# An Advisory System for Customers' Objective Needs Elicitation in Mass Customization

Dr. Thorsten Blecker
University of Klagenfurt, Austria
Department of Production/Operations Management
+43-(0)463-2700-4077, blecker@ieee.org
http://www.uni-klu.ac.at/plum/

Dipl.-Ing. Dipl.-Wirtsch.-Ing. Nizar Abdelkafi
University of Klagenfurt, Austria
Department of Production/Operations Management
+43-(0)463-2700-4073, nizar.abdelkafi@uni-klu.ac.at
http://www.uni-klu.ac.at/plum/

DI Gerold Kreutler
University of Klagenfurt, Austria
Computer Science and Manufacturing
+43-(0)463-2700-4075, gerold.kreutler@uni-klu.ac.at
http://www.ifi.uni-klu.ac.at/IWAS/GF/

o.Univ.-Prof. Dr. Gerhard Friedrich
University of Klagenfurt, Austria
Computer Science and Manufacturing
+43-(0)463-2700-3705, gerhard.friedrich@uni-klu.ac.at
http://www.ifi.uni-klu.ac.at/IWAS/GF/

## Abstract

To better understand customer requirements in mass customization, we introduce here a model distinguishing between the objective and the subjective customers' needs. The model points out that the explicitly expressed customer requirements do not necessarily correspond to what customers really want. This model enables the explanation of the main shortcomings of the existing customer interaction systems. We conclude that customers should be better assisted during the elicitation process. Then, we briefly examine recommender systems within E-commerce. However, they are not able to provide customer assistance based on objective needs. Therefore, we introduce the notion of advisory systems for mass customization and we outline its basic structure. To better elicit the objective customers needs, we identify main extension fields of the system. Furthermore, to ensure the implementation of the extended advisory system, we describe the required technical infrastructure.

## Introduction

Mass customization is a business strategy that aims at satisfying individual customer needs nearly with mass production efficiency (Pine, 1993). The information which arises during the customization process serves to build up a long-lasting individual customer relationship (Piller, 2001). In opposition to mass production which provides market-focused products corresponding to an average satisfaction of several customer needs, companies pursuing mass customization strive for an offering of customer-focused products with a high individuality level. However, customers generally do not seek out individualization per se. They do not want more choices, they only want the choice to meet their needs. That is why, the main goal of mass customization should be "…that nearly everyone finds exactly what they want" (Pine, 1993, p. 44).

The development of mass customization is essentially due to the advances realized in modular product architectures and flexible manufacturing systems. However, the progress made in the fields of information technologies and with the Internet can be considered as the most relevant enablers for a successful implementation of this strategy. Rautenstrauch et al. (2002) pointed out that information systems provide a necessary support for enterprises pursuing mass customization, e.g. virtual enterprises. Moreover, by implementing configuration toolkits over the web, the mass customizer provides customers the possibility to self design their products while keeping interaction costs at a low level. Thus, customers are integrated in the value chain and are considered as "prosumers" (Toffler, 1980).

In order to increase the likelihood that each customer can find the product configuration corresponding to his specific needs, mass customizers offer a wide range of product options and alternatives. However, especially in the business to consumer field, customers are not product experts and do not dispose of adequate product knowledge. Because of the limited human information processing capacity and lack of technical product knowledge, excessive variety generally confuses customers, who are overwhelmed by the complexity of the decision making process. As a result, customers could abort the configuration process or make a suboptimal decision leading to poor satisfaction. Thus, if customers are not supported by adequate tools during the buying process, the main goal of mass customization cannot not be achieved.

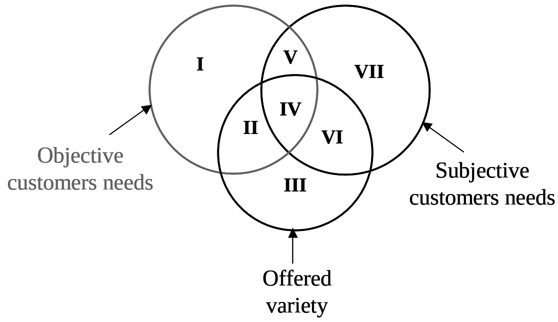
The elicitation process which is defined by Zipkin (2001) as the process customers go through to identify what they want, is a key capability in mass customization. This process located at the interface between customers and mass customizer will considerably affect the results of the product customization. Thus, the interaction system supporting this process is of high relevance because it is decisive for success or failure of the total customization process. Moreover, in order to determine the optimal characteristics of an interaction system the mass customizer has to understand at first customer needs.

## Differentiation between Objective and Subjective Customers' Needs for a Better Understanding of Customer Requirements in Mass Customization

The main objective of mass customization is to provide customers with individualized products at affordable prices. Customers generally accept paying a premium price as compared to standard products because they honor the additional benefit of customized products. Therefore, if mass customization does not succeed to offer main customers an optimal or a better solution than any mass products, then the product resulting from the customization process will have, from the customer's perspective, no more additional value than any other standard product. In order to explain the differences between what customers would really prefer and what customers may order, Blecker et al. (2003a) introduced the model of the objective and subjective customers' needs in mass customization. The subjective customers' needs are defined as the individually realized and articulated requirements, whereas the objective needs are the real ones perceived by a fictive neutral perspective. The subjective needs are explicitly formulated by customers, but often only lead to suboptimal satisfaction. However, the objective needs are implicit, but lead to optimal customer satisfaction. It is important to mention that customers' needs do not refer to single product attributes, but to a complete product variant. Blecker et al. (2003a, p. 8) explain that the discrepancies existing between the subjective customers' needs, the objective customers' needs and the offered variety (Figure 1) are due to the following faults during the interaction process between mass customizer and customers:

- The customers do not know their real needs.
- The customers cannot correctly express their real needs.
- The mass customizer wrongly interprets customer requirements.

Mass customization addresses a wide range of customers that goes by far beyond the scope of experts. Because of an existent lack of technical competence, non-expert consumers often do not know what they really want. Customers often are not aware of their preferences until they see them violated. Furthermore, even if they are capable of identifying their real needs, they will have problems to communicate them to others. Emotions and feelings regarding product alternatives are difficult to translate into verbal language which is much easier to capture. Moreover, the sender-receiver problem which can arise during the communication process between customers and mass customizer is a further reason leading to the misconception of customer requirements (Blecker et al., 2003b).




Source: Blecker et al., 2003a, p. 7 (modified)

Figure 1: Discrepancies existing between the objective and subjective customers' needs

Because of the discrepancies existing between the objective, the subjective customers' needs and the offered variety, we identify here seven regions:

- Region (I): The fulfillment of the customers needs situated in this region would generate optimal customer satisfaction. But the corresponding variants are currently not offered by the mass customizer. In comparison to the subjective customers needs, the objective needs of this region are because of their implicit character, not easy to detect with the currently available methods and techniques.
- Region (II): The customers' needs in this region can be fulfilled by product variants, which would generate optimal customer satisfaction.
- Region (III): The variants of this region are over engineered, not appreciated by customers and do not fulfill any type of customers needs.
- Region (IV): The variants of this region simultaneously fulfill the objective and subjective customers needs and are actually offered by the mass customizer. In regard to these variants, customers can select from the variety the offered variants which will exactly meet their needs and generate optimal satisfaction. This region is the most optimal one under all other regions.
- Region (V): In opposition to the product variants of region (IV) the corresponding needs are not fulfilled by the mass customizer.
- Region (VI): The customers' needs in this region are actually fulfilled by variants which would only lead to a suboptimal customer satisfaction. A variant which would better fulfill customer requirements may exist in the production program of the mass customizer and is situated in region (II).

- Region (VII): The needs in this region correspond to the subjective customers' needs. The variants fulfilling these needs are not offered by the mass customizer. Because these needs are explicit, they can be detected by using methods and techniques such as data mining or customer interviews. Thus, the fact that the variants fulfilling these needs are excluded from the production program is due to a conscious decision from the mass customizer.

According to the described model there are three challenges the mass customizer has to face, in regard to:

1. How to orientate a product design on objective customers' needs in order to reduce the surface of region (I) and thus, to fill the gap between the offered variety and the objective customers' needs.
2. How to rationalize the production program in order to reduce the surface of region (III) by eliminating over engineered variants.
3. How to help customers recognize their objective needs. This means in essence, how to make customers with subjective needs in region (VI) buy products in region (II) that better fulfill their requirements.

The first challenge relates to a multidisciplinary problem which requires solution approaches and competences especially from the fields of business administration, artificial intelligence, computational technology and consumer psychology. The second one rather refers to business administration and requires methods and techniques to rationalize the production program in mass customization. The third challenge refers to the implementation of adequate customer interaction systems (Blecker et al., 2003a). In the next section we will explain why the existing customer interaction systems are not capable of solving the problem which arises when distinguishing between the objective and subjective customers needs.

## Shortcomings of Customer Interaction Systems in Mass Customization

Compared to standard products, customers face a complex decision making process when buying mass customized products. Customers have difficulties to make preferences between different alternatives and to compare performance/price ratios of distinct variants. This problem often arises, because in practice, the technological perspective generally dominates the user perspective when addressing configuration. Sabin/Weigel (1998) informally defines configuration as a design activity with two main features:

- "The artifact being configured is assembled from instances of a fixed set of well-defined component types, and
- Components interact with each other in predefined ways."

Furthermore, the existing definitions related to interaction systems, called configuration toolkits have a strong technological orientation addressing a software tool. For example, Bourke (2000) defines a product configuration toolkit as "…software modules with logic capabilities to create, maintain, and use electronic product models that allow complete definition of all possible product option and variation combinations, with a minimum of data entries and maintenance".

In the technical literature configuration toolkits are more often criticized. Rogoll/Piller (2002) have shown through a market study on configuration systems that there is no standard software solution being able to fulfill optimal requirements from customizer and customer perspectives. Von Hippel (2001) criticizes the implemented configuration toolkits in the automobile industry and points out that "…auto makers allow customers to select a range of options for their "custom" cars - but they do not offer the customer a way to learn during the design process or before buying" (von Hippel, 2001). Learning during the design process means that customers should be provided with the possibility to verify, before placing their buying orders, whether the configured product meets their expectations exactly or not. In the computer industry, von Hippel (2001) also mentions that websites of computer manufacturers *simply* provide their customers with the possibility to select components such as processor, chips and disk drives from available options. Due to strong product orientation of available configuration toolkits, customers are not able to design the product corresponding to their real expectations. It often happens that customers notice that the product is different from what they have expected after receiving or using it.

Thus, configuration toolkits for mass customization with product centered features do not adequately support customers during the configuration process. These toolkits are only suitable for product experts with wide product knowledge, but not for customers with little or no idea about product characteristics. Moreover, the language in which customers identify and understand their needs is completely different from the language used by engineers and product centered toolkits consisting of modules and components. For example, when buying a car, customers would have the need to easily park. In product specific terms, this will mean to equip the car with a servo-steering mechanism.

Therefore, it is of great relevance to assist customers during the configuration process. In E-commerce, it is common that customers are supported by recommender systems that search for products or services corresponding to customer specific preferences or requirements. These systems use customer-specific knowledge, as well as statistical and knowledge based methods. Schafer et al. (1999) make a classification of recommender systems and distinguish between four main techniques, which are: non-personalized recommendations, attribute-based recommendations, item-to-item correlation and people-to-people correlation. Whereas a non-personalized recommendation is based on how other customers evaluate the selected product on average, attribute-based recommenders use syntactic product properties. Furthermore, as opposed to item-to-item correlation recommender systems which propose products on the basis of other products customers have expressed interest in, people-to-people correlation refers to "collaborative filtering" by analyzing correlations between the customer looking for the product and other customers.

However, current recommender systems are not capable of solving the problem when distinguishing between the subjective and the objective needs. They use product centered language or try to correlate the data of one customer with the data of other customers who have not necessarily bought products corresponding to their objective needs. That is why, we extend the notion of recommender systems in order to tackle the outlined problem. Consequently, we define advisory systems for mass customization as software systems that guide customers according to their profile and requirements through a "customized" advisory process ending with the generation of product variants which better fulfill their objective needs. Furthermore, they are customer oriented and do not assume any specific technical knowledge of the product.

We agree that configuration toolkits and advisory systems are technically two separate systems. Configuration toolkits are capable of generating all product variants in the solution space of a mass customizer. Furthermore, a configuration toolkit consists of two main components, which are a database where all product parts and modules are stored and a knowledge base defining the logic necessary to make up product variants from components and modules. However, an advisory system takes over the task of ensuring the interaction with the customer in a language which can be different from the language required to describe product characteristics, maps customer inputs and features into product specific terms and communicate them to the configuration toolkit. Then, objective needs-oriented product alternatives should be generated and displayed for customers. Although both systems are technically separated, they have to be integrated in an entire interaction system supporting customers during the elicitation process.

## Advisory Systems as a Solution Approach to Elicit the Objective Customers' Needs

### Basic Structure of an Advisory System

In a real world situation, human beings called advisors who have the required knowledge and experience try to gain a picture of the individual customer's situation by asking targeted questions. On the basis of the given answers, the dialog is adapted to better suit a specific situation. For example, when the customer has the required technical product knowledge, the asked questions can be more specific and product oriented. The advisory system has to simulate real advisory dialogs in order to capture customer requirements. This approach is customer-oriented and differs from other concepts such as those based on collaborative filtering that chooses products by analyzing the correlation between customers with similar preferences. The advisory system generates interactive and individualized advisory processes to support customers. It asks targeted questions and provides adequate assistance through answers and explanations. At the end of the process, the product or service alternatives corresponding to the customer needs are displayed. Furthermore, in order to capture customer requirements the system should be able to individualize the dialogs by implementing an advisory logic. Therefore, the main focus should be attributed to advisory and personalization (Kreutler, 2003).

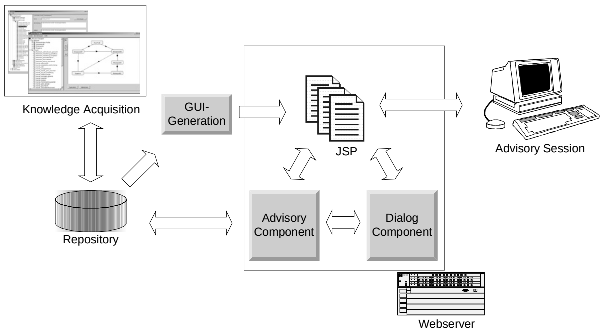



Figure 2: Advisory system architecture

Figure 2 points out the architecture of the developed web-based advisory system, which is in accordance with the Model-View-Controller approach where interaction control, presentation and data are independently constructed (Krasner/Pope, 1988):

- All relevant data is stored in a central repository: advisory logic, information for personalization, product and customer characteristics.
- The Graphical User Interface (GUI) is automatically created by a generation module.

- The users communicate over generated HTML-pages with a dialog module, located on the web server. This module validates and stores user inputs.
- The dialog module interacts with the advisory component containing the advisory logic and controls the communication process.

The system is based on Java technology, because Java ensures not only platform independence, but also a uniform framework for the programming of server and client components (Java Server Pages, Java Swing). In the following, we discuss two main system elements which are the dialog and the advisory components (Kreutler, 2003).

### ➢ The Dialog Component

In order to generate goal-oriented and situation-specific dialogs during the advisory process, the experts' knowledge should be made available in an explicit form that can be represented in the system. This requires a simple model for the advisory dialogs ensuring personalized communication between customers and the mass customizer. Furthermore, the model has to support an easy maintenance of the experts' knowledge base.

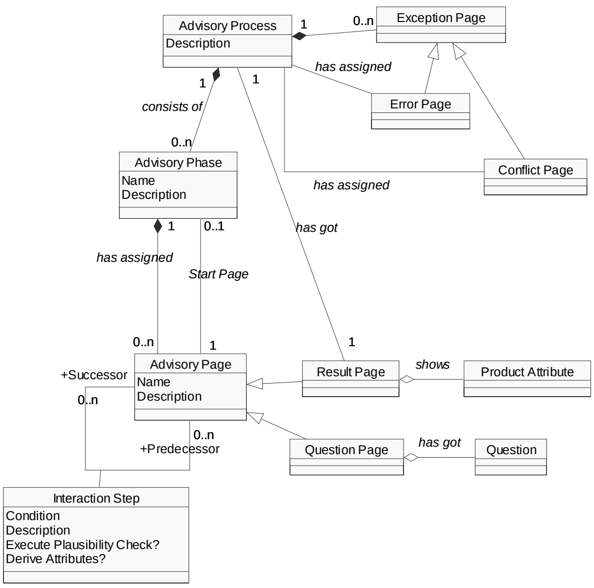



Figure 3: Conceptual model for advisory processes

Figure 3 describes the developed model with an UML-class diagram consisting of the following components:

- The dynamic advisory process consisting of many pages that the user can process step-by-step.
- The pages processed by customers contain, in turn, many questions with predetermined answers from which customers have to choose.
- The successive pages of one page depend on declarative rules which process user inputs.
- The dialog is organized in many steps consisting of a set of pages that provide the user an overview in the progress of the advisory process and also enable a direct navigation.
- Each dialog has exception pages, which are activated automatically and independently from the advisory process, in the case that a special event occurs, such as errors or conflicting user inputs.

The conception of the advisory process in terms of a pages' flow is ensured by a knowledge acquisition tool enabling one to model the real process in a simple manner. The advisory experts can graphically arrange the advisory steps, as well as the corresponding pages in the form of a tree. The modeling of the process flow can be carried out graphically by specifying the different paths between the advisory steps. In figure 4, the different nodes refer to the advisory pages, whereas the arrows to the conditions which determine the process flow. For example, one condition can be formulated as follows: "choose this path, if the user specifies that he is an expert". The specification of these conditions is supported by a context sensitive editor.

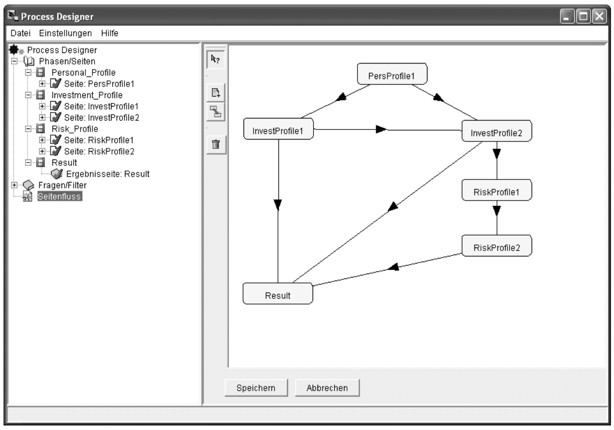



Figure 4: Knowledge acquisition component for the advisory process

Starting from the modeled process, the graphical interface is automatically generated. The interaction can be supported tabular or by a layout containing an Avatar. The whole web-application is generated on the basis of the framework containing the dialog and the advisory components, as well as Java Server Pages. These pages can be manually adapted and integrated in already existing websites if necessary.

The navigation referring to the possibility offered to the customer to change all inputs when he wants is the task of the dialog component. The process flow is supported by another component which is the advisory component.

### ➢ The Advisory Component

The advisory component evaluates customer inputs and makes product propositions by using filter and recommender mechanisms. In the knowledge base the following data are represented:

- Customer characteristics: These are derived from questions referring to the customers.
- Plausibility tests related to customer answers.
- Logic for the derivation of customer characteristics: By using a scoring-mechanism, it is possible to draw new characteristics on the basis of the available customer characteristics.
- Product characteristics: All products are characterized by attributes having predetermined value domains.
- Derivation logic for the generation of recommendations on the basis of filter conditions.
- Specification of a value utility analysis to rank the proposed products or services (Schaefer, 2001; Schuetz/Meyer, 2001)

The maintenance of the knowledge base can also be done by using a simple graphical maintenance tool. During the advisory process, the advisory component derives new customer attributes and verifies the plausibility of customer inputs. Customers can also request explanations for the asked questions, as well as for answer alternatives. At the end of the advisory process, the advisory system proposes product alternatives which are ranked according to their importance for customers by running a value utility analysis. An explanation component explicates, on which basis the proposed products are selected. The main advantage is to strengthen the confidence of customers in the advisory results.

➢ **Interfacing the advisory system with the existing configuration toolkit**

The described advisory system selects from the available solution space the product variants with the attributes that best fit customer needs. This selection is automatically done on the basis of rules being already stored in the knowledge base. However, it can happen that the proposed alternatives do not exactly correspond to the needs of the customers who prefer to introduce some changes to the suggested variants. In order to ensure a further degree of flexibility, the interaction system should make such changes possible and enable customers refining the proposed variants. During product refinement, the advisory component should be not deactivated and has to explain to customers why a certain attribute value is chosen. Furthermore, it is conceivable to capture the introduced changes and to evaluate them in order to better refine the product alternatives proposed to customers.

## Required Extensions of the Advisory System to Better Elicit the Objective Customers' Needs in Mass Customization

To better elicit the objective customers' needs in mass customization, the described advisory system should be extended in order to disable all three faults that may occur during the interaction process. We identify two levers capable of tackling the outlined problems, namely the dialogs with customers and the mapping techniques which permit one to translate customer needs into product attributes and vice versa. Furthermore, these levers should be supported by adequate technologies and tools. Whereas the main technology is web mining which enables one to process web data, the relevant tools to be implemented are customer interests modeling and web metrics. Both tools aggregate the data provided by web mining in order to present them in an understandable goal-oriented form (Figure 5).

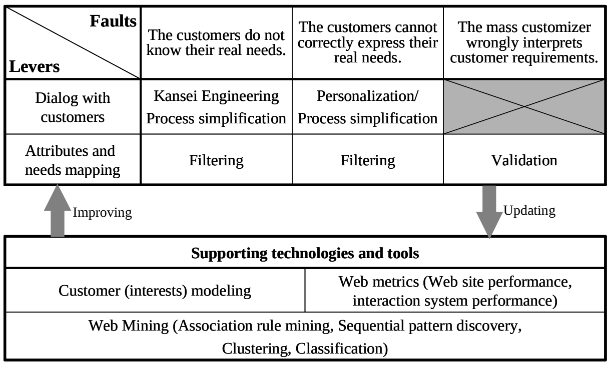



Figure 5: Levers and supporting technologies and tools for advisory system extension

Dialogs with customers refer to the communication interface during interaction. Customers should not perceive complexity when specifying their requirements. Therefore, they should be asked only appropriate questions. When customers do not know their real needs, Kansei Engineering and interaction process simplification are suitable solutions, whereas when customers have difficulties to express their objective needs, personalization and interaction process simplification are especially relevant. However, the extended dialogs are unsuitable to solve the problem arising when the mass customizer wrongly interprets customer requirements. This is due to three main reasons:

- Dialogs only deal with the front-end aspect between the customer and the interaction system.
- Dialogs do determine the communication process, but not the way information is interpreted.
- Only available information being no longer the object of dialogs can be interpreted.

To make customers aware of their requirements, a potential solution is to conceive dialogs according to *Kan-*

*sei Engineering* which uses verbal language being near to the language customers are used to understanding. It is a "translating technology of consumer's feeling and image for a product into design elements" (Nagamachi 1995, p. 2). For example, when buying a customized watch, customers are not asked to specify design components, they may be asked e.g. what is the "social position" they want to express.

Moreover, in order not to overstrain customers during the interaction process, it is relevant that the advisory system guides them to their optimal product configuration by following the shortest path. This refers to the interaction *process simplification*. For example, the advisory system appreciates the customer "knowledgeability" and then accordingly estimates what are the technical parameters the user is able to specify. If some product parameters are too difficult, the advisory system can set default values without asking questions (Ardissono et al.). A superfluous flexibility providing customers with the possibility to specify parameter values being difficult will confuse rather than help them.

The gained customers' data has to be used for *personalization* purposes. Personalization aims at recognizing special customer characteristics such as desires and preferences to individualize the interaction process. The advisory system should adapt the website layout to customer requirements and also personalize the formulation of customer dialogs.

The captured customer requirements during the interaction process have to be correctly translated into product specifications. This is ensured by the mapping techniques that not only adequately transform customer preferences and requirements into product specific characteristics (filtering) but also guarantee that product specifications are adequately mapped to customer needs (validation).

When customers do not know or cannot express their real needs, *filtering* methods are suitable solutions. Filtering is a collective term for techniques which automatically select product attributes that meet customer profile and preferences by applying predefined rules, similarities or clustering. For example, with content-based filtering, product configurations can be selected on the basis of correlations existing between product characteristics and user's preferences which can be captured either implicitly or explicitly. This will considerably restrict the domain of the products' solution space customers would be interested in.

As opposed to filtering, *validation* methods have to be implemented to ensure that the mass customizer did not wrongly interpret customer needs. Thus, the restricted solution space resulting from filtering can be further refined to ensure that the product specifications really correspond to customer requirements. For example, Scheer et al. (2003) use a clustering component as a validation method.

The described potential solutions have to be supported by web mining. This technology aims at processing the raw data being stored in web server logs by applying data mining techniques in order to extract statistical information, cluster users into groups and discover correlations between web pages and user groups (Eirinaki/Vazirgiannis, 2003). Web mining provides the information necessary to model customer interests in E-commerce and to compute relevant web metrics.

Customer interests modeling is a tool enabling one to better understand customer preferences and thus, to correspondingly support the personalization of dialogs during the advisory process. Web metrics are necessary to measure the performance of the entire website and especially the performance of the interaction system. For example, it is relevant to appreciate how long one customer has spent on a certain web page or what is the average number of pages customer show before they reach the interaction system. From the web metrics analysis, proposals can be derived for process simplification that can be introduced either automatically online or offline.

The integration of all proposed solutions in a comprehensive concept will satisfy the requirements placed on advisory systems for mass customization as we define them in section 3. With Kansei Engineering and personalized dialogs, customers who have no technical knowledge about products are adequately assisted during interaction. Furthermore, customer confusion which often leads to suboptimal product configurations is avoided by process simplification. Due to filtering and validation methods, the advisory system generates optimal product alternatives for customers. Moreover the advisory systems initiate a virtuous circle which is ensured by a learning process consisting of continuous improvement of the presented solutions and updating of the data processed by web mining techniques. The more customers use the advisory system in mass customization, the better they teach it what they want and the better the advisory system can refine product suggestions leading to a better fulfillment of customer requirements.

## Technical Implementation of Advisory System Extensions

We propose to base the personalization task on customer data already existing in a CRM system. Note that the CRM system manages only general preferences and properties of customers that are not related to a specific advisory domain. Nonetheless we can exploit these properties such as the customers' past buying behavior to personalize the interaction flow. As an example we can analyze as to whether the customer is in general interested in low price or premium products, and we can then parameterize the interaction flow for a specific advisory problem. Personalization based on these pieces of information can be carried out on the levels of content and interaction flow (i.e. the complexity level of questions), the style of the presentation (e.g. in form of additional explanations) as well as by proposing default answers that are expected to match the customers preferences. The overall goal of this personalization lies in simplifying the process and shortening the dialog. In order to exploit the information from the external CRM system, the following functionality has to be implemented:

- The knowledge contained in the CRM system and the advisory system has to be synchronized using defined data exchange interfaces. One possible implementation can for instance be based on a Web Service provided by the CRM system that allows the advisory system to remotely retrieve CRM data over the web using XML as an exchange format.
- The knowledge base in the advisory system has to be extended with business rules that take these additional customer characteristics into account.
- The dialog component has to be extended with the capability to customize the interface according to the customer's preferences and expertise and for instance present the questions on the adequate level of technicality or even in terms of indirect questions concerning emotions or feelings (Kansei Engineering). Technically, an implementation based on dynamic HTML page-generation such as Java Server Pages allows the system to select an adequate presentation format at runtime according to the current customer profile and the rules defined in the repository.

Regarding the filtering techniques applied we propose the adoption of a multi-technique approach where the advisory component selects one specific recommendation technique such as collaborative or content based filtering, depending on the customer's knowledge and the product domain: Collaborative techniques are for instance good when the match between customer preferences and products is based on quality and taste. On the other hand, content based approaches are suitable for customers with sufficient technical knowledge. Finally, case or critique based techniques allow the customers to express their preferences by comparing and rating product alternatives in an intuitive way. In addition to the implementation of these algorithms, the advisory component must implement a rule engine that selects the filtering techniques to be chosen. The interface must also be extended with algorithm specific web pages that for instance allow the users to submit their ratings over HTML.

Furthermore, a collaborative approach can incorporate information that is automatically extracted via web mining-techniques from web log-data and user interaction traces possibly stored in an external data warehouse. The result of such a data mining process can be manifold:

- New clusters of users with common preferences, characteristics, and buying behavior can be identified (Customer interests modeling). These clusters can be used by the advisory component to personalize the content for new users by assigning the most probable user class whereby the system can continuously update its beliefs according to the user interactions.
- Data on past interactions and buying transactions can be aggregated and new business rules candidates can be inferred (web metrics).
- A validation component attached to the advisory component verifies the results on the basis of behavior analysis which enables us to validate the business rules.

The following figure depicts the overall architecture of the extended advisory system.

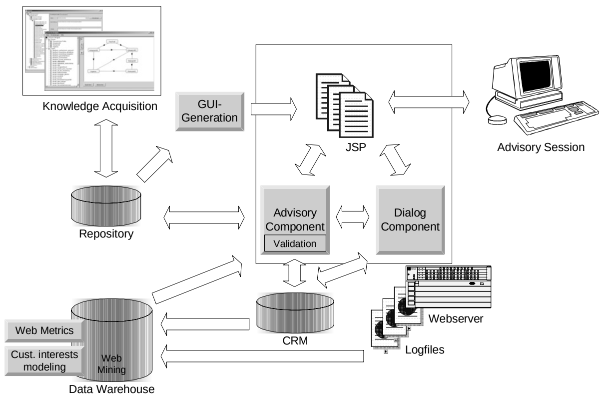



Figure 6: Extended advisory system structure for mass customization

## Conclusions

In this paper, we introduced a model distinguishing between the subjective and the objective customers' needs in mass customization. The subjective needs are the individually realized and articulated requirements, whereas the objective needs are the real ones perceived by a fictive neutral perspective. On the basis of this model we show that the configuration toolkits for mass customization are not capable of helping customers recognize their real needs. We conclude that customers require adequate assistance during the elicitation process. In E-commerce, recommendation systems have been already implemented to support customers. But these systems are either product oriented or make product suggestions on the basis of what other customers have recommended or bought. Thus, these systems are not suitable to cope with the problems which can arise during the interaction process. Therefore, we introduce the notion of advisory systems in mass customization and we define them as software modules which can perform customer assistance leading to a better elicitation of objective customer requirements.

The basic structure, as well as the technical infrastructure of an advisory system were described. This system has many advantages. It enables a simple maintenance of the knowledge base which can be graphically updated by the product experts themselves with little effort. Moreover, it generates personalized dialogs with customers to better elicit their needs. However, to be able to recognize the objective customers' needs, the described system has to be extended. That is why, the main levers and solutions, as well as the required supporting technologies and tools are identified. The levers consisting of dialogs with customers and mapping techniques are examined according to their contribution to the entire problem solving. Kansei Engineering, interaction process simplification, personalization, filtering and validation methods are main solutions which have to be integrated in a comprehensive concept. Moreover, the technical infrastructure being required for the implementation of a comprehensive solution is described. In comparison to the original infrastructure, the extended one requires an integration of the web server generating web log data, the CRM database and a data warehouse where customer interests are modeled and web metrics are computed on the basis of the information resulting from web mining.

However, the proposed advisory system solution enables to partially solve the problem arising when distinguishing between the objective and subjective customers' needs in mass customization. The extended advisory system is adaptive and guides customers to better recognize their objective needs. But a basic constraint remains the solution space of the mass customizer. It is conceivable that the interaction process will lead to no product configuration that corresponds to what customers really want. Furthermore, it is important to verify whether the purchased variants really correspond to objective customers' needs. For example, Blecker et al. (2003b) proposed a key metrics system capable of detecting whether the purchased product configurations meet objective customers requirements.

Furthermore, the advisory system reposes on some statistical methods, which require data input from customers. For example, a clustering component may need time until enough data is gathered from many different customers in order to be able to generate good results. Moreover, it is relevant to continuously adapt the content of dialogs. This can depend on the different phases of the product life cycle. For example, when asking for a mobile phone before several years, one customer would emphasize the hierarchical position he wants to express. But, by now, mobile phones are so outspread that the attribute referring to the hierarchical position is no longer relevant. A further limitation of the advisory system relates to technology-push innovations, where it is difficult to estimate the acceptance of customers in regard to the new technology. In this case, even sales experts will have difficulties to appreciate whether a customer with specific needs will have interests in the new product.

Another difficulty encountered that is triggering further complexity is how to make the implicit sales experts' knowledge being required for advisory explicit. In addition to technical knowledge, experts use intuition, as well as specific situational appreciations that are complex and difficult to be represented as e.g. rules for data processing.

Thus, further research is required for solving the problems related to customer needs in mass customization. We are convinced that a comprehensive solution should utilize the approaches from many fields, especially artificial intelligence, business administration, cognitive science and consumer psychology.

From a technical point of view, our approach is manageable, but its complexity should not to be underestimated. Due to the high number of independent components, a variety of different interfaces may be required. Although XML provides an open data interchange format, it would be necessary to implement proprietary, specific interfaces between the advisory system and existing components. Therefore, the proposed implementation should be seen from a software engineering point of view and not as an out-of-box solution.

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