

Extended Mass Customization – Creating Adaptive Products with Embedded ICT

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Abstract

Companies have started to apply Mass Customization (MC) strategies to fulfil customers' individual needs while maintaining cost-efficiency of operations to ensure low prices. Several authors have proposed frameworks and classifications of MC models and strategies. However, in none of these frameworks a product is seen as an active player in customization. Mass Customization is always seen to be a result of interaction between customer and provider (manufacturer/retailer). However, as the object of customization is often a product, why not make it also an active player in customization by adding some intelligence to product? The advancements in area of Information and Communication Technologies, like miniaturization of electronics, mobile connections and new sensor technologies, enables many new possibilities for this kind of development. This development is already on the way, for example, in software business producing intelligent applications and also in business-to-business environment by companies manufacturing machinery with a computer installed inside with capabilities to store, process and communicate data and information. In this study we try to conceptually identify the possibilities for this kind of 'extended mass customization' and how it differs from traditional Mass Customization. We also demonstrate this ongoing movement to adaptive products with one case description.

Keywords

mass customization, customer interaction, adaptive products, ICT

Introduction

The commercial use of Internet has promoted e-Business to be an important subject of decision-making and business planning since the mid-1990s. When e-Business comes widely used, and most of the operative order- and delivery routines move into information networks in many industries, e-Business will offer a new way to learn from business relationships, to deepen the interactions and provide better customer service.

Today's customers won't accept the Henry Ford's dictum 'You can have any color car you want as long as it's black' (Pine, 1993). "Every customer is unique" -phrase has challenged manufacturing companies. Fulfilling every customer's individual needs has been, if not impossible, targeted only to very solvent customers. Mass customization (MC) strategies have tried to achieve the goal to fulfill individual needs cost efficiently. One of the great

opportunities to this has been largely the development of information and communication technology (ICT).

Traditionally Mass Customization has happened in customer service situation for example, building product from modules to match preferred features of customer, or even before that, for example, by creating variety and product lines from which the customer can find a product best suitable for his/her individual needs. Also, some sophisticated MC methods have concentrated collecting detailed customer data to anticipate customer needs and offer customized products and services without disturbing customer with inquiries.

Mass customization has been considered to be a production paradigm on one hand and customer focused business paradigm on other hand. The customization has been seen to happen either in production lines or in customer service situation, as a result of provider-customer interaction. Some literature has also mentioned simple adaptation of standard products by customer him/herself belonging to scope of mass customization, but it has not been considered seriously. We would like to bring into discussion also the customization that happens only when customer has already purchased the product, in form of adaptive products.

Rest of the paper is organized as follows. In the next section we shortly describe the evolution of industrial production and concentrate to the concept of mass customization in the third section. In the fourth section we extend the mass customization models by considering an adaptive product as a new way to customize product and learn about customer. Supplementing previous literature on mass customization, we consider in fifth section adaptive product as a third active player in customization situation. In the sixth section we supplement our views with examples of different development paths and with one case description representing the development toward adaptive products. Lastly we present our conclusions in seventh section.

Development of industrial production

Industrial production is constantly developing and looking for more efficient and effective ways to organize. Historical evolution has gone through different phases starting from craftsmanship, evolving to mass production and process improvement and lately to mass customization (Pine, 1993). This new way to organize production has challenged all industries producing products and services.

Boynton and Victor (1991) and Pine (1993) have described these different strategies of industrial production with product–process change matrix (figure 1). For centuries, economic production was based on the notion of craftsmen (Pine, 1993). When the idea of mass production was introduced in the late nineteenth century, most of the enterprises were small, family -owned firms based on craft production. At the time machinery was coming widely to factories, not to replace the workers, but to help them in their work, which created the technological ground for mass production. Management paradigm, standardization work and technological development together with a great success story, spread out by Henry Ford's production engineers, made the break through of mass production. After the World War II mass production became the dominant manufacturing paradigm of the world's industrial production.

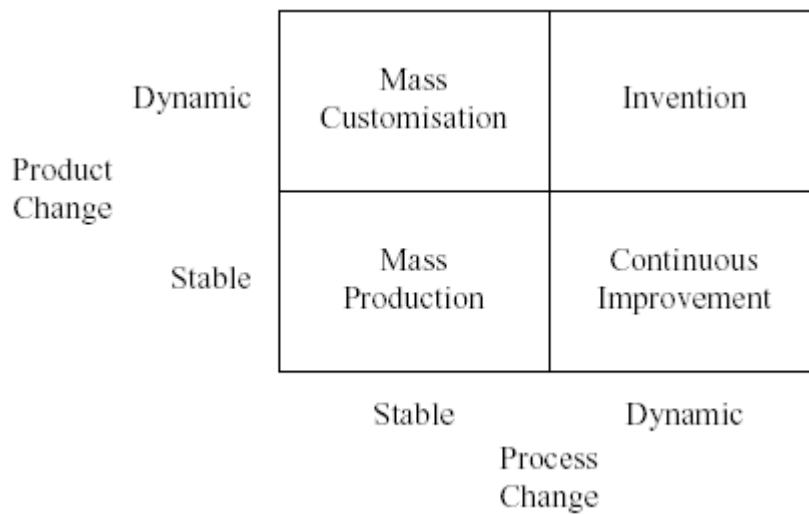


Figure 1. Adapted from Pine (1993, p.218), based upon Boynton and Victor (1991).

Idea of mass production is ‘the shared goal of developing, producing, marketing, and delivering goods and services at prices low enough that nearly everyone can afford them’ (Pine 1993). Mass production was heavily dependent on specialized machines and men to achieve smooth flow of production and low costs that resulted in low prices. Companies grew bigger, because achieving the ‘economies of scale’ guaranteed even lower prices, and thus, better position in the markets.

When more and more manufacturers changed their production strategy to mass production, competition tightened respectively. The total process efficiency and optimum quality of production was highlighted especially in Japanese firms. The goal of continual process improvement is to eliminate waste in processes and concentrate only to steps that add value. Decreasing inventories, concentrating on quality issues, lowering overhead and bureaucracy, and increasing productivity of workers enable flexibility and lower overall costs. And flexibility of production line makes it possible to produce greater variety of products at low cost, which lays ground for mass customization.

Using mass production and continual process improvement to produce mass products is an ideal way to produce goods for homogenous markets. However, in the end of twentieth century situation started to change significantly as the market became more fragmented. This situation has led to breakdown of mass production paradigm and introduction of new one, mass customization. Mass customization, as an organizational strategy, is arising in direct response to the turbulence that has splintered the mass market (Hart 1995).

Mass customization in customer interface

To retain customer loyalty companies should serve every customer as an individual offering customized products and services at a reasonable price (Pine, 1993). This contradiction of offering individual products and yet keeping reasonable prices can be solved with a mass customization strategy (Davis, 1987). Idea of Mass Customization is seen as ‘*ability to use of*

flexible processes and organizational structures to produce varied and often individually customized products and services at the price of standardized, mass-produced alternatives' (Hart, 1996).

Companies' mass customization strategies are always individually designed – or customized - from generic strategies. Mass Customization should be seen as an umbrella concept for a host of techniques, it is not something that one can simply tack onto an otherwise steady state of business conduct (Davis, 1992). However, many generic Mass Customization strategies have been described in literature. For example, according to Gilmore and Pine (1997) we can either customize product itself, or representation of product. These two dimensions create fourfold table, where different generic strategies are Adaptive, Cosmetic, Transparent, and Collaborative Mass Customization, which all have their own distinct features.

Several other authors have proposed continuous frameworks upon which MC may be developed; namely, MC can occur at various points along the value chain, ranging from simple “adaptation” of delivered products by customers themselves, up to the total customization of product sale, design, fabrication, assembly, and delivery (Da Silveira et al. 2001). Browne et al. (1996) presented a framework of decoupling points in different levels of mass customization. Four different designs are represented by varying the position of the decoupling point (Alfnes and Strandhagen 2000). These designs range from providing unique products (Engineer to order) via two customization levels (Make to order and Assemble to order) to providing standard products from a final stock (Make to stock). Lampel and Mintzberg (1996) define a continuum of five MC strategies involving different configurations of process, product and customer transaction.

In none of these frameworks a product is seen as an active player in customization. Mass Customization is always seen to be result of interaction of customer and producer/seller. However, as the object of customization is often a product, why not make it also an active player in customization by adding some intelligence to product? The advancements in areas of ICT, like miniaturization of electronics, mobile connections and new sensor technologies, enable many new possibilities for this kind of development. Thus, we suggest a product itself as a third active party in customization, as a way of extended mass customization mode.

Adaptive products

Basically, all products can be customized by provider (manufacturer, distributor, retailer) or by customer him/herself and customization level can vary all the way from changes in core features of product to simple adaptation of product by customer. However, in Mass Customization, products have to be customized at least once for every customer or customer group.

Recent discussion especially in software engineering literature has mentioned adaptive or intelligent applications. Discussions consider different aspects of adaptive applications, like adaptable user interface (Kantorowitz and Sudarsky, 1989), self adaptive software for signal processing (Sztipanovits et al., 1998), design methodology for adaptive applications (McIlhagga et al., 1998), adaptive web sites (Perkowitz and Etzioni, 2000), adaptive business intelligence applications (Bäck, 2002), controller synthesis algorithm for building self-

adaptive software (Tziallas and Theodoulidis, 2004), and integration of intelligent systems in development of smart adaptive systems (Juuso, 2004).

When introducing adaptive applications, beforehand customization work may be partially removed, as application itself adapts to user's needs and to different use situations (Mäkipää and Mattila, 2004). Thus, adaptive applications can be mass-produced and -distributed very economically, ensuring low costs of production per product. Yet, the product's ability to adapt to specific needs and wants of individual customer's creates great value for customer. However, at the moment adaptability has to be defined very clearly beforehand, which limits the application area.

In many respect the adaptability of other products lean on development of ICT. For example, development in B2B markets has started by applying logical circuit solutions but is already advancing much further. Companies manufacturing appliances, machinery or other goods meant for long-term use are starting to develop intelligence of appliances. In this kind of product areas ability to record usage information, make fault-analysis and control over quantity and quality of production can create significant competitive advantage for customers in manufacturing industries (Ruohonen et al., In Press). The same development is slowly starting to appear in consumer markets as well. This way information technology opens new doors for not only to make product's utilization possibilities more diversified, but also to manage customer relations and control the supply chain.

By installing ICT inside the products the product can be made much more 'intelligent'. It can be made to learn from customer behavior with product (used features, in which order, etc.), different use situations (using product for different purposes), location (home, office, traveling) or even user (e.g. facial expressions, heart beat etc.). By learning about user and different use situations product can be able to better adapt to different use circumstances.

Triangle of customizers

On the other hand, ICT, and especially mobile communication technology, offers also possibilities to update installed software, if necessary. For example, if customer's using habits change extensively and there exists different profiles of user-software combinations, provider can use this wireless communication link to update most suitable version of software to product drastically improving its use abilities for changed user needs.

This new way to customize product extend current literature on mass customization. Traditional literature on mass customization has concentrated on customization possibilities of product/service provider. Some literature has acknowledged possibilities for customization executed by customer, at least in a way product is used. The concept of Intelligent or Adaptive Application brings third customizer into a picture – the product itself. Thus, the customization of a product can be some combination of interaction of three customizers: provider, customer, and product (figure 2).

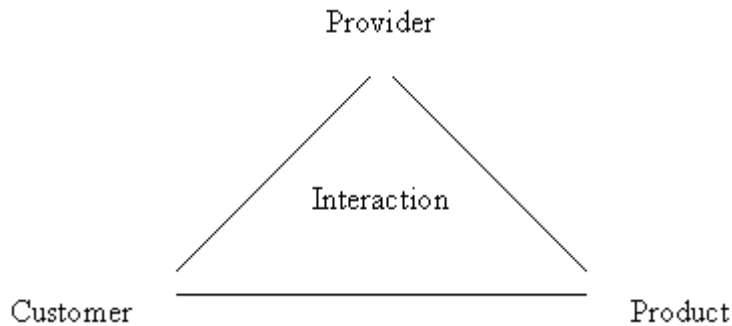


Figure 2. Different parties in mass customization

The adaptive products can adapt to different situations and different needs of users, alleviating some of the needs for beforehand customization work. This is possible by adding some 'intelligence' to product, making the product context aware (or situation aware) and enabling learning from past actions in different contexts. In this situation, the product adapts to the needs of the customer/user, and thus the customization in outcome of customer-product interaction. However, in most cases adaptability has limits and some producer-customer interaction is also needed to customize product. Producer can have, for example, different versions of product for different customer profiles or use purposes, which can differ greatly. This kind of variance might not be able to be catered with adaptive features, but they require some customization of core features of products. The rest of the variance of user requirements can be satisfied by adding adaptive features to product. This way product is combination of beforehand customization and ongoing customization.

If products overall features and qualities are quite standard, for example, specified by some law or regulation, and it can only be used differently, adaptive product offer a way to improve customer experience with product. This kind of product can be mass produced to great extent, only installing required ICT-components and software and product is able to adapt to different customer requirement. In this way, adaptive products are in the core of mass customization, truly combining mass and custom.

Case examples on the way

Some features of adaptive products are well on their way already in some specific contexts, but combining different features in one product is still far ahead. Software products intelligence is currently under wide debate, as noted above. For example, Microsoft® Windows® XP is well known software, which learns from users' behavior with product's features. The operating systems recognize which links and programs are used widely and which are not. Using this information user is offered fast and easy access to the most used links and those ones with little or no use are hidden to background.

Currently, under development, there are even more advanced technologies to observe users. Machine vision and recognition of facial expressions are under development, enlarging the possibilities to observe user's action with product and reactions to its functionalities. Speech- and gaze-based interaction technologies provide user with more powerful communication and steering capabilities with products and provide useful information about user's habits with

product, if properly collected. Other new advances in technologies are intelligent clothing systems that can observe different body functions of user, like heart beat, blood pressure, temperature etc. contributing to other ways to learn about user's reactions.

Positioning technologies, like Global Positioning System (GPS), provide further opportunities to learn about use of mobile and portable products. Being able to recognize different use profiles for different locations can also be handy, if for example, use profiles differ significantly according to location (e.g. home, office, traveling, shopping, etc.). Using the location information can further contribute to recognition of different use situations. A product might be able to recognize needed functionality in situ even before user starts using the products and signaling with the selected features the preferred profile by using the location information.

Next we provide one case example of development toward adaptive products. Firm T is producing highly reliable products for use in demanding conditions with sensor technology able to observe and record different quantities. This case represents one way to increase the products intelligence contributing to development of adaptive products.

Firm T

Firm T is a medium sized company concentrating on sensing devices to measure quantities like acceleration or angle of bank. T is a part of the much larger global consolidated corporation. Customers of T are typically large enterprises. Requirements on products and product reliability are tight. Typically products are applied in demanding conditions like shaking and pitching and working in very cold weather.

More commonly, when different types of products are considered, the fundamental role of the informative viewpoint is obvious. Already Porter and Millar (1985) noted that all products include a component of information. However, in a modern product that type of component may be multifaceted, and it may be represented in addition to various communicative features of the physical product, also by interactive long-lasting after sales services, by knowledge of the end- customer's business processes and consultation activities based on them, by interactive activities of customer relationship management based on CRM data, by shared experiences between the producer and the end-customer, etc.

In case T there is an example of this type of portfolio. Currently the core products of T itself do not include any software components - sensing devices are built as analogical solutions, but in any case that does not mean the products could not include remarkable information components.

T's viewpoint to mass customization can be characterized as collaborative (see Gilmore and Pine, 1997). For the most part the products are planned according to customer specifications and they are sold at entities customers want to have them, like semi-finished products or components. When new applications are needed by customers, a virtual model or simulation can first be built to demonstrate the final solution. A "living" relationship between the enterprise and the customer expects

knowledge about the needs and the business of the customer. The product delivery process is paperless, which is currently quite normal way to operate within business area of firm T.

The special informative feature of the products of T is the delivery of test data. That data is needed for quality control of end products. For product reliability customers typically want to analyze the test data very carefully. Every delivery includes also the large test data. Because there are a great number of products, there is also a great number of data.

What is interesting, the aims of the business of the firm T are to standardize and build generic products. It must be noted that product definitions and planning data creation are inseparable parts of modern, networked production. From an informative perspective mass customized products mean also standardized data and sharing it between the partners. When the parts, components and products are continuously changing in mass customized production paradigm, the process has concurrently more responsibility of documenting all the products accurately.

Networked enterprises and their shared processes need transparency of the networked enterprises and shared real-time data between the production parties. That includes among other things different production-related data, such as planning information, CAD blueprints, and PDM data (Product Data Management), but also information of end-customers and of the situation of the whole production chain/network. The heterogeneous practices mean new and more complicated documenting processes. More commonly, a lot of problems in firms are also caused by heterogeneous coding in the product data management. For example, one of the problems might be the managing of different revisions of products. All that mean, that for successful collaborative mass customization activities some common standardization guidelines are needed. That makes it possible to transfer to new types of mass customization, especially to the direction of adaptive mass customization.

According to firm T, it is quite possible to build also the core products more intelligent, to transfer more to digital products and embedded systems, but the question is not that simple. Again, for the tight demands of product reliability it may not be only a good thing if the customer could individually parameterize or change the product. It is also in view that the products are becoming more and more complicated. These products would increasingly get a systems nature with many different features, monitored by the same "black box", and that may increase the need of concentration of product management instead giving it all to customer.

Conclusions

The idea of producing standard products with some ICT installed inside to enable adaptability of products is fascinating, yet perhaps not totally realizable at least in near future. The fragmented market requires different kind of qualities and features from products and range of these requirements can vary greatly. Also the different technologies for applications to observe and learn from user are still in development phase, and offer currently only very limited possibilities for adaptation. Thus we see that currently and in near future traditional mass customization continue to be driving force of change in manufacturing, but it can be supplemented in ever increasing amount with adaptive features.

The main contribution of this paper is bringing a third customizer into picture – a product itself - which has been absent for great extent in the MC literature. The product's ability to actively adapt to various circumstances beyond mere user adaptation is an increasingly interesting research topic, and a topic for practitioners to develop in the real world.

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