Personalised Configuration of Products and Services in Co-operating Markets

L. Ardissono[1], A. Goy[1], M. Holland[2], D. Jannach[3], R. Schäfer[4], M. Zanker[3], and R. Simeoni[5]

[1]*Dipartimento di Informatica, University of Torino, Italy*
[2]*BTexact Technologies, Adastral Park, Ipswich, UK*
[3]*Computer Science & Manufacturing, University of Klagenfurt, Austria*
[4]*DFKI GmbH, Saarbrücken, Germany*
[5]*Telecom Italia Lab, Torino, Italy*

Abstract. Web-based selling of customisable products and services requires intelligent software support exceeding the capabilities of state-of-the-art configuration systems. First, the users of configuration systems deeply differ in interests and capabilities, so that intelligent user interfaces are needed to guide them through the configuration process. Second, complex and customisable products typically decompose into configurable sub-assemblies and services provisioned by co-operating suppliers. Thus, supply-chain integration of configuration capabilities is another requirement. The CAWICOMS project provides a framework for the development of advanced configuration applications supporting personalised user interfaces, knowledge-sharing among supply-chain participants and co-ordinated problem solving of different configuration systems.

1 Introduction

Nowadays, many companies sell products on the Web, enabling their customers to design the items according to their own needs. However, current configuration systems either support elementary tasks, or they are too complex to be used by non-experts, so that the need arises for systems actively guiding the users in the definition of the solution meeting their own needs. Moreover, in today's economy, consortia of companies jointly offer customisable products and services, but the co-operation in a supply chain poses new requirements exceeding the capabilities of current e-Business product classification schemes and business transaction protocols. In order to face these challenges, we have developed the CAWICOMS[1] workbench for user-adaptive Web-based configuration, which we have applied to the development of a prototype system for the configuration of Internet Protocol Virtual Private Networks (IP-VPN).

This paper is organised as follows: Section 2 sketches the framework architecture. Section 3 and 4 describe the personalization facilities offered by CAWICOMS and the requirements for distributed configuration, including a short sketch of our approach. Section 5 sketches the exploitation plans for the CAWICOMS workbench.

---

[1] CAWICOMS is the acronym for "Customer-Adaptive Web Interface for the Configuration of Products and Services with Multiple Suppliers". This work was partly funded by the EU through the IST Programme under contract IST-1999-10688 (www.cawicoms.org).

2 Architecture Overview

Figure 1 sketches the architecture of CAWICOMS (see also [10]). The constraint-based *main configuration engine* can configure complex products and services, based on a generic product model declaratively represented in a knowledge base of allowed product constellations. The knowledge base results from the integration of product information provided by the sub-suppliers and this process is based on the use of a shared domain ontology. During the configuration process, the main configuration engine also mediates the distributed reasoning process by forwarding user requirements to supplier systems and integrating and checking the results. The communication process between the supplier systems relies on an open XML-based protocol, designed to meet the requirements of distributed and co-operative product and service provision.

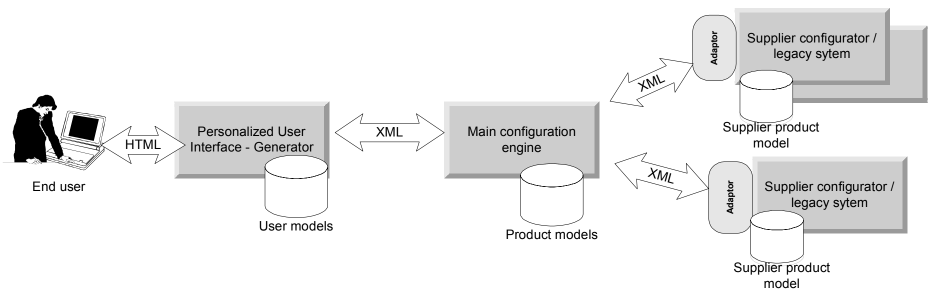

Figure 1 Abstract architecture of CAWICOMS

The end user interacts via a Web interface that dynamically generates the pages to be displayed during the configuration process. At each interaction step, a rule-based engine deduces the best-fitting interaction style, given her[2] estimated capabilities and interests, and these decisions guide the generation of the content for the next page to be displayed. The external page format is then produced by exploiting standard, XML-based generation techniques. The estimates about the user's capabilities and interests are derived and updated by monitoring her behaviour over time.

3 Personalisation of Interaction and Customer Profiling

We identified personalisation requirements on configuration by interviewing users (sales representatives) regularly accessing the systems of a company configuring telecommunication switches and occasional users of on-line configuration systems. Main emerging point was that a configuration system needs an intelligent user interface filling the gap between the technical representation of the service and the user's knowledge about it. For instance, the specification of values for the service features may be difficult if the user does not know the impact of her selections on the solution.

The CAWICOMS workbench supports the management of flexible configuration sessions by tailoring the elicitation of information about the user requirements and the presentation of the solution to the customer [11]. During the service configuration phase, the user is asked about her requirements and she is supported in the selection of the answers. The system's questions concern the preferred values for the product/service features, e.g., the required bandwidth of an IP-VPN. Moreover, there may be questions about the customer's interests in service properties, such as the speed of the network connection. This type of information is used to leverage the specification of technical data, by suggesting suitable values during the configuration session.

---

[2] We arbitrarily use female pronouns to refer to the end user or customer.

The management of configuration sessions is based on the integration of user modelling, personalisation and flexible dialogue management techniques, as well as on the declarative representation of personalisation-oriented information about services. For instance, the configuration parameters can be set, given the user's preferences for general service properties (such as speed or reliability), thanks to the estimates of the user's interests provided by the user model. Moreover, the decision of asking the user to set a parameter or eliciting information about related service properties is based on a comparison between her expertise and the difficulty of the parameter, aimed at estimating the likelihood that she is able to answer the question.

As far as the presentation of configuration solutions is concerned, different strategies, represented as rules, are applied to focus the presentation on the aspects of the solution most relevant to the user's interests [6]. The strategies may recommend the specification of a parameter in the main presentation page, or its presentation as technical, or supplementary information. The selection of the presentation criterion to be applied depends on the criticality of the parameter, on the user's expertise and her interests.

The user's interests and preferences are acquired by using an evaluation model that simulates the user's evaluation process, by relating the features of a service to its properties. For this model we use Multi-Attribute Utility Theory, MAUT [7]. According to MAUT the overall utility of an object is defined as the weighted aggregation of the utilities of the object on general properties, such as *speed* or *reliability*. CAWICOMS introduces high-level product properties (*interest dimensions*) to bridge the gap between the user's perception of the product/service (focused on its utility) and the technical details needed during the configuration process. CAWICOMS estimates the user's interests as follows: *Stereotypical information* about interests and expertise of the most relevant user classes (managers, sales representatives and technical engineers) is applied to initialise the customer profile, focusing it on the expected characteristics of the user's class. These stereotypes were defined in collaboration with the industrial partners of the CAWICOMS consortium and have to be refined for fitting real-world application. In order to take individual properties into account, the system's estimates are dynamically updated based on an *interpretation of the user's observable behaviour* during the configuration sessions. We use a probabilistic inference mechanism (Bayesian networks [8]) to take the uncertainty involved with these interpretations into account. For example, if the user selects a parameter value having negative implications on a property of the configuration solution, such as, for instance, the speed, she probably is not very interested in that property.

The integration of user modelling and dynamic generation techniques enables the system to interact with different types of users and makes it suitable for domain experts as well as for occasional users. Moreover, as the personalisation decisions are made at the granularity level of the individual product/service features and on the basis of the current estimates about the user's characteristics, the system tailors the interaction to the user in a reactive way.

4 Distributed Configuration in CAWICOMS

The open access to information resources and services offered by the World Wide Web opens new perspectives for conducting business. State-of-the-art eCommerce platforms enable many-to-many relationships between business partners in a web of highly specialised solution providers co-operating in a supply chain. However, these approaches are typically based on common (but partially incompatible) standards for data exchange like OBI, cXML or BizTalk [3] and are limited to standard products that are not *configurable* to the customer's needs according to the paradigm of *mass-customisation* [4]. Therefore, CAWICOMS aims at enabling *configuration systems* to deal simultaneously with multiple suppliers over the Web. This allows for end-to-end selection, ordering, and provisioning of complex products and services supplied by an extended value-chain. For supporting this integration, we developed techniques and methods for ontology-based knowledge integration, open communication protocols and interfaces, and advanced distributed reasoning mechanisms.

The basis for any B2B communication is the agreement on a common vocabulary or ontology for the domain. Existing standardisation efforts for general product classification (like UNSPSC[3] and eClass) or for a specific domain (like RosettaNet) are suited for business transactions with standardised and non-configurable products. Moreover, the communication protocols like cXML only cover standard business processes like quotation or ordering and do not address the advanced negotiation and synchronisation capabilities required for the provisioning of complex services. For grounding future extensions of these emerging standards, we developed a meta-ontology for the domain of configurable products, i.e., an UML-based method for the conceptualisation of configurable products and services. Starting from this, domain specific ontologies with precise semantics can be modelled and agreed upon among the business partners. These conceptual product models are used both to guarantee semantically correct interpretation of communication content and to automatically generate knowledge bases for the configuration systems [2]. In this approach, co-operative design of the configurable service is based on an intuitive (graphical) representation in the form of a generic bill-of-materials.

In addition, our XML-based business protocol comprises performatives required for distributed configuration problem solving, like, e.g., initiation of the remote search process, conflict resolution or publication of configuration results. This protocol conforms to the standards established for open, web-based communication (SOAP) and addresses the requirements for emerging *Semantic Web Services* [14] by having attached defined semantics for the performatives.

Distributed problem solving for configuration problems is addressed in CAWICOMS by extending reasoning techniques from the field of Distributed Constraint Satisfaction [5] for the configuration domain based on the commercial constraint-based *JConfigurator* libraries: see [12,13]. Moreover, the framework is extensible in a way that the distributed reasoning process can be parameterised and extended for specific application domains. For details about reasoning for the distributed sales configuration for IP-VPNs see [1].

5 Conclusion

The CAWICOMS workbench for the development of Web-based configuration systems brings two main innovations in the field of configuration systems and has important effects on companies' business model: the system tailors the configuration process to the individual user, supporting customers in the configuration of their own services; at the same time, the companies' expert personnel can exploit the same configuration systems for configuring services for third parties. Moreover, the system supports the management of distributed configuration on the Web, therefore favouring seamless management of the supply chain in B2B applications.

In order to test the personalisation and distributed configuration facilities offered by the CAWICOMS framework, we have used it to develop two prototype web-based configuration systems. The first one, aimed at the configuration of telecommunication switches, has been tested with a limited number of users in order to retrieve feedback for further development and revision of the workbench. The second one, operating in the IP-

[3] See, for instance, www.eclass.de, www.unspsc.org, and www.rosettanet.org

VPN domain, has been developed by exploiting the revised CAWICOMS workbench and will undergo further testing in the near future.

The CAWICOMS approach has drawn considerable industrial interest and results of the project are already contained in commercial toolkits from project partner ILOG. This includes in particular the developed techniques for SOAP-compliant communication (ILOG *WebConnector*) and the knowledge representation and acquisition methods. Forthcoming steps for industrial dissemination of the results include both co-operation with standardisation bodies (e.g., the EC Workshop of CEN/ISSS) as well as awareness activities for telecommunication industry. The exploitation plan for CAWICOMS will be carried on as a three-tiered strategy: (1: Technology) ILOG will market components developed with CAWICOMS technology. (2: Integration) Consulting companies will sell the concept and help implement it, using CAWICOMS technology plus products from Tier 1 where possible. (3: Use) Industrial partners (BTexact Technologies and TILab) will use the CAWICOMS technology, using products from Tier 1 and Tier 2.

References

[1] A. Felfernig, G. Friedrich, D. Jannach, and M. Zanker, Web-based configuration of virtual private networks with multiple suppliers. *7th Intl. Conf. on Artificial Intelligence in Design (AID'02),* Cambridge, UK, 2002.

[2] A. Felfernig, G. Friedrich, and D. Jannach. UML as domain specific language for the construction of knowledge-based configuration systems, *International Journal of Software Engineering and Knowledge Engineering (IJSEKE)*, Vol. 10(4), pp. 449-470, *World Scientific,* 2000.

[3] D. Fensel, Y. Ding, B. Omelayenko, E. Schulten, G. Botquin, M. Brown, and A. Flett. Product Data Integration in B2B E-Commerce, *IEEE Intelligent Systems*, 14(4), 2001.

[4] B.J. Pine II, B. Victor, and A.C. Boynton. Making Mass Customization Work, *Harvard Business Review*, Sep./Oct. 1993, pp. 109-119, 1993.

[5] M. Yokoo. Distributed constraint satisfaction - foundations of cooperation in multi-agent systems. *Springer Verlag*, Berlin, Germany, 2001.

[6] L. Ardissono, A. Goy. Tailoring the interaction with users in web stores. *User Modeling and User-Adapted Interaction*, 10(4), 2000.

[7] R. Schäfer. Rules for Using Multi-Attribute Utility Theory for Estimating a User's Interests. *Proc. of the 9th GI-Workshop*: *ABIS-Adaptivität und Benutzermodellierung in interaktiven Softwaresystemen*, Dortmund, Germany, 2001.Available via http://www.kbs.uni-hannover.de/~henze/ABIS_Workshop2001/ ABIS_2001.html

[8] D. von Winterfeld, and W. Edwards. Decision Analysis and Behavioral Research. *Cambridge University Press*, Cambridge, UK, 1986.

[9] J. Pearl. Probabilistic Reasoning in Intelligent Systems: Networks of Plausible Inference. Morgan Kaufmann, San Mateo, CA, 1988.

[10] CAWICOMS Consortium. Deliverable D01: Requirements, Application Scenarios, Overall Architecture, and Test Specification. 2000. Available via: http://www.cawicoms.org.

[11] L. Ardissono, A. Felfernig, G. Friedrich, A. Goy, D. Jannach, M. Meyer, G. Petrone, R. Schäfer, W. Schütz and M. Zanker: Personalising on-line configuration of products and services. Proc. 15th European Conference on Artificial Intelligence, Lyon, France, 2002.

[12] D: Mailharro. A classification and constraint-based framework for configuration. AI in Engineering, Design and Manufacturing, (12), pp. 383-397, 1998.

[13] ILOG: ILOG JConfigurator 1.0 Reference Manual, www.ilog.com, 2001.

[14] W3C: World Wide Web Consortium: www.w3c.org