Computers in Industry 59 (2008) 767–776

Contents lists available at ScienceDirect

Computers in Industry

journal homepage: www.elsevier.com/locate/compind

Optimizing customer's selection for configurable product in B2C e-commerce application

Xinggang Luo [a,b], Yiliu Tu [a,*], Jiafu Tang [b], C.K. Kwong [c]

[a] Department of Mechanical and Manufacturing Engineering, University of Calgary, Calgary, Alberta, Canada T2N 1N4
[b] School of Information Science and Engineering, Key Laboratory of Integrated Automation of Process Industry of MOE, Northeastern University, Shenyang 110004, PR China
[c] Department of Industrial and System Engineering, The Hong Kong Polytechnic University, Hung Hom, Kowloon Hong Kong, PR China

ARTICLE INFO

Article history:
Received 3 March 2007
Received in revised form 10 March 2008
Accepted 14 March 2008
Available online 29 May 2008

Keywords:
e-Commerce
Product configuration
Product family
Recommendation system

ABSTRACT

Many companies provide configurable products on Internet to satisfy customers' diversified requirements. Most of business-to-consumer (B2C) e-commerce software systems use tree- or wizard-like approaches to guide customers in configuring a customized product on Internet web pages. However, customers may feel confused while they are selecting components of a product from option lists, since they are usually not familiar with the technical details of these components. A few e-commerce sites use recommendation systems to provide suggested products for customers, but they have to maintain user profiles and have limitations such as new user problem and complexity. Therefore, they may not be suitable for small and medium-sized enterprises. This research proposes a new approach to help customers configure their expected products. By using this approach, once a customer inputs the levels of importance of requirements, total budget of the expected product, the software system can figure out a customized product which maximally meets the customer's expectations, and can also provide the suboptimal solutions for further selections. A mathematical model to formulate this optimization problem is established. A case study is used to demonstrate the feasibility and effectiveness of this approach.

1. Introduction

In the past decade, e-commerce has emerged as an increasingly important information technology to businesses. Many enterprises have been using e-commerce as an effective and necessary trading tool in their daily business processes [1]. Particularly, as an important form of e-commerce, business-to-consumer (B2C) e-commerce is popular to more and more customers due to its convenience, quickness and price advantage.

Today, many products sold on the Internet are designed as configurable products to satisfy the diversified requirements of customers [2], such as computers, cars or software packages, etc. Most of the B2C e-commerce applications use tree- or wizard-like approaches to guide a customer in configuring a customized product on-line. By using these applications, a customer can simply select each component of a configurable product from a list of available options step by step, and eventually get the customized product. For example, Dell™ uses a wizard-like B2C application to sell configurable personal computers on website (www.dell.com).

One problem with either tree- or wizard-like approaches for product selection is that a customer may not know the technical parameters of a product and their meanings to this product [3]. For example, to order a computer from the Internet, a customer may be confused by technical terms such as 'CPU L2 cache size', 'dual channel DDR2' or 'display refresh rate', etc. Hence the customer may feel hard to select a CPU or determine the size of the RAM that matches the selected CPU. Moreover, a customer may not know how to select well-balanced components within a predetermined budget and other expectations. For instance, a customer is going to buy a computer on-line for 2-D drafting purpose within a budget of US$ 1500. The computer has to be very reliable for professional use and has to be available in 4 weeks. In this situation the customer may find that, without a profound understanding of computer system, it is difficult to select appropriate components for the computer to avoid overall performance bottlenecks with the given conditions.

To solve this problem, a promising technology called recommendation system is used by some e-commerce sites to provide the suggested products for customers [4]. The most popular

* Corresponding author.
E-mail address: paultu@ucalgary.ca (Y. Tu).

0166-3615/$ – see front matter © 2008 Elsevier B.V. All rights reserved.
doi:10.1016/j.compind.2008.03.003

recommendation methods in these systems are content-based filtering (CBF) and collaborative filtering (CF) [5]. Content-based filtering involves recommending items similar to those the customer has liked in the past; collaborative filtering, on the other hand, involves recommending items that customers, whose tastes are similar to the user seeking recommendation, have liked [6]. However, besides limitations of each paradigm indicated by Adomavicius and Tuzhilin [7], a common drawback for both of them is the new user problem [8,9], i.e., a new customer is unable to get accurate recommendations because there is no historical preference records available in the system. The recommendation system could not understand the customer's preferences before the customer has to rate a sufficient number of items. In addition, recommendation systems have to record customers' rating profiles and apply various advanced techniques [7], such as clustering, artificial neural networks, neighborhood search, case-based reasoning (CBR), data mining, semantic analysis, etc. Therefore, the complexity of the recommendation systems should not be underestimated [10]. For many e-commerce enterprises, especially small and medium-sized enterprises, the complexity may keep them away from applying these recommendation systems.

Regarding this problem, we propose an alternative approach to help customers to find the rational product profiles from a product family. The customer requirement (CR)–technical attribute (TA) mapping matrix of HoQ (House of Quality) is used to translate customer requirements to technical attributes, and conjoint analysis is applied to construct the component performance matrix. Eventually an optimization model is established to maximize the overall performance of the selected product profile with the total budget constraints. By applying the software system based on this approach, a customer is only required to input the levels of importance of his/her requirements for the product and total budget of the product. Then the system can automatically generate a set of product profiles, which are optimal or suboptimal solutions of this problem, for the customer as recommendations.

The rest of this paper is organized as follows. Section 2 reviews the relevant literature on product family, product configuration and recommendation systems. Section 3 specifies the relationship matrices used in the mathematical model, then describes the optimization problem and establishes the mathematical model. Section 4 illustrates a case study to empirically verify the feasibility and effectiveness of the developed model. The characteristics of this approach, limitations, and some future research potentials are discussed in Section 5. Finally, conclusions are drawn in Section 6.

2. Literature review

To the best of our knowledge, a report or literature, which meaningfully addresses the research work in this paper, has not been found. However, in our research some literature and research reports have been used as useful references. In this section, these highly related references are briefly reviewed under three classes: product family, product configuration and recommendation systems.

2.1. Product family

Product family is one of the technologies developed to provide sufficient varieties of products for customization. In general, a product family is a group of similar products that are derived from a product platform to satisfy a variety of market niches [11]. A product platform can be defined as 'a set of common components, modules, or parts from which a stream of derivative products can be efficiently developed and launched' [12]. Another definition of product family by Erens and Verhulst is 'a group of related products with identical internal interfaces; these interfaces must be standardised in each of the functional, technological and physical domains to allow the full exchange of components' [13]. The benefits of product family normally include increased flexibility, reduced development time, and improved ability to extend products.

In practice, there are two kinds of product families. One is the module-based (or configurable) product family wherein product family members are instantiated by adding, substituting, and/or removing one or more functional modules from the platform [11]. The Hewlett-Packard Corporation, for instance, has successfully developed a family of laser jet printers to simplify manufacturing and assembly processes [14], which provides a typical example of a module-based (or configurable) product family. Another one is the scale-based (or parametric) product family, in which several key variables are used to scale the product platform to form a variety of products. The latter one is often used in engineering design but rarely used in e-commerce [15]. Therefore in our research, only the module-based product family is discussed.

There is an extensive amount of literature related to module-based product families. These papers are mainly focused on design, such as modular design methodology, design optimization, modular architecture or modularity, etc. None of these papers has been found to meaningfully deal with how to automatically select appropriate modules to configure a customized product, which aims at maximally meeting the customer expectations, under the constraints of total budget of the product.

2.2. Product configuration

Product configuration can be defined as: 'given a generic model of a configurable product family with all possible variants and options, in which a generic model is a set of components plus a set of various constraints; and given a set of requirements, in which each requirement can be expressed by a constraint, how to find at least one component set that satisfies all of the constraints' [16]. According to this definition, the key point of configuration is selecting and arranging combinations of components without violating the constraints.

In the research of product configuration, efforts have been mainly focused on problem representation and configuration algorithms [17], which are reviewed as follows.

(1) *Rule-based reasoning*: It uses production rules as a uniform mechanism to represent both domain knowledge and control strategies. Many product configuration systems have been built by rule-based reasoning approaches. For example, Barker et al. [18] developed the XCON system, which is a typical rule-based reasoning system for configuring Digital Corporation's products. Another example is the modular VSCF electrical systems built by a rule-based expert system development tool, i.e., OPS5 [19]. However, the heavy work required to maintain the huge knowledge base is a problem with various rule-based product configuration systems.
(2) *Logic-based approach*: It uses semantics and logical operations to represent and reason configuration knowledge. There are some applications and research work related to this approach. McGuinness and Wright [20], for instance, developed the Prose system, which is based on CLASSIC (a description logic-based knowledge representation system). Roller and Kreuz [21] used knowledge-based configurations in connection with CAD systems to choose components and check consistency. A disadvantage of the logic-based approach is the trade-off between the efficiency of reasoning tasks and the expressiveness of knowledge-representations.