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Abstract Generally, a firm can provide its customers with a great variety and quantity of self-produced and externally bought products. However, the time and effort a customer can spend deciding which product to choose according to her needs and preferences is the limiting factor. With the advent of the Internet and the ongoing virtualization and digitalization, segmentation approaches widely used in the past to target customer groups are outdated. Therefore, new methods have to be developed, enabling intermediaries to deliver the right product at the right time to the right customer, thus optimizing customer benefit by using his scarce time and effort efficiently. Consequently, the aim of this paper is to transfer the well-known concept of mass-customization to digital products and EC in order to evaluate the differences and specific problems. It will been shown that there exist significant differences between the mass customization of digital and physical products and how this poses different problems, that require new solutions in methodology and IT-architecture:

1. Introduction

With the advent of the Internet and the ongoing virtualization and digitalization, segmentation approaches widely used in the past to target customer groups are outdated. In the Information Age Economy one-to-one marketing and mass customization approaches are applied using information technology (IT) to individually target customers according to their specific needs and preferences (see e.g. [5], [18], [20]; on mass information and customization systems [8], [9], [1], [19], [26], [27]). Currently, the financial services industry - as an example of one of the most important eServices industries - is undergoing a fundamental shift, since it is questionable whether the traditional approach of just selling financial commodity products in increasingly transparent and global markets will still be profitable in the future (see e.g. [4]). Most likely, an intermediary that "owns" the customer (trust) relationship will be the only one able to enhance the shareholder value of the company in the long run. Therefore, Electronic Commerce Customer Relations Management (ECCRM) that enables firms to individually and professionally mass customize products has become increasingly important.

Generally, a firm can provide its customers with a great variety and quantity of self-produced and externally bought products. However, the time and effort a customer can spend deciding which product to choose according to her needs and preferences is the limiting factor. Therefore, new methods have to be developed, enabling intermediaries to deliver the right product at the right time to the right customer, thus optimizing customer benefit by using his scarce time and effort efficiently. For the decision, if a special product is the right one for the customer with respect to the above formulated objectives, information and knowledge about the customer (particularly the WWW is a well suited medium for gathering customer data and conducting marketing research, see e.g. [5]) as well as product properties have to be considered. To automatically match products on the one hand and the customer's interest on the other hand, both of which have to be described by a fixed set of attributes, which have to be known at design-time. Hence, a customer and content model and intelligent matching-algorithms have to be developed to satisfy the needs of customers and to provide smart solutions. (See e.g. [4], [11], [7], [13], [24])

Consequently, the aim of this paper is to transfer the well-known concept of mass-customization to digital products and EC in order to evaluate the differences and specific problems. The paper is organized as follows: After these introductory remarks, we will define and explain the special properties of digital products and electronic commerce (EC) in comparison to traditional products and markets in section 2. Section 3 describes the consequences of these differences for mass customization. Consequently, we will derive a framework for the mass customization of digital products in section 4. We will discuss some limitations of the model and prospects for further research in section 5. In our research we draw both from the German National Science Foundation (DFG) funded theoretical research and an ongoing project with Deutsche Bank, AG.

2. Digital Goods in Electronic Commerce

Trading with digital goods can hardly be compared to the market of "traditional goods". On the one hand, producers and distributors of digital goods might profit from new chances and possibilities provided by the nature of digital goods, whereas on the other hand they have to deal with new threats and challenges. The reason for these developments are based on the very special nature of digital goods.

2.1. The Nature of Digital Goods

The nature of digital goods is constituted in their immaterial form of bits (represented by a binary code of 0 and 1), which leads to the property of having no weight and moving with speed of light. Moreover, digital goods can be copied, causing hardly any costs, whereas the copy cannot be distinguished from the original [17]. Thus the marginal costs of one more copy of a digital good are zero. Consequently, digital goods can easily be produced and distributed on networks, such like the internet hardly causing marginal costs or time of delivery and without having to be transformed or changed in media. Examples of digital goods are *digital products* like software tools, *digital services*, such as digital information, and *digital rights*, e.g. financial products. In this paper, we will focus on the latter two, since those are mainly traded in EC.

Finally – and probably most importantly -, digital goods can easily and without costs be varied and differentiated, since they can simply be divided into atomic units and bundled again according to any consumers' needs [2]. All product combinations are attainable.

2.2 The nature of Electronic Commerce

The core difference between traditional business and EC is based on the subject of trade: Whereas the old economy deals with physical goods and services, electronic commerce is focused on digital goods in form of digital information or digital services. This leads to a new economy and a new way of doing business, where tradition and already acknowledged theories have to be critically reviewed and new rules have to be defined, new variables have to be considered.

Whereas the traditional economy could mostly be restricted to a certain local area (local competition), a producer in EC automatically becomes a global player. The Internet as distribution channel reaches all Internet users around the world, no matter of place and time.

According to Porter [21], a firm can have two basic types of competitive advantages: cost leadership or differentiation. Still, a firm cannot pursue both strategies, because it will be stuck in the middle. However, a producer of digital goods trying to gain advantages from a strategy of differentiation will fail, since digital goods can easily be transformed or varied. Thus, if a producer offers an innovative digital product, every other producer can imitate this good, failing to gain competitive advantage by differentiation to both of which. Pursuing a cost leadership strategy, firms have to compete in prices. This might be a fatal strategy in EC as well, since the neglectable marginal costs of production and the winner-takes-all-properties of such markets might lead prices down to zero according to microeconomic theory. Consequently, when producing digital products, a competitive advantage can neither be gained through differentiation, nor by pursuing a cost leadership strategy.

2.3 The Customization Strategy in Electronic Commerce

A winning strategy in EC might be the customization of digital goods according to the individual needs and preferences of each customer. A customized product is unique, since it is perfectly adjusted to the needs of one single customer. The incentive for other firms to imitate a digital good diminishes, because the product does not satisfy the individual needs of another customer. Therefore, a competitive advantage according to Porter's theory can be achieved. Moreover, the producer might even be able to gain advantage through cost leadership, since digital information goods can easily be customized by the help of modern and innovative information technology (IT). Consequently, a producer of digital goods might gain competitive advantage through customization as well as low costs (see [19]).

The key to the success of this new strategy of customization is the knowledge of the customers' needs and preferences. In order to get to know the customers' preferences, each client has to be integrated in the production process. This integration in the producers value chain leads to the new customer status of "prosumer"[19], which is a combination of the client as *producer* as well as *consumer*. The prosumer's preferences are an important input in the production and adjust the digital good to the specific customers needs.

To sum up, the main factor leading to the success of customization lies in the customer know how. The company which will be most successful in getting detailed customers needs and moreover,

will be able to build digital goods fitting these needs, will gain competitive advantages. This might be the key to the success of the new economy.

3. Mass Customization of Digital versus Physical Goods

In general, - i.e. in relation to traditional physical goods - [1], [19], [27] describe the main challenges and problems of mass customization as follows:

- A very flexible manufacturing organization and control is required, in order to produce a number of differentiated products in arbitrary order.
- The distribution and logistics has to fit and enable a such kind of flexible manufacturing process.
- The provision and maintenance of this infrastructure induce additional costs of production, which have to be justified by sufficient additional revenues.

Consequently, based on the results of chapter 2 these challenges and problems do not seem to apply anymore for digital products and EC, since they can be bundled and unbundled without any costs. However, in EC the depicted problem of a flexible production process is substituted by the problem of automatically integrating the customer, its attitudes, preferences, tastes etc.:

- How has the customer interface to be designed in order to receive relevant information?
- How can a customer's needs and preferences be derived from this information?
- What is the adequate form of representation of this information and know-how?
- How can a customer's needs and preferences be matched with the available assortment of products?

As it can be seen easily, the focus has switched from the product side to the customer side of the process, since product diversification is assumed to be trivial and without any costs, but the proceedings of getting to know your customer and offering him individual products seems to be the decisive competitive advantage. Therefore in the next section, we will present a framework, that incorporates these results.

4. Framework for the production of Mass Customized digital Products

The problem of providing customers with individualized product solutions to their problems is a very complex one. Firstly, the customer himself has to be modeled and a machine readable representation of his (changing) preferences, attitudes and (latent) needs has to be provided. Secondly, the products have to be modeled in terms of for the customer relevant product attributes. Finally, intelligent matching algorithms are needed to combine the customer on the one hand and the products on the other hand, that is, there has to be a matching based on the information provided in the customer and product models in order to get a customized product. This basic architecture is represented in figure 1 (based on [7], [13]).

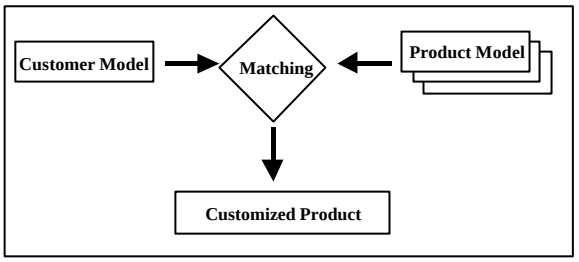

Figure 1: The basic matching process

4.1 Customer Model

Recently, there has been written a lot about customer modeling in literature (see e.g. [16], [7],). For a domain model that filters the key attitudes of a customer see e.g [22]) and a variety of quantitative methods to solve "quantitative" customer problems (see especially [28], [26]; see also [24]). However, there is a lack of customer models that combine both quantitative (such as income) and qualitative data (such as taste or the preference for certain products). Therefore, a customer model will be developed, that also represents qualitative data on a higher level of abstraction, that can be applied in various situations.

Like every model, a user model is a view on reality that reflects what is relevant in order to solve a problem. Whereas information on customers is not scarce even if distributed throughout companies from central databases to the customers' individual sales assistant or consultant, consultation requires not only information but knowledge. Knowledge today is limited to individual human consultants. Our customer model aims at changing that and thus at enabling IT-supported customization of digital products. Knowledge shall be seen as applicable information that is separated from simple information by a

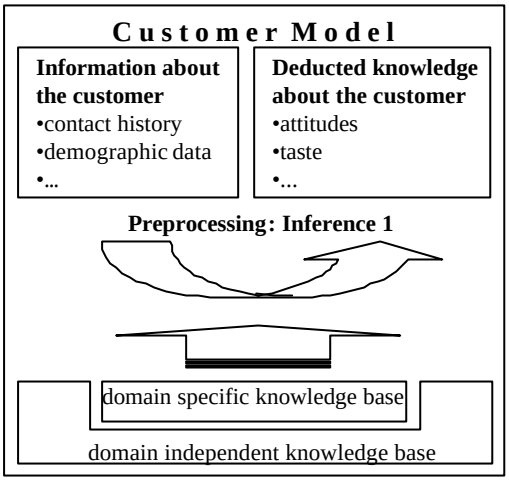

Figure 2: The Customer Model

higher degree of abstraction and is generated from simple collected information by experience, deduction, or induction.

- *General knowledge about the domain*:
  The necessity to model customers' needs also constitutes a minor difference to Kobsa's [11] perspective: he focuses on goals. As we are designing a customer model adequate for product customization, we cannot rely on the assumption of general correctness of customers' goals. We have to model the customers' needs that may vary from the goals. That happens if a customer went wrong when defining his goals. In order to know where the customer should go, we need knowledge about the domain.

- *Attitudes as knowledge about individual customers*
  As shown, the customer model has to be able to express the customer's needs. Statements that express closeness or distance towards problems, products or product properties shall be called attitudes. From the attitudes addressed a customer's preferences could be deducted [e.g. multi-attribute value functions, see e.g. [6]. Individual attitudes are not permanent but change over time. A change is triggered by new information and on the base of general knowledge.

- *Information*
  Knowledge should play the dominant role in the consultation process. Nevertheless, we believe a usable customer model is also required to include information about the customer. As mentioned, a wide range of information about customers is present in most companies.

4.2 Product Model

A content model ensures that the information about the available products needed to identify the right product for a specific customer, is accessible to an automatic matching process [13].

To achieve this, we deduce the necessary content attributes by arguing from the customer's point of view, since it is the customer's needs which have to be satisfied with the matching process using the attributes. This is done by finding valid arguments why a certain attribute contributes to the objectives. Although it could well be the case that an attribute contributes to more than one of the objectives discussed, having identified at least one contribution, the attribute is added to the catalog of relevant attributes.

The elicitation of the product attributes from the product properties can be done in several ways. Most commonly it is probably done by humans. However, an application of some kind of artificial intelligence might be feasible as well. However, the product description with adequate attributes is a onetime process for each product. Hence – compared to the customer model -, it neither causes much effort, nor does the elicitation process seem to be very sophisticated.

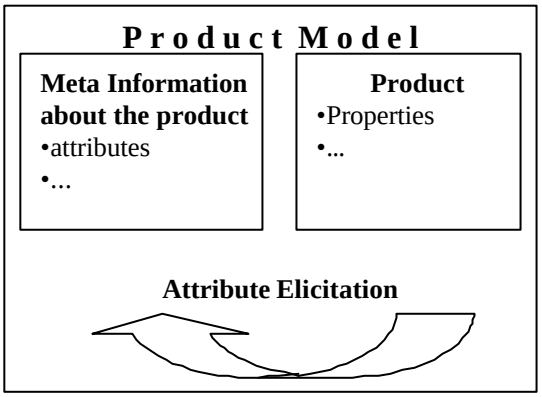

Figure 3: The Product Model

4.3 Matching Inference Mechanisms

Based on the depicted customer and product model, a more sophisticated 2-step inference process can be derived (see figure 4). The main features of this process can be described as follows

a) The inference process I_1 deducts the customer's attitudes, corresponding to his/her needs, from the customer information base built up. This deduction is done by using domain specific and domain independent knowledge about building customer models. I_1 is also called pre-process,

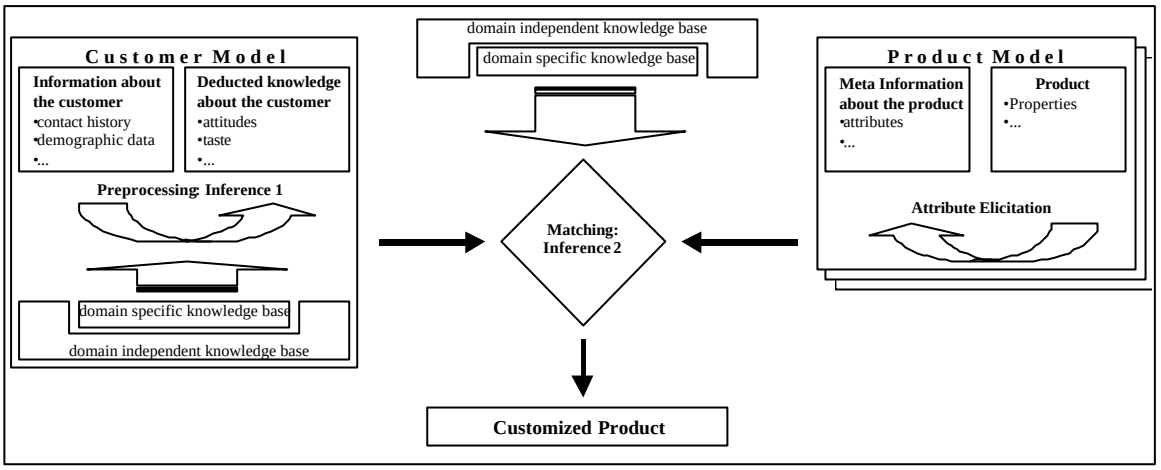

Figure 4: Sophisticated Production Process for customized digital goods

because its goal is to prepare the customer model for the final matching process.

b) I2 is the actual sales assistance or consulting process, which determines - starting from an instance of the customer model - the adequate individualized action. This process is supported by a domain specific and domain independent knowledge base built up for consulting processes as well. I2 refers mainly to the attitude base which was built up in a), but it may be necessary to include plain user information as well, e.g. for parameterizing selected product offers.

c) As described in the previous section, product attribute elicitation process is not a vital step within the mass customization process, especially since it would not be a dynamic and ongoing but onetime event. Therefore, it will not be considered part of the matching process, but a prerequisite, and therefore excluded from further considerations.

During a session, a customer or his/her assistant can enter new information at any time and thereby override information stored in the customer model, made available by stereotypes. The new information may indicate a change in the customer's needs, which triggers the inference process I_1 to start again and usually results in a new process I_2. As it is useful to store the generated knowledge about the customer longer than for just one session, the customer model will be completely preserved in a customer specific knowledge base and can be restored at the beginning of the next session. This process, addressing implementation and efficiency considerations, is not shown in figure 4 for simplicity of illustration.

So far, there exist several approaches applying different inference mechanisms within customization systems, e.g. Broadvision (www.broadvision.com) uses a rule-based system, NetPerceptions (www.netperceptions.com) a collaborative filtering system, and Autonomy (www.autonomy.com) applies a combination of neural networks and bayesian probabilities. Moreover, other mechanisms exist, like nearest-neighbor-algorithms or ideal vector models, which are more of academic interest so far. However, there is no analytical research about the eligibility of the various mechanisms for the given problem available. (See e.g. [3], [15], [22] for basic information about matching algorithms; [25] discusses two matching techniques (rule base matching and collaborative filtering) for individually addressing virtual community member segments.)

5. Conclusion

It has been shown that there exist significant differences between the mass customization of digital and physical products:

- Digital products can easily be unbundled to atomic units and rebundled according to a specific customer's needs and preferences with no additional costs.

- Traditional mass customization approaches focus on the product side. However, with EC and digital products, the competitive advantage is to know, which customer needs which differentiated product. Consequently, the matching process of the given product attributes with the derived customer attitudes is the challenge.

- Unlike traditional markets, the mass customization of digital products in EC is not an strategic option, but a necessity. Hence, the application of mass customization will become

a competitive advantage and a focus of further work, in practice as well as in research.

Consequently, the mass customization of digital products poses different problems, that require new solutions in methodology and IT-architecture:

- A powerful customer interface is required for a successful eCCRM, that provides the customer information and know-how for effective mass customization.
- The implementation of a behavioral model for the description and forecast of customer needs and preferences – e.g. on the basis of attitudes - in a customer model provides a powerful means for the succeeding matching process. Consequently, further research should on the one hand focus on the explanation of customer behavior, and on the other hand on the representation of thereby derived customer know-how.
- For the description of the products by means of relevant product attributes, a meta model and language, like e.g. XML, is required, that is applicable for various kinds of product categories.
- In order to efficiently match the customer model with products, a taxonomy of matching problems and adequate matching inference mechanisms is to be developed.
- Especially in EC, an high performance IT system is key for satisfied customers, customer retention and high sales. Therefore, research focus should also be on efficient IT-infrastructures [10], [12].

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