Chapter 2

PERSONALIZED NEEDS ELICITATION IN WEB-BASED CONFIGURATION SYSTEMS

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Abstract: The high product variety of a mass customization strategy induces a high level of complexity both from the mass-customizer's perspective as well as from the customers' viewpoint. In particular, a high number of different product variants and configurable features can be challenging for the end-user who is often overwhelmed during the configuration and buying process. As customers are generally not technical engineers, but rather less-experienced, they are often confused and unable to choose the product that best fits their needs. As a consequence, customers can be dissatisfied with their buying decision later on, which finally leads to frustration and a decrease of customer loyalty. Web-based product configuration systems are nowadays well-established in commercial environments and enable users to specify desired product variants typically on a technical level. Thus, they efficiently support product experts in configuring their desired product variant. However, most current systems do not take into account the fact that online configuration systems should be usable and helpful for quite heterogeneous user groups. Online customers typically have a different background in terms of experience or skills or are simply different in the way they prefer to (are able to) express their needs and requirements. Thus, we argue that the typical "one-style-fits-all" approach for needs elicitation is not adequate for customer-supplier-interaction in mass customization. As users are different, it is necessary to adapt the interaction to the customer, i.e. to take the user's background or his capabilities into account and tailor the interaction accordingly. Within this paper, we comprehensively discuss personalization and adaptation possibilities for interactive needs elicitation in online configuration by categorizing the different levels and dimensions in a conceptual framework. Throughout, we describe adequate techniques for effectively implementing such functionality and give examples for personalization opportunities for the different levels. Finally, we discuss architectural aspects when building and maintaining such highly-adaptive web applications.Our work extends already existing work on personalization for product configuration systems. However, while most existing approaches base their adaptation features on long-term user models, we focus on (knowledge-

based) techniques that allow us to personalize the interaction style also for first-time users, for which there is nearly no support in most existing systems.

Key words: Personalization, Web-based Configuration Systems, Needs Elicitation

1. INTRODUCTION

Today, the competitive situation of companies is characterized by a strong orientation towards product individualization. The market's demand for customer-individual, configurable products has been constantly increasing. As a consequence, the mass-customization paradigm, which aims at satisfying individual customer needs with a near mass production efficiency (Pine, 1993), has been applied in different industrial sectors.

The high product variety of the mass customization strategy induces a high level of complexity both from the mass customizer's perspective as well as from the customer's view-point. Internal complexity induces additional (hidden) costs at the manufacturers' level, external complexity can lead to confusion during the customers' decision making process. In particular, the high number of different product variants and configurable features can be challenging for the end-user who is often overwhelmed during the configuration and buying process (Scheer et al., 2003). As customers are generally not technical engineers, but rather less-experienced, they are often unable to choose the product that best fits their needs. As a consequence, they can be dissatisfied with their buying decision later on, which finally leads to frustration and to a decrease of customer loyalty.

Web-based product configuration systems are important enablers of the mass customization paradigm and nowadays are well-established in commercial environments. They enable users to specify desired product variants – typically on a technical level, because in practice the technological perspective dominates the user perspective (Blecker et al., 2005). Thus, they efficiently support product experts in configuring their desired product variant. However, most current systems do not take into account the fact that online configuration systems should be usable and helpful for heterogeneous user groups. Online customers typically have a different background in terms of experience or skills or are simply different in the way they prefer to or are able to express their needs and requirements (Felfernig et al., 2002). Thus, we argue that the typical "one-style-fits-all" approach for needs elicitation, e.g. based on static HTML fill-out forms, is not adequate for customer-supplier-interaction in mass customization environments. As users are different, it is necessary to adapt the interaction process to the customer, i.e. to take the

user's background or his capabilities into account and tailor the interaction accordingly. For example, if we think of a system for configuring personal computers, there will be users who want to specify technical details of the desired model, whereas others will only be able to express for what purposes they intend use the computer; others again only want to compare preconfigured models and decide by themselves.

In particular, the quality of the results, i.e. the accuracy of the acquired customers' real needs and consequently the proposed product configurations that best fit these needs, can be significantly improved when the system interacts with the user in a personalized way. Extensive personalization of the interaction between the user and the configuration system can bring us one step closer to real-world face-to-face communication where the communication partners adapt their communication style to their vis-à-vis. Thus, users are enabled to express their requirements in a natural way and their confidence in the system's results increases when they have the feeling that their requirements are taken adequately into account.

Within this paper, we comprehensively discuss personalization and adaptation possibilities for interactive needs elicitation in online configuration by categorizing the different levels and dimensions in a conceptual framework. Throughout, we describe adequate techniques for effectively implementing such functionality and give examples for personalization opportunities on different levels. Our work extends already existing work on personalization for web-based product configuration systems, e.g. Ardissono et al. (2003), introducing new personalization concepts that are already applied in web-based guided selling systems (see, e.g. Jannach (2004), Jannach and Kreutler (2004)). Whereas most existing approaches base their adaptation features on long-term user models, we focus on techniques for the personalization of the interaction also for first-time-users, for which there is nearly no support in existing systems up to now. Finally, we discuss architectural aspects for building and maintaining such highly-adaptive web applications.

2. PERSONALIZATION AND ADAPTATION IN THE CONFIGURATION PROCESS

Personalization can be considered as a means to help individuals satisfy a goal that efficiently and knowledgeably addresses their need in a given context by understanding their preferences (Ricken, 2000). In web-based e-commerce settings, personalization consists of activities that tailor the user's web experience to his or her particular needs, e.g. by adapting online applications to individual user's characteristics or usage behavior on several levels. In order to find a general classification scheme for the different person-

alization possibilities in the web-based configuration process, we follow the basic structure of Kobsa et al. (2001) who identified three basic categories of personalization opportunities for general hypermedia applications: Content level, interaction level, and presentation level. Note that a strict separation of these levels is not always possible, which may lead to overlaps in the categorization.

In contrast to existing work in this context, like for instance Ardissono et al. (2003), we do not primarily focus on the acquisition of a long-term user model, but rather on short-term personalization possibilities that can be immediately applied during an interaction, e.g. in the case of new users. Thus, it is possible to cope with the new-user-problem (Rashid et al., 2002). However, it is also possible to improve the presented concepts by the application of long-term user models that provide further information about the user.

2.1 Personalization on the Content Level

Configuration Steps and Configuration Dialog. A product configuration dialog typically consists of a set of subsequent questions about desired product features, i.e. the user is repeatedly asked to select or enter one or more values for a certain feature or option. The configuration engine uses these inputs to refine the current user's configuration, i.e. the product variant. This process is repeated until all required product features are selected. In non-adaptive approaches, every user is asked the same set of questions in the same order. However, this is problematic because it can lead to a configuration result that only poorly corresponds to the user's needs and preferences. The typical problems are, e.g.,

– the user does not understand a configuration step because of missing background knowledge. Thus, the user is unable to select some product features and the default value or even a wrong value is chosen.

– the user is annoyed by too many steps in the configuration process that are already irrelevant in the current situation due to previously given answers.

– the user is frustrated by a non-natural interaction style in which the system statically poses questions about product features without reacting situatively on the user's current answers.

Such situations do not only cause poor configurations that do not match the customers' requirements, they also reduce the user's confidence in the system's results, in particular if he has the feeling that he was not able to clearly express his needs.

In our approach, we aim at mitigating these problems by the application of personalization techniques during the configuration process on different levels. On the one hand, the presentation of the questions and the selectable features can be personalized, as well as the dialog flow between the user and the configuration system itself in order to achieve a more natural conversational interaction style (cf. Bridge (2002), Carenini et al. (2003)). Figure 2-1 depicts an overview of the personalization possibilities on a configuration page on the content level. The individual contents of the page can be dynamically constructed on the basis of a declarative knowledge base that contain the required text fragments as well as the personalization rules that determine the page content based on the current user's characteristics (Jannach, 2004).

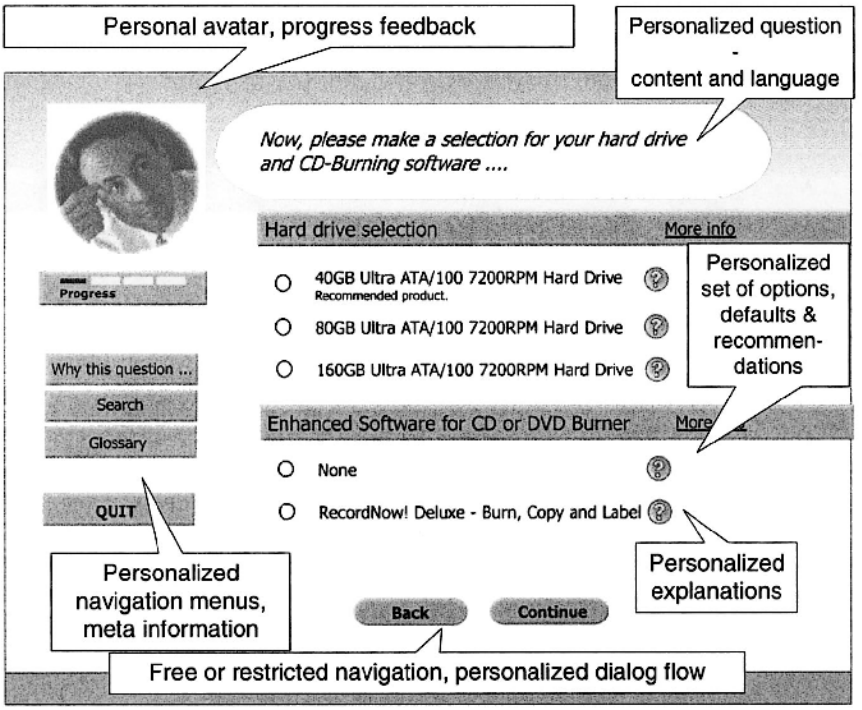

Figure 2-1. Personalized configuration page

In this context, the personalization capabilities comprise, for instance, the following items:

– The selection of a certain language or jargon that different user groups might be used to or feel most comfortable with, e.g. a formal or an entertaining language.

– The dynamic construction of the set of configuration features that can be selected by the user. This means that depending on the current state of the configuration, i.e. the user's previous inputs, some alternatives can be added or removed. Thus, irrelevant options (in the current situation) or too complex ones (for certain user groups) are removed.

– The automatic selection of appropriate situation-dependent defaults (system proposals) in order to minimize the number of required clicks, which is particularly important in longer dialogs.

– The amount of optional detailed information for a configuration step or options, depending on the user's estimated domain expertise.

On the level of the dialog itself, we propose a knowledge-based approach to design personalized user dialogs. Therefore, the web-based conversation can be modeled in terms of a sequence of configuration pages. These pages typically contain one or more questions where the user can set a product feature in his most convenient style. This comprises on the one hand the presentation, e.g. a product feature's graphical representation, on the other hand the content of the question. For instance, whereas product experts prefer to select product features directly, novice users are more familiar with customer-oriented questions about their needs where the configuration system then internally infers suitable product features.

In a knowledge-based approach, all the personalization rules, i.e. the selection of a configuration page and their contents in a certain situation, as well as the selection of a suitable presentation style or language, can be modeled as declarative conditions over the current user's characteristics. At run-time, the configuration system can automatically evaluate these conditions and choose appropriate configuration pages with a suitable presentation style. Note that the user characteristics to be evaluated can stem from already given answers of the user; in addition, also models of known users can be exploited.

Phases are a further means of personalization that structure the dialog. They can be used to provide the user some feedback on the dialog's progress and to vary the degrees of freedom with respect to navigation, i.e. whether a user is allowed to freely navigate between configuration steps.

Hints. The provision of optional opportunistic hints is another possibility of personalizing general hypermedia applications identified by Kobsa et al. (2001). Particularly in online product configuration, such hints are a major means to enrich the otherwise mostly system-driven dialogs because they give an immediate and personalized feedback on the user's inputs. Consequently, users get the feeling that the system actively monitors their inputs and participates in the dialog. Hints are applicable on different levels and can be again modeled as conditions over the current user's characteristics.

The major benefit of hints is to provide additional information about certain configuration options, i.e. product features that can be set by the user. Thus, it is possible to provide non-expert users with detailed technical information or to display additional information for cross-selling or up-selling purposes. Additionally, hints can be used to actively interrupt the dialog, in particular in cases where the user has to be informed about possible inconsistencies in his requirements that lead to an empty configuration result. Finally, they allow for the personalization of the result page, i.e. the last dialog step presenting the configured product proposals. There, it is possible to provide supplementary information on the displayed configurations. Furthermore, it is possible to explain additional inferences on the user requirements in cases when the system applied internal reasoning rules to infer user preferences that cannot be directly acquired.

Explanations and Reasoning. The results of the product configuration process are valid product configurations that correspond to the customer's real needs and preferences. In order to increase the user's confidence into the system's output, the system has to provide understandable explanations. We argue that these explanations also have to be personalized to be understandable and useful for different kind end-users. Depending on the current user's capabilities and interests, several points can be varied, such as:

– The language used in the explanations (e.g. technical or non-technical terms).

– The level of details of the underlying reasoning process that are presented, i.e. information provided by the configuration engine.

A specific form of personalization of the reasoning process is to enable the user to override the outcome of the reasoning process to some extent (Jannach and Kreutler, 2005). In online configuration systems, a typical example are indirectly acquired (derived) customer characteristics where the system infers some estimate of customer properties that cannot be acquired directly, e.g. the risk class of a customer in an investment scenario. The further reasoning process is then based on the outcome of that classification which should also be part of the explanation the system provides. Moreover, enabling the (advanced) user to override these estimates can also lead to a more accurate elicitation of the user's personal needs and better configuration results.

Finally, the personalization of the configuration system's reasoning behavior can also influence the treatment of unsolvable user requirements. This means that the configuration system is not able to find a valid product configuration that corresponds to the preferences and requirements of the user, i.e. to his/her inputs. In these situations, the system has to remove some user constraints in order to find a valid product that fulfills as many requirements as possible (see, for instance, Freuder and Wallace (1992)). Therefore, the

user has to state priorities for his requirements, which consequently increases the accuracy of the estimate of his/her interests. In the explanation phase, the system can then use the lists with all requirements that were fulfilled as well as the requirements that were dropped.

Result Presentation. Even in the phase when the suitable product configurations are presented, there are some personalization opportunities to enable the user to refine his requirements.

One possible option is the presentation of alternative products, both relatively similar ones as well as reference products from other classes of products. Thus, the application of different similarity measures and the provision of adequate explanations, e.g. how a product fits the user's stated requirements or not, lead to a more accurate user model.

In general, the result presentation phase can be used to monitor the quality of the configuration process over time. This can be done for instance by letting the users submit ratings whether he found the proposal useful or not, or by monitoring the click-behavior of the user (e.g. for clicking on a link for viewing detailed product information).

2.2 Personalization on the Interaction and Presentation Level

On the interaction level, two aspects of personalization can be considered: the interaction style and degrees of freedom in navigation. Regarding the interaction style, in online configuration systems one basic form is common – a system driven dialog with fill-out forms (which can be extended by extensive personalization through a dynamically adapted front-end). Most importantly, online users are well-acquainted with this interaction style; they also often feel comfortable when the system actively guides them through the configuration process. Nonetheless, depending on the current user and on the application domain, other forms of interaction can be more intuitive for the user and finally lead to better results in the elicitation process.

Natural Language Interaction. In this context, the most important personalization aspect is the decision how "user driven" a dialog should be designed, i.e. whether the user should be enabled to actively steer the dialog, e.g. by directly posing questions. In theory, the ultimate solution for this would be a full natural-language interface based on an intelligent agent that has both the knowledge in the application domain as well as the required knowledge to carry out a conversation, i.e. how to steer the dialog or react to specific situations. First natural-language style approaches are already applicable in e-commerce settings (see, e.g., Thiel et al. (2002), Thompson et al. (2004)), but there are still open problems. Particularly the requirement of massive knowledge acquisition and modeling efforts to reach an acceptable

dialog quality is a restraint for the implementation of such a system. Most importantly, it is difficult to cope with general user utterances beside from domain knowledge. This could be interpreted as a "poor" dialog quality by the user, which consequently leads to a frustration because users attribute more intelligence to the system than there actually is. Furthermore, in many application domains the dialog cannot be fully user-driven because the user's background knowledge is too limited (i.e. he cannot properly articulate questions).

Degrees of Freedom in Navigation. Another way to vary the interaction style according to the current user's needs and capabilities is the variation of the "degrees of freedom" with respect to navigation. This refers to the guidance of the users in the dialog. whereas some users might prefer a strong guidance, i.e. a strict order of configuration steps, others feel more comfortable when they can steer the dialog on their own. This comprises the possibility of selecting the order of questions they answer, moving forth and back in the dialog, revising answers, or trying different alternatives for product features. Additionally, the amount of visible navigation functionality for the user can be personalized, such that experts do not feel restricted in their possibilities, while beginners are not overwhelmed or frustrated by the complexity of the application.

Domain-specific Interaction Styles. In state-of-the-art product configuration applications, users have to specify the details of the desired configuration by going through a guided dialog where they have to answer several questions about desired product features and/or their preferences. In real life, however, customers are not tied to one single style in human-human-interaction. They prefer different communication styles with their vis-à-vis, depending on the current situation and the domain they are in. For instance, in the financial domain, clients are used to be presented a product proposal from their sales person after an intensive requirement elicitation dialog, whereas in domains of consumer goods, e.g. digital cameras, expert customers could expect support from the sales person in comparing several products.

Therefore, in the online channel customers also must not be constrained to one single interaction style. Depending on the current user's situation, personalized online configuration systems also should offer several interaction styles. Besides the described standard dialog that leads to product configurations, some users could prefer to start with a basic, pre-configured model and adapt one or the other part; others again only want to specify some key components and functionality and let the system decide on the rest. The selection of the appropriate interaction style can be done either explicitly by the user at the beginning of the configuration process, or implicitly by

the system, e.g. by asking the user a few questions to determine the most suitable interaction form.

Domain-specific interaction styles enable users to express their requirement in several ways. Therefore, we argue that the overall quality of the results of the online configuration process also increases.

Presentation Style. Kobsa et al. (2001) identified the presentation level as the third level of personalization. In our context, this level is strongly related with the interaction and content levels. In general, all "standard" personalization possibilities as described by Kobsa et al. (2001) can be applied. This comprises, e.g., support for different end-devices or handicapped users by different font-sizes or adaptable contrast. In the special context of online product configuration, personalized presentation variants could be provided with respect to the following dimensions.

First, the configuration dialog can be executed in an own window that focuses the user on a small area of interest, or integrated in a surrounding website or portal. There, additional information like, e.g. glossaries, further links or frequently asked questions), can be easily incorporated, which is advantageous for users that actively search for more information during the configuration process.

Another form of personalization of the presentation can be an appropriate interface layout that is coordinated with the language style used in the configuration process. For instance, a less formal or entertaining language can be supported by an animated "avatar" that serves as virtual conversation partner. This livens up a guided dialog and increases the user's online experience.

3. ARCHITECTURAL REQUIREMENTS

There are some major challenges involved in the development of extensively personalized web applications: Personalization is known to be a knowledge-intensive task (Kobsa et al., 2001). Such systems therefore have to feature adequate means for acquiring, representing, and – in particular – maintaining the required personalization knowledge. In addition, personalized user interfaces have to be extremely flexible, because both the content as well as the navigation options have to be dynamically determined and displayed based on the underlying personalization rules. Typically, there are also strong interdependencies between user interface, reasoning, and the knowledge base, which are challenging from an engineering perspective, because a clear separation between the application components in the sense of the Model-View-Controller approach (Krasner and Pope, 1988) can be difficult.

In Figure 2-2 we give an overview of a possible architecture for a personalized configuration service (compare, e.g., Jannach and Kreutler (2005)). One of the major features of this architecture is that we propose having as much as possible of the required knowledge in a shared repository. In particular we argue that the knowledge representation mechanism needed for expressing e.g., configuration and personalization knowledge should be based on a shared conceptualization and on compatible problem solving techniques as much as possible. Note that a different approach was taken e.g., in the CAWICOMS (Ardissono et al., 2003) project, where the core configuration task was based in Constraint Satisfaction, whereas personalization was based in rules and dynamic evaluation of user preferences.

In addition, also the required the knowledge acquisition and maintenance tools have to be integrated in a way that the knowledge engineer can edit the different pieces of knowledge in a consistent way, e.g., by using the same sort of "constraint language" for expressing configuration and personalization rules.

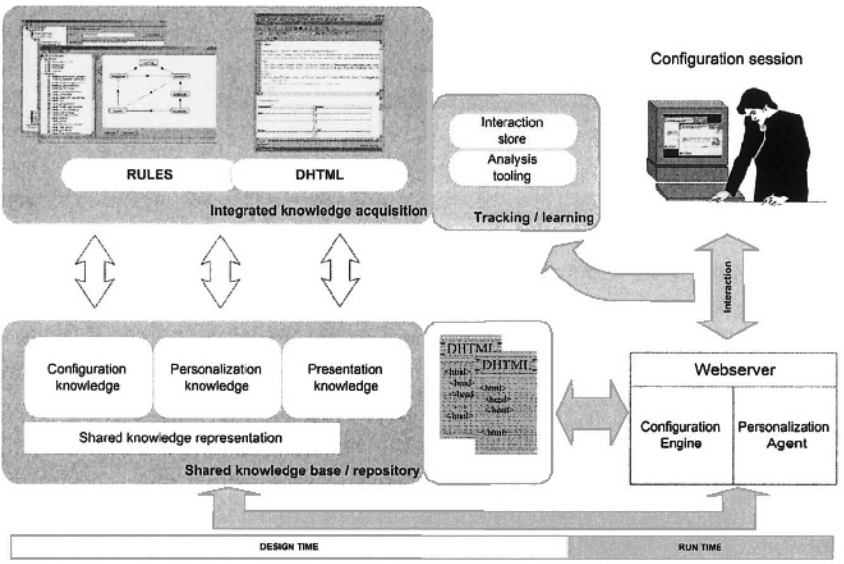

Figure 2-2. Possible architecture for a personalized configuration service

In many applications, the hardest part can be the integration of the development of the dynamic web pages: First, we have to deal with the limitations and shortcomings of dynamic HTML. In addition, we also have to take into account that – although most of the personalized content has to be generated dynamically – the pages have to be maintainable by Web developers that

e.g., adapt the layout according to a company's web site. A possible solution for the domain of personalized, content-based product recommendation was presented by Jannach (2004), where the dynamic web pages are constructed from modular page fragments and JSP "Custom Tags" where used to hide the complexity from the Web developer.

At run-time, our architecture proposes two modules, a configuration engine and a personalization agent that manages the interaction with the end user. Of course, both engines can make use of the same underlying problem reasoner, e.g., a constraint solver.

A final part of the architecture is "tracking/learning". Depending on the used personalization mechanisms it can be possible that the system fine-tunes itself over time (e.g., when using a sort of Multi-Attribute-Utility mechanism, or that a knowledge-engineer can do offline analyses and manually adapts/corrects the personalization rules, which is needed in many personalized systems after the initial setup.

4. SELECTED EXAMPLES FOR SUCCESSFUL PERSONALIZATION TECHNIQUES

Up to now, personalized needs acquisition has not been an important research issue in the field of configuration systems. Instead, personalizing the preference elicitation process was primarily addressed in the context of recommender systems. In this chapter, we describe some deliberately selected approaches that describe already established personalization techniques in the field of recommender and configuration systems.

McGinty and Smyth (2002a) propose an approach for recommender systems that is based on a more casual conversation. This means that there should be several degrees of feedback that an online user can provide during the dialog. For instance, leading users through deep dialogs that replicate customer buying models from real world is not appropriate in most online recommender settings. In such dialogs, users are asked direct questions about important product features, as real-world sales assistants would do in some cases. However, online users are less tolerant of being asked detailed questions, which prevents them from entering such dialogs.

Therefore, the authors argue that there should also be a low-cost form of feedback for users and propose a comparison-based recommendation approach, in which the user is asked to choose a recommended item as a (positive or negative) preference. The further product recommendation is based on the difference of the preferred products and the remaining alternatives.

In further work, McGinty and Smith (2002b) give an overview on different techniques for user feedback, e.g. value elicitation, tweaking, ratings-

based, and preference-based. In their paper, they focus on a low-cost preference-based feedback model which is evaluated in a recommendation framework.

The proposed feedback techniques for recommender systems can also be applied in the context of configuration systems. For instance, in the result presentation phase comparison-based approaches can be applied. In the sense of our work, different feedback techniques are a suitable means for the personalization on the interaction level and are comparable to domain-specific interaction styles.

Shimazu (2001) proposes the agent system ExpertClerk that imitates a human salesclerk that supports customers in finding the suitable product in online stores. The system supports two basic techniques: *Navigation by asking* and *navigation by proposing*. First, the system carries out a natural-language conversation with the customer in order to find a set of suitable products. Then, after a pre-defined threshold of questions, the three most-contrasting products among the remaining products are compared. Both steps are repeated until an appropriate product is found.

When compared with our work, the proposed system applies techniques on the interaction layer. It is noteworthy that ExpertClerk alternately takes use of different interaction styles during one dialog with the user, which enables the system to situatively react on the current state of the interaction. The system also depicts the current state of the dialog, i.e. it is show how many products are left for recommendation. Thus, the user can not get lost during the elicitation process.

The ClixSmart Navigator architecture (Smyth and Cotter, 2002) introduces personalization capabilities for mobile portals on the interaction level. It supports users navigating to the content of their interests in WAP portals. The authors identify that excessive navigation times, e.g. for navigating through a series of menu, frustrate users and are jointly responsible for the little success of WAP portals. Therefore, the ClixSmart Navigator adapts the structure of a mobile portal to the personal needs of users by storing hit tables which track an individual user's navigation behavior. Based on these tables, the menu is adapted (i.e. the position of menu items is reordered) to minimize the navigation distance for the most probable navigation options for a user.

Although the field of the proposed architecture is quite different from the product configuration domain, the main idea can also be applied for configuration systems: It is essential that the dialog with the end-user is carried out in a personalized way. This means that the user must not be annoyed with configuration steps that are not useful in the current situation of the dialog. Thus, it should be possible to shorten the dialog by dynamically selecting only relevant configuration steps.

In the domain of configuration systems, Pu et al. (2003) consider preference elicitation as a fundamental problem. Stemming from experiences in building decision support systems in various domains, they identify some principles for designing of the interactive procedure of finding a solution, i.e. a suitable configuration in the solution space.

In a survey of 10 commercial online flight reservation systems, they find out that a personalized order elicitation improves the preference elicitation process for the end-user. Thus, users should be able to state values for those options that correspond to their main objectives, which leads more quickly to a more accurate preference model. Furthermore, example critiquing in a minimal context, i.e. making critiques on a personalized (minimized) set of attributes, is also identified as adequate means.

The authors also consider the visualization of the result set with the possibility of revising previously stated preferences during the elicitation process as crucial because users can immediately see the consequences of their stated preferences and possible changes.

5. CONCLUSIONS

Nowadays, web-based configuration systems are well-established in industrial environments and essential for the success of the mass customization paradigm. However, state-of-the-art configuration systems are mainly product-oriented and do not optimally support heterogeneous groups of end-users in the configuration process, which often overwhelms customers and leads to frustration. In this paper, we have argued that personalization is a key factor to hide the external complexity and elicit the customer's real needs to lead him successfully to a suitable product configuration. Therefore, we have given an overview on personalization in this context and made a conceptualization of the personalization possibilities. Throughout, we focused on techniques that are also applicable for first-time users where no long-term user model exists. Finally, we have presented some architectural aspects for the development and maintenance of such extensively personalized web applications.

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