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Personalisation versus Adaptation? A User-centred Model Approach and its Application

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Abstract: In this paper, a terminological and pragmatic paradigm shift is proposed and undertaken from the field of Personalisation Systems towards the field of Adaptive Systems. A new conceptual framework for both topics is developed in order to enable a deeper insight into the challenges and benefits of merging the fields. The aim of this paper is to define a generic and component-based *Personalisation Model (PM)*, which is derived from an analytical perspective on systems that are pertinent to adaptation. Furthermore, validity and applicability of the PM are demonstrated for the field of adaptive e-learning. Thus, practical experiences within the AdeLE (Adaptive e-Learning with Eye-Tracking) research project are discussed.

Keywords: adaptation, personalisation, e-learning, adaptive systems, adaptation systems, personalisation systems, user modelling, user profiling, adaptive e-learning, eye tracking
Categories: H.4, J.4, K.3, I.5

1 Introduction

Personalisation and Adaptive Systems are relevant issues in several research fields as well as for the design and development of commercial products. The topicality of both terms can be explained as a consequence of the impulse given by the broad dissemination of the World Wide Web (WWW). Almost all users of such systems are conscious of the increasing amount of well-tailored information they may access for particular needs. Further, they are also aware of the fact that, in the majority of cases,

they have to pay the price or hazard the consequences of delivering personal data to ensure those services. In order to corroborate these observations let us mention that according to surveys (e.g. [ChoiceStream 2004]) most of them are willing to do so.

Specifically, the high value of personalisation and adaptive systems can be identified in various application fields, such as e-commerce and adaptive e-learning ([Hof et al., 1998], [Kobsa 2001], [Cooperstein et al., 1999]). No doubt, rather than a 'trend', there is a real 'need' for such systems in several situations of modern life.

The main issues we address in this paper are focused, firstly, on the semantic relationships between *Personalisation and Adaptation (P&A)*, and secondly, on the usage of both terms in modern software solutions, in this case for e-learning.

1.1 Background Issues and Motivation

At least within the research communities it should be known that the topics (P&A) are neither new techniques in the field of Computer Science nor new issues of research in other fields, as can be identified e.g. in Cybernetics, Evolutionary Research, Biology or Climatology. If we would know that computer scientists have at the present a common understanding about both topics, we would not address this subject as a problem. But this is not the case: there is a semantic problem, and consequently, a pragmatic one.

In the last 20 years much research work took place to discuss critical terminological issues regarding P&A. Fact is, researchers have been contributing to (re)define a single term in different ways, sometimes as an attempt to reinvent the wheel or only to give the impression of talking about something different, innovative or modern. For example, consider modern software solutions of 'adaptive systems' for which the terms customisation vs. personalisation, or adaptability vs. adaptivity are used to express rather the same thing (often in a misleading, incorrect or incomplete way).

1.2 Providing a Working Basis

In order to better expose the aim of this paper let us start with a first attempt towards a (deliberately abstract) *formulation* for shifting Personalisation towards the field of Adaptation: As a response to some *stimuli*, a system *alters something* in such a way that the *result* of the alteration corresponds to the *most suitable solution* in order to fulfil some *specific needs*. In the context of this paper, the specific needs are linked to the goals of the *person interacting* with the system.

Based on this formulation, we argue that this 'definition' applies to both, P&A systems, as it describes at the same time their main purpose. Further, we aim to motivate others to investigate P&A as interdependent concepts. Thus, the need arises to find a *model*, which semantically establishes a terminological order, systematically describes both topics, and methodically defines participatory components and interactions. In addition, the model should support the visualisation of involved processes as well as represent a basis for future analytical steps and e.g. support the design of systems' architectures, as in the case of the AdeLE project (see section 3).

The next chapters depict the design of such a model deriving it from findings in well-established disciplines and its application on the field of adaptive e-learning.

2 From Adaptation to Personalisation?

The aim of this section is to collect and discuss a set of findings and arguments in order to confirm our point of view with respect to our hypothesis that *personalising* is the same as *adapting towards a specific user*, or in other words, personalisation systems represent a specific subtype of general adaptation systems.

For this purpose, we move towards the development of an adaptation-based *Personalisation Model (PM)*: we start from an analysis of general adaptation from the point of view of different well-established research fields, continue through the identification of relevant issues in context, and end with the definition of the main components of a personalisation system.

An extensive literature research work at IICM in the field of adaptation systems, [García Barrios 2004], constitutes the bibliographic basis of this chapter.

2.1 Learning from other Research Fields

Well-established fields like Control Systems, Climatology, Biology, Cybernetics, Evolutionary Research or System Theory, allow a deeper insight into the thematic of *adaptation* and contribute to a better understanding [García Barrios 2004]. 'Old' findings from these fields have already provided terms, which describe the characteristics of systems that are pertinent to adaptation and thus, facilitate the identification of participatory components and interaction processes.

Some examples of the most relevant characteristics in context are identified and explained as follows: *Sensitivity* (degree to which a system is affected by or responsive to environmental stimuli, i.e. responsiveness to stimuli), *Vulnerability* (degree to which a system is susceptible to injury, damage, or harm; thus, susceptibility is one part - the problematic or detrimental part - of sensitivity), *Robustness* (degree or strength to which a system is not given to influence), *Resistance* (degree to which a system opposes to or prevents an effect of a stimulus), *Adaptive Capacity* (potential or capability of a system to adapt to environmental stimuli or their effects or impacts), *Adaptability* (property of being adaptable; it may be also seen as the sum of adaptable entities), *Responsiveness*[1] (degree to which a system reacts to stimuli), *Stability* (degree to which a system is not easily moved or modified from a stable state), *Feedback* (*feedback* loops are taken into account for *regulation* processes, i.e. a system's effort to maintain an *equilibrium* or to reach a goal; furthermore, it is argued that integral feedback control is not only sufficient but also necessary for robust adaptation).

By means of these terms basic components that participate in adaptation processes are identifiable (*Components for General Adaptation, CGA*). Details about CGAs are not given in this paper, because the evaluation of their validity scope is still in progress. Though, mentioning them gives a systemic overview over the topic and serves as a basis for further observations.

Thus, CGAs are divided in the following groups: *External Components* (*EC*, e.g. Environment, Adaptation Targets, Stimulators), *Interaction Layer* (*IL*, e.g. Adaptation Interfaces, Expression Places, Sensors), *Internal Components* (*IC*, e.g. Adaptable

[1] Responsiveness is a broader term than adaptability, because in the context of general adaptation responses do not need to be 'successful'.

Objects, Adapter, Feedback Provider, Modelling Components), and *Adaptation Parameters* (*AP*, e.g. representations of needs for or goals of adaptation).

2.2 The Paradigm Shift

Based on our *formulation* stated in section 1.2, and taking into account the terms and components listed in section 2.1, a first attempt is undertaken to join P&A together. In concrete, the paradigm shift from General Adaptation to Personalisation takes place by means of transformations of CGAs, which lead to the generation of the main components of our *Personalisation Model (PM)*. The PM is illustrated in Figure 1.

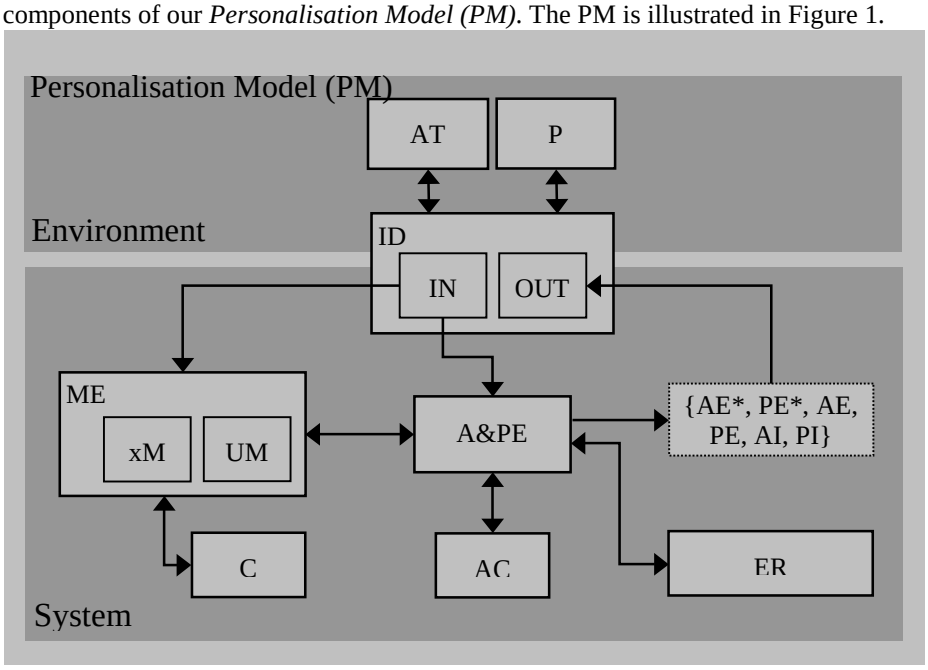

Figure 1: Personalisation Model (PM)

The PM is basically defined by the interactions among its components. Thus, the paradigm shift from adaptation to personalisation (by means of CGA transformations) and the functionality of PM can be defined as depicted in the reminder of this chapter.

'Personalisation is adaptation towards a specific user', i.e. main Stimulators are reduced and mapped to *Persons (P)* in PM. In order to embrace further requirements on general adaptation, we define additional *Adaptation Targets (AT)*. Thus, ATs enable adaptation towards environmental entities that also interact with the system but are not 'explicitly personal' (i.e. do not belong to a specific user). Further, the main components of the CGA group Interaction Layer (Sensors and Expression Places[2]) are

[2] In order to make adaptations perceivable to users, 'places' (more precisely equipment or facilities) are needed to 'express' them. Thus, the impact/success of adaptation can be measured in so called 'expression places', e.g. a display screen, speakers or any other output device.

represented in the PM by *Interaction Interfaces (ID)*, which in turn are divided into *Input (IN)* and *Output Interfaces (OUT)*.

Generally speaking and in most cases, a system can not adapt if it is not aware of its external world (Environment). Thus, an internal knowledge about the environment (Modelling Components in CGA) is needed in PM and represented by a *Modelling Engine (ME)*. ME is divided into *User Model (UM)* and *other Models (xM)* in order to personalise or adapt, respectively. It is important to state at this point that knowledge about the external world must not originate from INs but also through interaction with other information sources[3], i.e. the definition of an additional *Collector (C)* is needed.

We call *adaptors*[4] the components in charge of controlling and supervising an adaptation process. In PM, a general Adaptor (also known as 'adaptive system') is defined by the *Adaptation & Personalisation Engine (A&PE)*. Further, adaptation is mostly limited to specific conditions and requirements, which correspond to the AP group in the CGA. Thus, adaptation context, rules, constraints, goals, etc. are defined in PM by the *Adaptation Configuration (AC)*.

Adaptability and adaptive capacity are defined in PM by an *Entities Repository (ER)*, where all adaptable entities are represented. A&PE may take *Adaptable* or *Personalisable Entities (AE* or *PE)* from the ER and produce *Adapted* or *Personalised Entities (AE** or *PE*)*, which are mostly transferred to and expressed in OUTs. We also consider the particular case, for which *Adaptation* or *Personalisation Instructions (AI* or *PI)* are generated in order to produce changes directly on or in OUTs.

For the purpose of better clarifying the applicability of the PM and the differences between personalisation and adaptation, two examples are depicted as follows:

1. A system may *adapt* the brightness of the user's screen (e.g. according to the stimulus 'environmental illumination'), but may additionally *personalise* the colours of the delivered content layout on the screen (e.g. because the specific user suffers from colour blindness). This case may only find validity if the brightness of the screen is not interpreted as a dynamic element of the user model. However, we assume that this adaptation takes place towards the room illumination and not towards a specific user, because exactly the same adaptation will take place for any other person using the same screen. Therefore, when we refer to personalisation we refer at the same time to a specific 'named user' for which the system uses a personal user model. In PM the two processes take place, respectively, as follows: {AT → IN → xM → A&P → AI → OUT} and {P → IN → UM → A&P → PE → OUT}.
2. A system may *adapt* the size of a document (e.g. compress it due to a slow connection speed of the computer system), but *personalise* the language of the content according to the preferred language of a specific user. Thus, personalisation implies explicit knowledge about the user, i.e. the system needs either a model of or an interaction with the user. By means of PM both processes take place, respectively, as follows: {AT → IN → xM → A&P → AE → OUT} and {P → IN → UM → A&P → PE → OUT}.

[3] To clarify this fact, consider a system that manages an internal user model by retrieving user data via an external search engine or by interacting with an external user modelling shell/server.
[4] In the context of this paper we distinguish between Adaptor and Adapter: an adaptor describes a component that can adapt something, and adapter is an entity that is used to alter an adaptable object. Thus, an adaptor may generate or choose an adapter in order to alter an adaptable object.

Concluding, the PM allows us to state the following definition: *Personalisation is adaptation towards a named user for which an internal and individual model is needed, i.e. the adaptor (adaptive component) will alter some known adaptable entity and must interact with the user or with its abstract representation (user model) in order to generate the best suitable solution to satisfy a user's need or interaction goal*.

This definition leads, among others, to the following statements regarding Personalisation: (a) personalisation processes imply knowledge about a very specific user, (b) an adaptation controlling component is needed, i.e. adaptive component or personalisation engine, (c) the adaptive capacity of the system depends on the set of adaptable entities, which in turn defines the adaptability of the system, (d) a personalisation process begins with a stimulus and ends with a best-suitable response.

3 Personalisation and Adaptation in AdeLE

The *AdeLE* (*Adaptive e-Learning with Eye-Tracking*) project aims to research on adaptation-based e-learning as well as to develop a prototype implementation for personalised e-learning. This section describes some functional aspects of the used strategy, deriving from them concrete scenarios for P&A. For details about technological aspects or issues concerning e-learning please refer to [AdeLE 2005].

3.1 The AdeLE Prototype

With respect to [Shute and Towle 2003], *adaptive e-learning (AEL)* comprises a research and development stream dealing with educational systems adapting learning content and user interface according to pedagogical aspects. In [Mödritscher et al. 2004] we already examined the four most relevant approaches for the description of AEL: macro-adaptive instructional design, aptitude-treatment interaction (ATI), micro-adaptive instructional design, and the constructivistic-collaborative approach. To which extent these approaches deal with P&A can be summarised as follows:

(1) *Designing the courseware* may depend on three approaches. The macro-adaptive theory focuses on adapting decisions according to didactical models (e.g. levels of detail or paths through a course). The ATI approach provides personalisation on the level of content aggregation and instructional sequencing according to specific user traits. The constructivistic-collaborative approach considers personalisation by means of new learning paradigms, motivational aspects, collaborative tasks, context-depended learning etc. In AdeLE we defined a set of pedagogical requirements for the learning content.

(2) The *adaptation process by means of user observation* can be best realised with respect to the micro-adaptive approach for AEL, which is about two main components: a diagnostic process assessing the learner's states and learning progress as well as a prescriptive process adapting content and control elements in terms of didactical objectives. Therefore, adaptation is based in AdeLE on a rule-based engine.

At the current state the AdeLE prototype consists of four main components. The *Learning Management System (LMS)* is realised by ADL's Sample Runtime Environment and extended by a package that encapsulates the functionality to interact with the *Adaptive System (AS)*. For each user interaction, the LMS notifies the AS

about the action. The AS, thereafter, adapts certain aspects of the LMS or asks the user for feedback. For personalising, the AS may also adapt instructional sequencing or content aggregation according to a user model provided by the *Profiler System (PS)*. In addition, AS and PS are initialised via a *Configuration System*, where basic services like a data-handler, basic configuration settings, and other, are defined.

3.2 Different Types of Personalisation

Considering our view on AEL and the realisation of the AdeLE prototype as well as for the purpose of showing the applicability of the PM, different types of personalisation can be identified and depicted exemplarily as follows:

(1) *Explicit vs. implicit personalisation*: Explicit personalisation describes the adaptation according to a concrete user profile. For instance, the AdeLE system provides adapted learning content (e.g. more textual or more graphical) by using a specific learner model. Implicit personalisation is about adaptation resulting from a certain context (situation or environment) and without using a profile, e.g. adapting the content's layout according to the output device the learner is just using.

(2) *Perceivable vs. hidden personalisation*: Personalisation is called perceivable, if a user recognises the result of personalisation, e.g. the AdeLE system may show or hide control elements, such as tree-view, visualising the course structure according to user-specific cognitive traits. Hidden personalisation does not affect the user interface or the presented content at all, e.g. if it is intended to update a user model according to some adaptation rule, the user may not 'see' the result of this personalisation step.

(3) *Predictive vs. deterministic personalisation*: Predictive personalisation comprises some 'work in advance', e.g. if the best instructions to go on through the courseware are generated for a learner, this personalisation step is not only hidden, but also predictive. Deterministic personalisation takes place within one adaptation process, e.g. if the chosen instruction is aggregated and displayed right now.

(4) *Controlled vs. uncontrolled personalisation*: Controlled personalisation makes the system scrutable for a user and describes also the idea that the user may take control of adaptation processes at any time. Consider the simple case for which the system can not decide the aggregation of an instruction and the learner is asked to choose the appropriate instruction given by a set of suggestions. Uncontrolled personalisation would not allow the user to influence the adaptation process.

(5) *Individual vs. stereotyped personalisation*: Individual personalisation comprises personalisation towards 'one specific person'. Stereotyped personalisation allows 'personalisation towards groups or anonymous users', e.g. an adaptation towards the 'customers' of a company aims at 'all users known as customers'.

4 Conclusions and Future Work

In summary, issues of Personalisation can be explained through a generic Personalisation Model as well as extended and enhanced through its interpretation as a part (or sub-type) of general Adaptation.

As may be concluded from the observations stated in this paper, several interpretations of the concepts Personalisation and Adaptation can be found on dependence of the research field in consideration. Nevertheless, a set of relevant key

issues can be derived from the different well-established disciplines and applied in 'newer' fields or 'modern' application areas, as in the case of adaptive e-learning.

The Personalisation Model developed and presented in this paper involves the most important components that participate in a personalisation process (described as a pure but specific adaptation process) and shows how a generic solution approach may be constructed in order to develop a flexible and modular software solution. In addition, the model comprises the most important terms in context and permits a notion of personalisation and adaptation as both, a process within the system and a condition of the system.

The viability and feasibility as well as the validity scope of the model will be evaluated in future work at IICM. On the account of this last fact, it is important to emphasise again that the model is considered by the authors of this paper as a first proposal and attempt towards a final model. Future analytical, research and practical work should lead to enhanced variants of this solution approach.

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