Customer-Adaptive and Distributed Online Product Configuration in the CAWICOMS Project

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Abstract

This paper reports on the goals and first results of the CAWICOMS[1] project. This EU-funded project has two main goals: The first one is providing technologies for the development of customer-adaptive Web-interfaces for the configuration of mass-customized products. The second one is the integration of configuration systems along the supply-chain.

Within this paper we first motivate the demand for personalized and adaptive Web-interfaces for the domain of product configuration. In addition, we sketch scenarios where product configuration takes place at several stages in the supply chain and the involved configuration systems have to cooperatively solve a distributed configuration task.

An overview of the CAWICOMS architecture is given as well as first results on distributed problem solving and the integration into the surrounding enterprise's software infrastructure.

1. Introduction

Web-based product configuration tools enable businesses to market complex customizable products and services by using the new technologies of electronic commerce, whereby customers can tailor the configurable products according to their specific needs and requirements. Although there is a long history of knowledge-based product configuration technology [12], typically, these stand-alone systems do not meet the new requirements imposed by online (sales) configuration in a Web of cooperating product and service providers.

The CAWICOMS project is carried out in order to overcome those shortcomings of current configuration technology and is conducted by an international consortium consisting both of partners from academia and industry. The main objectives of the project fall into two categories, namely adaptiveness of the interface and distributedness of the configuration task. We will shortly sketch the basic environment that makes these aspects important features for future configuration technology.

Adaptive user interfaces: Configuration systems supporting the sales of complex, customizable products online are used by a wide range of different classes of users, differing in properties such as skills, needs and knowledge levels. However, these systems typically offer only one standard interface having a predefined interaction style, that can not be tailored to these different types of users. A typical example for such a possible adaptation is given, if the system behavior depends on the level of experience of the user. In case of an experienced one, the product may be configured at some detailed technical level, whereas a novice user will possibly only enter some high-level features and will need more guidance and extra help during the configuration process.

An adaptive configuration tool will classify the current user with respect to different properties (e.g., expertise or interest in product characteristics such as reliability) and generate an interface that adapts flexibly according to this classification. The goal is that the online selling (configuration) system behaves like a real sales person to the extent that it changes its own behavior while interacting with different customers by eliciting information about their requirements and making specific suggestions in a personalized way.

Distributed configuration: The business model of the digital economy (*B2B e-commerce*) shows a trend towards specialized solution providers that are organized in a supply chain. The final product offered to the customer consists of an assembly of subproducts provided by the individual specialists and manufacturers. This fact intensifies the demand for supply chain integration, which is quite well known for standardized products but for the case of complex and configurable products it is still an open issue. Nowadays' configuration and supply-chain technology do not provide adequate means for the cooperation between different configuration systems. However, the individual subproducts of the suppliers may all be configurable. Therefore, there is an increasing demand for solutions that integrate different configurators to assemble a complete system satisfying both the customer requirements and the given constraints on legal product constellations for the overall solution. Such an integration is needed because we cannot assume a central point of (configuration) knowledge, e.g., because of

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confidentiality issues. Furthermore, for the integration we have to face the problem of heterogeneity, i.e., we cannot assume that the participating configuration systems rely on the same knowledge representation or problem solving mechanisms. Therefore, we have to define adequate protocols and knowledge exchange mechanisms between such systems.

Application scenarios: The work in CAWICOMS is driven by two major real-world application scenarios provided by the industrial partners.

- Configuration of private telecommunication solutions,
- Configuration of virtual private networks (VPN).

For presentation purposes, we will shortly sketch the requirements for distributed problem solving and adaptivity for the domain of the telecom switching systems.

Our partner (or one of the resellers) sells telecommunication solutions concerning, e.g., in-house telephony, switching of calls to the local telephone exchange for outside calls, end-user devices, as well as add-on products like *voice-mail* or *voice-over-IP* applications. While the main switch is manufactured in-house (and the configuration knowledge is completely known) the add-on products mentioned above are provided by suppliers (or another organizational unit) and are in turn customizable. The detailed knowledge about how to configure the supplier's products is only available to the supplying organization and incorporated in a *local* configuration knowledge base. However, the main switch and the add-ons cannot be configured independently, because there are interdependencies between these subproducts. For instance, when adding the *voice-over-IP* application, additional hardware has to be installed and connected to the main switch onto one of the free slots. Furthermore, installing the additional hardware may, e.g., require a special power supply. Note that it is not possible nor reasonable to integrate the complete knowledge into one large knowledge base due to security or maintainability reasons, knowing that there are different points of knowledge and expertise involved. Our goal is therefore to find a way of *knowledge sharing* based on a common ontology of configuration and domain concepts. Note that it is important for the customer to have only one single point of interaction (configuration).

The telecommunication scenario also shows some interesting challenges concerning the personalization of the user interface. As already mentioned, the configuration system may be used by heterogeneous users, having different knowledge and skill levels: Small switching systems may be sold directly, i.e., the actual end-user configures the switch and will need a simple interface with advanced user guidance. For larger systems, a sales representative or sales engineer will use the system for different purposes. First, during the *quotation phase,* only a few high-level parameters have to be entered that are possibly personalized to the user's preferences, e.g., the sequence of interaction, level of additional technical explanations or for instance country-specific defaults. In the subsequent order processing phase, technical details, e.g., physical components and their structure, have to be specified for production. The interface of the configuration system should therefore support interactions at different detail levels, to take into account, on the one hand, the requirements of the interaction phase and, on the other hand, the user's expertise. Moreover, the interface should support the use of defaults, in order to produce default configurations, based on the customer's preferences and characteristics, while constraining the number of choices to be explicitly asked for.

The rest of the paper is organized as follows. In Section 2, we will shortly describe the specific adaptivity requirements as well as applicable techniques for the domain of product configuration and online selling. Section 3 gives a definition for a distributed configuration task based on a logic theory. Afterwards, we sketch the overall architecture of the CAWICOMS framework, discuss the technologies used for the components of the architecture and describe the requirements for the integration into the existing software infrastructure.

2. Personalized Interaction

Based on the specific requirements of personalized interaction in the product configuration domain, we will now outline the personalization techniques used in the CAWICOMS framework. In particular we show how the interaction with the user can be tailored on the basis of estimates on the user's properties (characteristics) stored in the user model.

2.1 Estimating User Properties

The characteristics of the individual user of the configuration system will be estimated by observing his/her behavior during several (interactive) configuration sessions. We will employ Bayesian networks [9] as an inference mechanism to relate user actions to characteristics relevant for the personalization of the interaction, i.e., *interests* and *knowledge*. In particular, the continuous monitoring of the user's behavior and the resulting revisions of the user model will support a reactive adaptation to changes concerning both the user's interests and his/her knowledge about the products to be configured.

2.1.1 User's Interests

For determining the user's interests and exploiting them for personalization, we ascribe the *Multi-Attribute-Utility Theory (MAUT)* [13] as evaluation process to the user. The evaluation of a configurable artifact is done by adding the evaluations of the artifact with respect to a set of high-level properties (that we call *dimensions*) which are depending on its technical characteristics. The dimensions can be used for presenting the user a compact view onto the artifact which can be used by him/her to judge whether the artifact fulfils his/her needs. Based on the estimates of the user's interests, default values are selected (cf. Section 2.2). For instance, *reliability* and *performance* are typical dimensions for a telecommunication switch. In particular, the dimension *reliability* may (among others) be related to the type of

power supply to be suggested by the configurator. For each user, the system estimates a relative weight for each dimension expressing the user's interests in the dimension. Later on, we utilize those estimates of the user interests to generate personalized defaults during the interactive configuration session.

We use the user's observable behavior as evidence for inferring his/her specific interests, i.e. for estimating the relative weights of the different dimensions, whereby the estimates are maintained in the user model as a probability distribution. The following user actions can be exploited during an interactive session.

- Self assessment of the user: The user manually describes his/her interests for the individual dimensions (e.g., being questioned by the configuration system).
- Accepting/rejecting a solution: If the user accepts or rejects a proposed configuration, we can determine the rating of the proposed configuration according to the high-level dimensions and adapt our current user model. For instance, if the user rejects a very reliable system,we may infer that reliability is not an important dimension to him/her.
- Input of a parameter value: Whenever the user enters a choice for a configurable parameter (whether changing a proposed value or entering a new one), and the parameter is related to some dimension, we may update the user model. As an example consider a user selecting an optional *encryption package* for the switch, we may revise the current user model and assume that the user's interest in *security* will be high.

2.1.2 User's Knowledge

The other category of user properties that can be exploited for personalization is the user's domain expertise (*knowledgeability*). Again, we try to estimate the user's knowledgeability based on his/her observable behavior and later on utilize the user model during the interaction process. (See [6] for details on how to estimate the knowlegeability of a person). The representation of the user's expertise is twofold.

Knowledgeability by dimension: Usually, the user's knowledgeability is not an undifferentiated characteristic. For example, in the domain of cars, some users may know very much about aspects regarding the *environmental-friendliness* of the car, but they may not be familiar with the features having implications on its *sportiness*. Therefore the user's knowledgeability for each dimension has to be estimated. These dimensions are usually the same dimensions used to measure the interests of the user.

In order to address the complexity of the information which should be introduced by the user during the configuration of an artifact, we attach a weight to the configurable parameters describing their technical difficulty. Roughly speaking, the weight specifies whether some parameter is a low-level technical feature that can only be configured by a technical expert, or if the selection of a parameter value can be done also by a sales-representative or end-customerBased on an estimate of the user's knowledgeability in a certain dimension and the difficulty of the related configurable parameters, the system can estimate whether the user will be able to specify a value for such parameters (i.e., if the he/she knows the implications of selecting a certain value). If the parameters are too difficult for him/her, additional help could be displayed, or the configuration system should propose a default value without asking any questions.

Knowledge of parameters: Beside the estimates on knowledgeability in general dimensions we can also represent information in the user model about estimated knowledgeability for a certain configuration parameter. We may increase the knowledgeability estimate for a particular parameter, if the user changes this specific parameter value manually (in several configuration sessions) or is explicitly informed about the meaning of a parameter (e.g., by an additional help screen).

2.2 Adapting the Interface

The customization of the user interface is based on the use of personalization strategies, on the basis of the user's interests and knowledgeability. As the user interface is dynamically generated during the interaction with the customer, the level of detail addressed during the configuration of the product can be continuously adapted to the most recent hypotheses about his/her knowledgeability and interests, e.g., if the user becomes more knowledgeable, the system will present not as many helping texts than before. Besides the amount of information to be displayed, several further aspects of the interaction can be customized: For instance, the layout of the interface, or the type of questions asked for during the configuration of the product (see [1] for the definition of personalization strategies for a B2C application). In this description, we will focus on the last aspect, which strongly depends on the user's knowledgeability and interests and is critical to the usability of the configuration system.

The basic idea is that the information in the user model and the dependencies among user interests for product dimensions and the related configuration parameters in the product model should be used as much as possible to predict the user's choices during the configuration process. The ultimate goal is to carry on this process while limiting the number of questions to the user (therefore gaining shorter interactions) and avoiding difficult questions, which he/she might not be able to answer.

Another important criterion to decide whether a direct question can be avoided concerns the *criticality* of a parameter during the configuration process. This level of criticality is also defined for the individual configurable parameters in the personalization component.

- If a parameter is extremely critical, the system can not take the responsibility for a decision on its values and the user must be asked about it. In this case, if the user is not assumed to know the parameter, the system can support his/her decision by providing additional

information about the meaning of the parameter and the impact of its values on the product dimensions.

- If the parameter is not too critical, the system can determine a value by applying defaults, given the information about the user's interests, or by eliciting indirect information from him/her. Defaults can be inferred by the system on the basis of the user's interests in certain product dimensions. For example, if the user model predicts that the user is interested in a high reliability, two power supplies, instead of one, would be the default value for the parameter.

Of course, a user should be enabled to manually define personal default values. The user-defined default values will then override the default values estimated by the system.

Finally, indirect questions can be exploited when the predictions of the user model are not certain enough to support the exploitation of defaults. In this case, the system can ask questions about concepts more abstract than the configuration parameters to be filled in, or about related product dimensions. Depending on the user's answer, a suitable default value will be applied. For example, the number of power supplies to be placed into a telecommunication switch could be derived by asking the user about the preferred level of reliability.

3. Distributed Configuration

In order to allow a set of distributed configurators to co-operatively solve a configuration task, we employ a general logical framework based on the component-port representation [8]. This logical model serves as a general ontology for the configuration domain. We allow that all involved configurators may employ a proprietary representation mechanism. However it must be assured that the content of the communicated messages can be mapped onto the concepts of this logical theory. According to [2], a configurable artifact is composed of a set of predefined component types that are characterized by a set of properties and can be interconnected using pre-enumerated connection points (ports). We assume that the configuration knowledge (available types as well as additional logical sentences restricting the allowed product configurations) are contained in the domain descriptions (*DD*) of the configurators. In addition, there are domain-independent sentences C_{Basic} describing e.g., that one port can only be connected to one other port.

3.1 Defining Configuration Problems

Configuration problems are solved according to some specific user requirements (*SRS*) whereby these requirements are again expressed in terms of logical sentences. For describing an actual configuration result we restrict ourselves to a limited number of predicates contained in a set *CONL*, where *CONL = {type/2, conn/4}* for a very simple case. The *type(c,t*) predicate associates a component *c* with one of the predefined types, or the *conn(c1,p1,c2,p2)* predicate describes a connection between two component instances on port *p1* and *p2* respectively.

Definition (Configuration Problem): *A configuration problem is described by a triple (DD,SRS,CONL) where DD and SRS are sets of logical sentences, and CONL is a set of predicate symbols. DD represents the domain description, SRS the system requirements specification for a configuration problem instance. A configuration CONF is described by a set of positive ground literals whose predicate symbols are in CONL.* ❒

Definition (Consistent Configuration): *Given a configuration problem (DD,SRS,CONL), a configuration CONF is consistent if* $DD \cup SRS \cup CONF$ *is satisfiable.*❒

To ensure completeness of the configuration, additional completeness axioms have to be added and the notion of *valid* and *complete configuration* can be defined ([4]).

However we cannot assume that the problem can be solved in a centralized approach due to e.g., security reasons, i.e., none of the participating configurators has complete knowledge about the problem domain. Therefore we will define a distributed configuration problem and sketch how the distributed search takes place.

3.2 Defining Distributed Configuration

Analogously to the definition of the configuration problem, we define a *Distributed Configuration Problem*:

Definition (Distributed Configuration Problem): *A distributed configuration problem involving n different configurators is described by a triple* $(DD_{set}, SRS_{set}, CONL)$ *where*

$$DD_{set} = \{DD_1, ..., DD_n\} \text{ and}$$
$$SRS_{set} = \{SRS_1, ..., SRS_n\}.$$

Each element of DD_{set} *and of* SRS_{set} *is a set of logical sentences and CONL is a set of predicate symbols.* DD_k *corresponds to the domain description of configuration system k and* SRS_k *specifies its requirements. A configuration CONF is described by a set of positive ground literals whose predicate symbols are in CONL.* ❒

Definition (valid solution to a distributed configuration problem): *Given a distributed configuration problem* $(DD_{set}, SRS_{set}, CONL)$*, a configuration CONF is valid iff* $DD_k \cup SRS_k \cup \overline{CONF}$ *is satisfiable* $\forall k \in \{1, ..., n\}$. $\overline{CONF}$ *denotes a configuration extended with the completeness axioms.* ❒

In order to come to a complete solution for the distributed problem, configurators collaborate by exchanging (partial) configurations. The configuration result of one system may impose additional requirements on the configuration of another system, that have to be fulfilled during progessing cycles of interaction. The domain descriptions DD_k and the system requirements SRS_k of each involved configurator are basically independent except the assertions regarding the configuration. We achieve this property by using disjoint sets of predicate symbols in each DD_k and SRS_k but allow the joint use of predicate symbols contained in *CONL,* i.e., for every pair of configurators *i, j* the intersection of $DD_i \cup SRS_i$ and $DD_j \cup SRS_j$ contains only predicate symbols from *CONL*. We call this property *defined interfacing*, that helps us

relating the centralized and the distributed configuration problems.

Theorem: *Let (DD,SRS,CONL) be a configuration problem and (DD_{set}, SRS_{set}, CONL) be a distributed configuration problem with defined interfacing, where*

$DD = \bigcup_{dd \in DDset} dd$ *and*

$SRS = \bigcup_{srs \in SRSset} srs$.

CONF is a valid configuration for (DD,SRS,CONL) iff CONF is a valid solution for the distributed configuration problem (DD_{set}, SRS_{set}, CONL). ❒

For a sketch of the proof see [3]. It builds on the property of defined interfacing. As only predicates from *CONL* are used for describing a configuration result, it must be ensured that the configuration result *CONF* does not conflict with any of the involved configurators (resp. with their knowledge bases and system requirements i.e. $DD \cup SRS$).

Definition (Conflict): *Let (DD,SRS,CONL) be a configuration problem and CONF be a consistent set of sentences in CONL. CONF is a conflict for (DD,SRS,CONL) iff* $DD \cup SRS \mid\!- \neg CONF$. ❒

In the following, we describe the rationale behind our approach towards distributed configuration. The configuration agents configure sequentially as well as concurrently and send their local solutions to a facilitating agent that acts as a coordinator. The latter unifies all received solutions and communicates them back to the involved agents. If all configuration agents determine the validity of the joint configuration then a common solution is found. As soon as a configuration agents detects a conflict with the joint configuration, the others are informed and measures for conflict resolution are taken. This resolution strategy has to ensure that a conflict never occurs twice during a session and that the non-existence of a valid configuration for the overall task is detected.

However, in a realistic supply chain setting we may assume the existence of a tree-structured ordering that defines the dependencies among the involved subproducts (hierarchical decomposition of the final product). Consequently, a partial sequentialization of the solution search for a distributed configuration task exists. One destined configuration agent will act as a main vendor that also fulfills the task of the facilitator for the supplying configurators. The main vendor or service provider configures locally as far as possible and, once the configuration process reaches a phase where supplied parts need to be specified in more detail, a configuration solution is requested from the supplier. This way the solution space of the suppliers is restricted and the probability for conflict occurrence obviously diminished. The configuration agent of highest order starts the configuration process that is then resumed by the configurators of lower order. Agents of the same order may perform an asynchronous solution search. Further a partial ordering of configurators can also be used for an advanced negotiation strategy for conflict resolution, where agents with lower priority are the first ones to repair their configuration [14].

The distribution of configuration knowledge among the configuration agents is given for organizational and privacy reasons of business entities. However, this partitioning of the domain knowledge was not done randomly. Each configurator comprises the local knowledge necessary to customize products and services of the company behind. Configurable products and services being part of a distributedly configured overall solution may share resources and have defined interfaces and connection points vs. each other. Consequently, the local knowledge bases must not be seen as arbitrary logical theories, they are characterized by the sets of domain concepts in use. Based on this partitioning of configuration knowledge, we are able to identify the vocabulary of product domain concepts that specifies the configuration capabilities and informational needs of each agent on the domain of the overall problem. Each agent has informational interest on components and connections for which it has constraints defined in its local knowledge base. By employing domain ontologies we give an abstract description of the product domain of a configuration agent. Therefore not every agent needs to see the complete unified configuration, but only those parts that correspond to its domain ontology.

4. CAWICOMS Architecture

In this section we will give an overview of the architecture of the CAWICOMS framework for distributed configuration with adaptive user interfaces. Figure 1 depicts a typical deployment scenario for the CAWICOMS framework with one main vendor and a supplier of an add-on product.

4.1 Integration Aspects

Product configuration systems (online selling systems) are typically not stand-alone applications but are integrated into an existing business software infrastructure (e.g., an Business-2-Business or ERP platform providing a product catalog or product ordering functionality).
Therefore we have to define interfaces between the CAWICOMS components and such a generic B2B system, in order to *a)* retrieve information about the configurable product (i.e., component descriptions or pricing) and *b)* hand over the results of the configuration process back to the underlying system in order to trigger e.g., the ordering process. Furthermore, supply-chain integration typically involves some long-term contracts and communication between the partners to automatically trigger an order at the supplier system. For supply chain integration of standard, non-configurable products, several tools and technologies are available (that for instance involve an e.g., XML-based communication protocol). For our framework we assume, that such a platform exists between the participants of the supply chain.

On the other hand, there is a wide range of configuration technologies available [12], that differ both in knowledge representation and reasoning. The goal of the CAWICOMS project is to integrate different existing configurators. Therefore, we define a set of minimal functionalities that such an existing configurator has to supply, e.g., check

and/or complete a partial configuration, as well as a simple communication protocol between configurators. For supporting cooperative problem solving we therefore have to use adapter components (*CAWICOMS enabling*) that translate the requests expressed using our general communication protocol to the proprietary representation of the local configurator.

4.2 Distributed Problem Solving

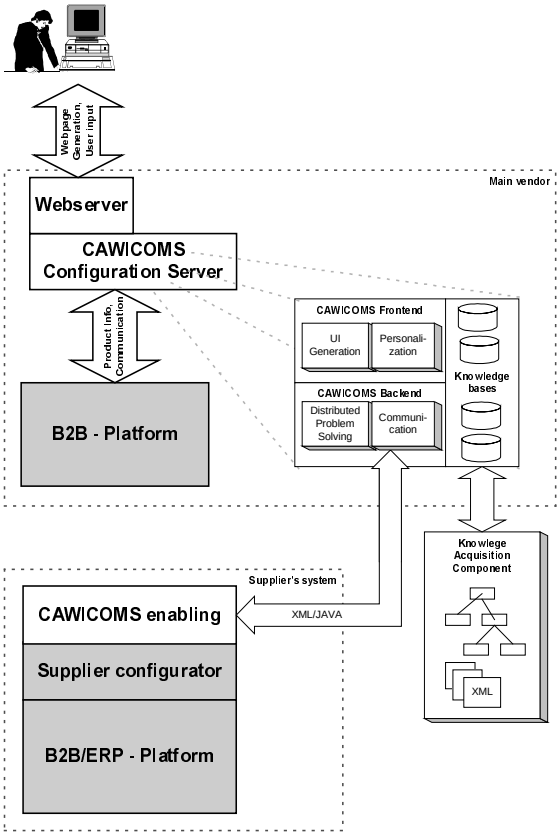

Figure 1 CAWICOMS Architecture

The main component of the *CAWICOMS Backend* provides functionality for the distributed problem-solving task. At the main vendor's site a configurator with facilitation capabilities is located that has an integrated view on the supplier's products. Note that this integrated view only contains relevant portions of the supplier's product structures and is constructed during the knowledge acquisition phase based on common ontological concepts (see Section 4.4). The CAWICOMS Backend processes user requests (e.g., selection of options or initiation of compatibility checks) that are entered by the user and handed over by the *CAWICOMS Frontend*. When a request for a configuration solution is entered, the facilitator initiates the distributed problem solving process and contacts the supplying configurators if needed.

From a technological point of view the following techniques are applied in our framework. We use and extend the state-of-the-art industrial configuration library ILOG Configurator ([7]) as the basis for the distributed problem-solving component. We extend it with a modular component that enables the communication of partial configurations and configuration requests to the suppliers. Furthermore a generic layer is developed that facilitates the exchange of complex data structures (that are typically used in the configuration domain, e.g., partial configurations). The exchange of information can be done both in terms of JAVA data structures as well as by means of XML documents. In addition, this layer also defines a protocol for data exchange (e.g., passing user choices or partial configurations) but also for method invocation, e.g., initiation of the solving process. This data-exchange layer and the protocol is used both for the communication between configurators along the supply chain as well as for communication to the Frontend with the effect, that the individual components of the CAWICOMS Configuration server (e.g., the configurator at the main vendor site or even the user interface generation component) can be exchanged by other tools. Finally, the possibility of exchanging XML documents with a defined protocol between cooperating configurators allows easy integration of existing configurators at the supplier's site.

4.3 Generation of Personalized User Interfaces

The *CAWICOMS Frontend* is responsible for the generation of personalized user interfaces. Two main activities are carried on during the interaction with a customer:

- The acquisition of the information necessary to the configuration process (by asking the user, or by predicting suitable values, on the basis of the user's knowledgeability and estimated preferences).
- The presentation of the (possibly partial) solutions produced by the back-end.

Both tasks can be personalized by exploiting specific strategies, given the information stored in the user model. A back-ground activity carried on by the Frontend during the interaction concerns the analysis of the user's actions, aimed at discovering precise information about him/her and revise the user model accordingly.

The Frontend exploits a set of knowledge bases, storing information about the properties characterizing the most typical classes of users (novices, experts, and so forth), user modeling acquisition strategies and personalization strategies. The Frontend also exploits a domain ontology, storing product information which is essential to the personalization task. This ontology describes information about products which can be used to describe them and ask information about the preferred values in a perspective easily understandable to the user (in contrast to the configuration-based perspective adopted in the back-end).

Based on the estimate of the user's properties (see Section 2.1) the Frontend selects a personalization strategy (see Section 2.2), for instance "to present only top-level features and no technical details" and generates an adequate user interface using the predefined available graphical elements. Furthermore, the Frontend is able to preset certain

configurable options with default values, whereby these defaults correspond to the estimated interests of the current user.

The user inputs and the defaults suggested by the Front-end are handed to the Backend and the distributed problem solving mechanism is initiated. After the calculation of results – that are passed back using the generic data exchange mechanism – these results are also presented to the user in a personalized way, i.e., for instance the technical details are omitted.

4.4 Knowledge Acquisition

One of the most important issues within the CAWICOMS framework is knowledge acquisition and representation. Because of the wide variety of knowledge representation and reasoning techniques that were developed during the long history of product configuration, up to now there is no agreement upon standards for designing product models or knowledge exchange. However, recent trends show that extensions relying on the component-port model for configuration from [8], as well as conceptual modeling techniques (e.g., based on the *Unified Modeling Language*) are useful in finding a unified view on the configuration problem ([1], [10], [11]). This view on the configuration problem can also be found in commercial configuration tools [7]. Our knowledge acquisition approach relies on the idea of using the *Unified Modeling Language* to model generic product models [1], because the notation is widely used in industrial environments and we are able to compile the knowledge bases mostly automatically from the comprehensive graphical depictions.

For the integration of the different product models of the individual suppliers we employ the approach described in [5] that relies on the exchange of *functional architectures*: Using this technique the suppliers *publish* relevant parameters of their product models in order to be integrated into the main view of the facilitator. Because of this partial publishing, there is no need for having a centralized point of knowledge because e.g., low-level technical details are never shown to the others. During this (manual) integration phase the relevant knowledge on the supplier product has to be modeled with this modeling mechanism which shows to be possible even for systems that are e.g., rule-based because of the generality of the modeling technique.

Finally, the integrated product model can be automatically translated into a standardized XML-based representation that is enhanced with additional knowledge, i.e., personalization information (e.g., user-specific defaults) or distribution information (e.g., which supplying configurators can provide this component). The XML representation can then be parsed in order to parameterize the main configurator (i.e., load the product model) and the user interface generator.

Additional information on the CAWICOMS project: *http://www.cawicoms.org*

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