, and they provide declarative means for the purpose of adaptivity to channels and end-devices and presentation preferences. We will present this view on conceptual WIS specification in Section 5.

Personalisation can be addressed on both these levels. On the higher level the formalisation by KATs allows us to specify user preferences and goals by equations and postconditions, respectively. We may formalise personalisation as an optimisation problem and therefore apply term rewriting to obtain a simplified plot, which will represent a version that is personalised according to these preferences and goals, which themselves depend on user types. We will describe this conditional term rewriting approach to personalisation in detail in Sections 3 and 4 including completeness and complexity. In a second step we question the need of the user profiles as such, as their major purpose is to give conditions to the preferences. This leads us to replacing the preferences equations by Horn clauses, but it will not much change the conditional term rewriting approach.

On the conceptual level the refined operations give rise to abstract programs, and the conditions are no longer propositional, but have to be expressed in higher-order logic. This leads us to reformulating the personalisation problem in higher-order dynamic logic [20]. We first present a proof obligation for personalisation following initial work in [34], then address how the term rewriting approach can be generalised under these challenging constraints. This will be done in Section 6.

2. High-level modelling of web information systems

In this section we briefly describe *storyboarding*, the method for high-level modelling of WISs from [38]. A storyboard comprises three parts: the story space, the actors, and the tasks. For our purposes here we can neglect the tasks. However, we cannot neglect the actors, as preferences of users are intrinsically bound to user types, i.e., indirectly to the actors.

For the story space we may view a WIS as a set of abstract locations, which abstract from actual pages. A user navigates between these locations, and on this navigation path she executes a number of actions. We