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VIRTUAL PRODUCT DEVELOPING ENVIRONMENT IN CUSTOMER-CENTERED DESIGN APPROACH

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Abstract: *Improvements in computer and communication technologies enable a shift from manufacturer-centric innovation to customer-centered innovation. As customers` needs are often heterogeneous, many customers are dissatisfied with the commercial products.*
This article determines a need for customer-centered approach in product development domain. Recent improvements in collaboration environments that would systematically involve users into the innovation process and enable user customization are described.
Key words: customer-centered design, virtual product designing environment, mass customization, Axiomatic Design, e-manufacturing

1. INTRODUCTION

The biggest driving force in innovation is competition. A product or service may stand out in terms of the prize, product shape and function or the attached value or experience that the product or service offers [1]. As customers` needs are often heterogeneous, the strategy of "a few sizes fit all" leaves many users dissatisfied with the commercial products.
Many companies are starting to realize that innovation can arise not only from the R&D department but also from the interaction with partners, suppliers and customers. The shift of innovation to customers has some very attractive qualities. Innovations developed by users can improve manufacturers' information on users' needs and so improve their new product introduction success rates. Also innovation by users appears to increase social welfare. [2]. Computer-games is one area, where the consumer assumes an active role in developing new products [1].
Improvements in computer and communication technologies have a great potential to engage users into the product development process earlier and help them design products virtually.

2. CUSTOMER-CENTERED DESIGN

2.1 Need for customer-centered design

Meta-analysis of market-segmentation studies suggests that customers` needs for products are highly heterogeneous in many fields [3]. Empirical studies show that many users- from 10 percent to nearly 40 percent- engage in developing or modifying products. Since lead users are at the leading edge of the market with respect to important market trends, one can guess that many of the novel products they develop for their own use will appeal to other users too and so might provide the basis for products manufacturers would wish to commercialize [2].
In order to develop a successful product, two types of information are needed:

- need and context-of-use information
- generic solution information

Bringing these two types of information together is rather difficult task. However, innovations in computer and communication technologies make customer-centered approach a potential strategy for enterprises to stay competitive in the market. Virtual product developing

environment (VPDE) seems to be a feasible and suitable solution for connecting user requirements and engineering solutions.

Manufacturer-centric design	**User-centered design**
generic solution information	need and context-of-use information
Market segmentation	Custom needs
Standard products	Special requests
Unifies information about customer needs	Originating from personal needs
Attempting to conserve the applicability of a low-cost solution (to them)	Requires best overall tradeoff between solution quality and price
Mass production	Fully satisfying product

Table 1. Characteristics of manufacturer-centric and user-centered product designs.

Open source software projects are object lessons that teach us that users can create, produce, diffuse, provide user field support for, update, and use complex products by and for themselves in the context of user innovation communities. In physical product fields, product development by users can evolve to the point of largely or totally supplanting product development—but not product manufacturing—by manufacturers [2].

2.2 Present versions of mass-customization

Several innovative enterprises have already been adapting customer-centered approach into their product designing domain, mostly by giving their customers an opportunity to complement their product via the Internet. Customers can combine modules from the list and specify some required parameters.

As an example, a snowboard producing company, Revolution has an online design environment (http://www.rideharder.com/revolution/). A customer can choose the type of board, the color and specify the desired parameters. Due to the standard size and shape of the boards, customization can be done easily.

Fig. 1. Toolkit for designing a snowboard.

The design kit itself is programmed in Adobe Flash Player and the web page uses hypertext preprocessor (PHP). This is probably one of the near future options on how to involve casual customers in the product development. Casual customers are just interested in the result and they don't care how it's achieved. It's up to engineers to determine the materials and processes to make the customers design a reality

The biggest shortage in this approach is the limited involvement for the customers. A company must already have a standard product that customers can change to their likening.

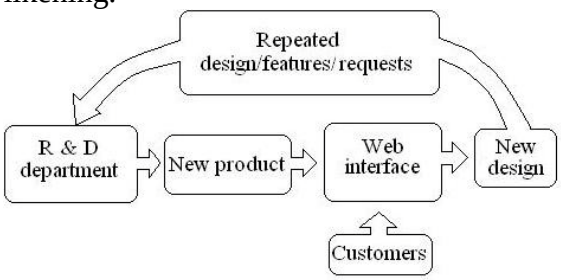

Fig. 2. Customers' involvement in new design.

In car industry, the customer cannot yet design his/hers own car but rather choose from already existing solutions. Buying the car no longer involves only picking the manufacturer, the model and color of the car but choosing different dashboard designs, shape and size of the shift knob etc. At this point the selection is between already existing solutions. However, the trend is to give customer a car that is distinguishable from the rest. A car manufacturer in USA, Scion is using this method (http://www.scion.com/bys/pub/).
The same principle is being adapted also by the bigger automobile companies. For example a new Volkswagen Phaeton factory in Dresden does not have the traditional line. They have workstations where the cars can be assembled exactly to the customer's specification.
This is the second possible solution for involving customer in designing a product: customers are presented with different alternatives, from where customer can choose the design and parts that he/she likes.

2.3 Product development project on mobile robot platform

With intent to obtain a real-life experience on customer- centred product development, Tallinn University of Technology participated in ELIKOs` project (the competence centre for electronics and IT). The overall purpose was to develop RFID antenna rack assembly, needed for research on mobile iRobot Roomba 530 platform. [4].
While developing rack assembly, several problem solving methodologies, such as Axiomatic Design (AD) and Morphological matrix were used and analysed regarding e-business possibilities in the area of niche products, like mobile robot platforms. During AD client needs, functionality of the product, parametric design requirements and manufacturability are analysed, whereas it is possible to use the achieved data for further analysis and save it into knowledge base [5].

2.4 Environments for virtual product development

One of the existing environments for online product development is TeamCenter 8 (TC). Its` main function is product lifecycle management. It is programmed in Java and it's not an "active" program, only a management program- you still need a CAD program to change or add any new CAD models.
The main advantage of TC is that it has a database that can be used by the whole product development team, who has a computer and access to the internet. TC also allows storing the products development history.
A possible solution for the future would be a virtual environment that combines CAD, production development and audio/video communication. This environment can be used by engineers that can show their ideas in real time with CAD models and explain them by using Skype for audio communication.
This environment could be also used by the customers. Depending on the field of the company, clients can be involved more or less in the production development. In most cases, the client determines or guides only the design of the product and it's the engineers' job to asses if this design is feasible or not. The designing of a product by an inexperienced customer requires an environment that can be easily learned and used. Good and clear menus, simple tutorials and very easily graspable program are required.

3. METHODOLOGIES AND TECHNOLOGIES AVAILABLE

There are several communication technologies available that would help establishing exchange of information between customers and product developers

in suitable manner. VPDE seems to be the most perspective.
Adapting AD methodology into product development environment might help developing of a decision support system using an accumulated database consisting of each systemized database for a given AD module. This will reduce the required period of development, minimize failures and mistakes during the design and development steps, and provide instant cause analysis [5].

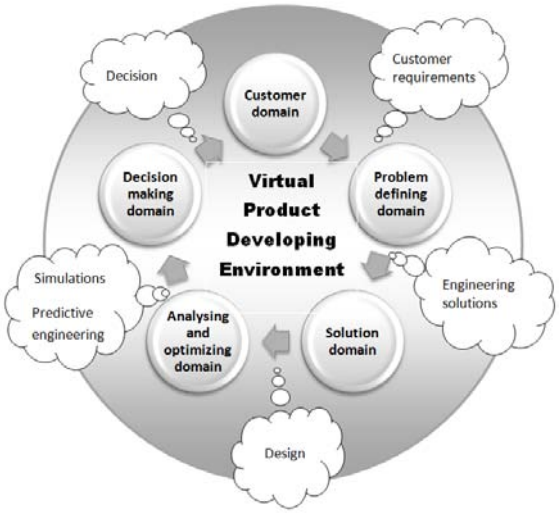

Fig. 3. Adapting Axiomatic Design methodology into Virtual product designing environment.

4. OPTIONS FOR APLYING CUSTOMER-CENTERED DESIGN

Virtual customer environments, which provide services ranging from online discussion forums to virtual design toolkits, enable firms to involve their customers in innovation and value creation from the early stage of product development project.

4.1 Current challenges in designing a VPDE

Designing sufficient VPDE seems to be a promising direction to study in order to systematically involves users into the product designing and customizing process. In order to reduce the time for product development, predictive engineering tools need to be included in virtual customer-centered environments, partitioning product-development projects into solution-information- intensive subtasks and need-information-intensive subtasks.
Virtual product creation accompanied with predictive engineering should assure low prize and short production lead time. Environments ability to predict behaviors of products as precisely as possible throughout the entire product development process would significantly enhance product readiness and quality at start of production, during lifetime customer usage and for potential reuse of product systems at lifetime end [6].
Efficient virtual product creation combined with predictive engineering requires high-capacity computing and communication technologies as well as fast and transparent supply of knowledge, information and data. For this purpose, grid technologies offer great potentials for virtual product creation. One objective of grid computing is to perform more realistic simulations for better prediction of effects with reduced costs [6].
In the last two decades, production development departments in bigger enterprises have become more and more digitalized. However, the digitalization has been almost all in the output of the department. The development itself is still done the old fashion way: sketches on paper, different possible solutions etc.
There is a production tool development underway in the Aalto University, Finland. But at this point, it is just a collection of tables that still need data on paper. In the future, e-manufacturing and virtual product development every aspect of the process should be electronic, so it can be easily documented.

4.2 Requirements for computer capacities

For virtual product design, the impact of predictive engineering is increasing

continually. This includes not only to simulate individual components of the product according to today's standard but also to process the product holistically including all relevant component and system interactions. The prediction is not limited to product characteristics and behaviors. In addition simulation of manufacturing processes is possible according to full digital factory paradigms [6]. In order to reduce the time for designing a product, decision making aids should be included. In this manner, also the need for involving engineering experts reduces [8].
However, these simulations and optimizations are rarely done because of the lack of enough compute capacities. For this purpose, grid technologies offer great potentials.

4.3 Requirements for user toolkits

With intent to make virtual customer environments easy to use, it seems to be necessary to add special toolkits in user interfaces. User toolkits for innovation are specific to given product or service type and to a specified production system. Within those general constraints, they give users real freedom to innovate, allowing them to develop their custom product via iterative trial-and-error cycle. That is, users can create a preliminary design, simulate or prototype it, evaluate its functioning in their own user environment, and then iteratively improve it until satisfied [7].

4.4 Requirements for product data sharing

Efficient product data sharing is another objective. Usually product data is not centrally managed, but distributed across different locations. With the aim of facilitating the communication between manufacturers, suppliers, engineering service providers and variant developers, the continuous and consistent availability of product and process data have to be improved. This is relevant for all stages of development.
At the moment, even in one company the data for the simulations is distributed in different information bases, e.g. PDM system, file system and material databases. The engineer has to know from where he/she retrieves the data and needs access to all of these systems. In collaboration this becomes even more complex [6].
One important focus of the research needs to be the development of a collaboration environment with an integrated simulation data management system for all data, which is necessary during the CAE processes. In order to reduce the time for designing a product and need for involving engineering experts in the process, decision making aids need to be included. This collaboration environment should also enable a transparent access to grid technologies.
A data grid can be understood as the integration of different data managing systems to supply the user with knowledge, information and data. Grid technologies offer a great potential for virtual product creation. Virtualization is the key term of future information systems. In complement to existing distributed systems, grid systems of the next generation virtualizes information and computing services by hiding technical details of the specific distributed implementation behind user interfaces [6].

5. USABILITY IN THE DIGITAL FACTORY

Product development will definitely have its place in the digital factory. Online product development has not been unified yet, but different parts of it are developing separately and very rapidly. For the past two decades, more and more of products no longer have 2D drawings but are represented as a 3D digital model. This allows for a much faster product development. Because of digital prototypes and models, companies like Boeing and

General Motors were able to reduce the product development time by 40% and 50% respectfully [10].
Traditionally companies would conduct almost all of their tests with real test specimen which is very costly. Most of the parts have to be handcrafted and usually more then one part is needed. With the development of computers plus the increased usage of digital models of parts, many tests can be conducted digitally. Of course real tests are needed to confirm the calculations, but digital modeling can cut the testing phase in half bought in time and in cost. To give an example, Boeing was able to reduce the cost of tests by 25% and General Motors by 50% thanks to digital models and digital testing [10].

6. CONCLUSION

As the need for customer-centered products increases and time for market decreases, it is necessary to engage the customers into product development process from the early stage. Depending on the field of the company, customers can be involved in the product development in different levels. Customers can customize the look of standard parts or combine different, already existing alternatives.
One promising direction to study is to use VPDE for bringing need and context-of-use information together with generic solutions. VPDE should enable managing product data (CAD, BOM, supply chain, data history ect.), help customer design a new product (AD framework, toolkits, simulation, optimization, predictive engineering) and use standard information transfer protocols (XML), applicable in e-manufacturing.

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8. REFERENCES

1. Rosted, J. *User-driven innovation*. FORA, Copenhagen, 2005.
2. Von Hippel, E. *Democratizing Innovation*. The MIT Press, Gambridge, 2005.
3. Franke, N., & Reisinger, H. *Remaining within Cluster Variance.* Working paper, Vienna, 2003.
4. Randmaa, M. *Sustainable RFID rack assembly solution for mobile robot platform manufacturing*. 8th International Symposium “Topical Problems in the Field on Electrical and Power Engineering”. Pärnu, Estionia, 2010, 198-201.
5. Lossack, R., Grabowski, H. *The axiomatic approach in the universal design theory.* Proceedings of ICAD2000 First International Conference on Axiomatic Design, Cambdridge, MA, 2000, ICAD005.
6. Stark, R; Hayka, H & Langenberg. *New potentials for virtual product creation by utilizing grid technology*. CIRP Annals- Manufacturing Technology, 2009, **58,** 143-146.
7. Von Hippel, E. *PERSPECTIVE: User toolkits for innovation.* Journal of Product Innovation Management, 2001, **18**, 247-257.
8. White, A. S; Shen, S-T & Prior, S. D. *Including design in e-manufacturing*. International Journal of Electronic Business Management, 2008, **6**, 99-105.
9. Lett, C. *User involvement competence for radical innovation*. Journal of Engineering and Technology Management, 2007, **24**, 53-75.
10. You-lun. X,. Zhou-ping. Y. *Digital manufacturing – the development direction in manufacturing technology in the 21st century.* Frontiers of Mechanical Engineering in China, 2006, 125-130.