V. Modrak
Professor
Technical University of Kosice
Faculty of Manufacturing Technologies with a seat in Presov, Presov, Slovakia

P. Krus
Professor
Linköping University
Division of Fluid and Mechatronic Systems
Department of Management and Engineering Linköping, Sweden

S.Bednar
Assistant Professor
Technical University of Kosice
Faculty of Manufacturing Technologies with a seat in Presov, Presov, Slovakia

Approaches to Product Variety Management Assuming Configuration Conflict Problem

Complexity problems in mass customized manufacturing are frequently discussed and analysed in order to find suitable methods to optimize extent of product varietes. Moreover, product designers have to consider also constraint satisfaction problem, since some serious conflicts may occur when requirements of the customer are specified based on a wide portfolio of modules or components and given configurations cannot be found. The main scope of this paper is to explore the possibilities of using axiomatic design theory and entropy based measures for quantifying product variety induced complexity. For this purpose, two approaches will be applied on a real case. Then a comparison and analysis of obtained results are included. Computational experiments showed that proposed approaches offer comparable results and can be effectively used to quantify variety-induced complexity in terms of mass-customized manufacturing.

Keywords: *information entropy, complexity, configuration, variety, axiomatic design.*

1. INTRODUCTION

Mass customization (MC) is considered to be one of the important global market strategies, by which manufacturing and service companies can increase their competitiveness and industries can ensure their long-term profitability. Today's manufacturers of customized products are confident that if they find the right balance between product variety offer and customer requirements, it will allow them to maintain or even increase market share. Recent research studies revealed that the increasing number of product variants is directly related to an increase of the number of modules integrated into these varieties of products. This fact negatively affects the complexity of the product and generates turbulences in the manufacturing systems, leading e.g. to higher direct production costs. Taking this into account, the success of MC strategy depends, apart from other factors, on the balance between product variety induced complexity and usability of mass customized manufacturing system. To solve this problem it is expected to develop efficient methods for measuring this aspect of variety (complexity). In general, marketing strategies and systems with unpredictable demand and requirements of the customers are complex. Complexity in the context of MC appeared in the literature recently and became an important problem seeking for a satisfactory solution. The main scope of this paper is to investigate the possibilities of using axiomatic design theory and entropy based measures for quantifying product variety induced complexity. For this purpose two approaches will be applied on a real case. Then a comparison and analysis of obtained results are included.

2. RELATED WORK

Many authors consider customization as a response to growing consumers' demands for tailored products. According to Coletti and Aichner [1] the concept of mass customization (MC) seeks to develop, produce, market and deliver goods and services with enough variety and customization as such, so that almost everyone finds exactly what he/she wants in affordable price. Naturally, various authors define MC as concept differently to suit different views and circumstances. The implementation of mass customization was particularly characteristic for manufacturing companies [2], [3]. However, there are many examples how this business strategy was successfully implemented in service sector [4].

Research done by Anderson [5] brought an interesting finding that the real customer strive to minimize time and effort when specifying or buying product and are actually willing-to-pay for it. Babin et al. [6] pointed out that when the purchasing activity becomes time consuming and even difficult, buyers may turn to another offer or product category as customers might be bored by the extent of variety for their product. These findings are in a line with Suh's complexity theory [7] saying that system complexity is proportional to the risk that the functional requirements cannot be satisfied. In this context, reducing the extent of product variety and complexity becomes a pertinent issue for researchers [8], [9], [10]. Matt [11] states, that despite a significant research efforts have been carried out in the area of variety management, still some focused research must be carried out in order to provide enterprises involved with MC with an effective and optimal design structure. Theoretical framework or even knowledge of complexity is definitely not widely known. According

Received: September 2015, Accepted: November 2015
Correspondence to: Prof. Vladimir Modrak
Faculty of Manufacturing Technologies, TU Kosice,
Bayerova 1, 080 01 Presov 1, Slovakia
E-mail: vladimir.modrak@tuke.sk
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to Suh [7], mass customized systems are designed without any complexity framework. His Axiomatic Design (AD) theory defines complexity as the property of a system whose satisfaction of functional requirements (FR) cannot be predicted [7]. In the context of AD, other authors [12], [13] applied so called probability of satisfying all FRs. Any customizable product has therefore a minimum set of independent requirements characterizing its functional need. Later, it was shown that Axiomatic design framework can be effectively applied not only to design of products but also to engineering and non-engineering problems [14]. Application areas of AD such as manufacturing [15], software development [16] and even decision making [17] are very often bringing new challenges. Togay et al. [18] proposed a V-Model based on the AD to address component selection issues. Lindkvist and Söderberg [19] developed a method for comparison and selection the best assembly concept alternative. The classical information theory of communication was founded in 1948 by C.E. Shannon with his paper "*A Mathematical Theory of Communication*" [20]. Suh [7] introduced it as a measure of quality in Axiomatic Design. Information theory has also been used to define complexity in software, and notably by Bansiya et al. [21] to describe complexity in object oriented systems.

Generally speaking, a small number of papers addressed variety issues in terms of MC so far. Our ambition in this paper is to propose and quantify combinatorial-based and entropic variety measures and to apply them onto the AD-based complexity in accordance with Information Axiom 2.

3. CONFIGURATION CONFLICT PROBLEM

3.1 Component concepts

In the context of MC, build-to-order and assembly-to-order concepts assume thousands of components within a production portfolio. Individual elements are either self-produced or are being delivered from global suppliers along the supply chain. In order to satisfy customers, all requirements on components (functional or design) should be fulfilled.

This brings enormous problems in the designs of product structure, in other words, the problem is a composition of the product with required and incompatible connections. To solve this problem, a rational reduction of product component types is needful.

3.2 Problem description

An important facet of product variety management in finding optimum product structure and variety is identification and solving of configuration conflict problems, known also as constraint satisfaction problem (CSP). In order to demonstrate a practical importance of this research subject, it was decided to use realistic problem situations to provide motivation for similar cases.

For this reason, an assembly model of personal computer adopted from Yang and Dong [22] has been used to identify product configurations as seen in Fig. 1. Constraint satisfaction problem (CSP) as a method is very common especially in the variety of products made by MC. CSP solution can be easily implemented and integrated within an enterprise product configurator. Once we have the best product structure design, managers can decide about the most suitable and costless product architecture.

With regards to component restrictions, there are different reasons for restrictions or obligations between two components. There may be functional, design, connection or other reasons for relation or for execution of the link between them. Besides the structural, hierarchy or aggregation restrictions, four types of configurations rules may arise [22]:

- Require rule,
- Incompatible rule,
- Port-connection rule, and
- Resource balancing rule.

Model depicted in Fig. 1 is a representation of MC assembly of personal computer consisting of five basic modules: CD-drive (1 option), HD-unit (6 individual customer option), Motherboard (MB) (3 options as MB_1, MB_2 and MB_3), CPU (586_I, 586_II, 486) and Server Operating system (OS) (OS_1 and OS_2). Case model has various customizable options depending on the customer choice but with predefined restrictions in the form of rules ($R_{1\text{-}7}$) defined in Fig. 1.

4. DETERMINATION OF PRODUCT CONFIGURATIONS

4.1 Basic concepts - preliminaries

In order to determine all possible product configurations (PC) a brief concept for classification of product components will be outlined. The framework consists of entry components that are basic elements for calculation of PCs. Component, in this context can be understood as part, module, group of products, property or other characteristic of the final product. The components are divided into three categories, stable components, voluntary optional components and compulsory optional components. Any MCA structure consists of a number of assembly stations – nodes. These can be identified within a multi-level network. Each assembly node of individual assembly operation always results with a single product, but during time the same node can produce numbers of product configurations based on the number of entry components. The single product in the downstream assembly node is considered as a stable component.

In order to formalize the three types of initial assembly components, the following notation can be used. Stable component is the obligatory initial assembly element and its number "i" is uniquely determined. Unlimited number of stable components may be further assembled with number "j" of voluntary components (VO). The selection of these components is voluntary (it is possible that $j=0$) (see simplest examples

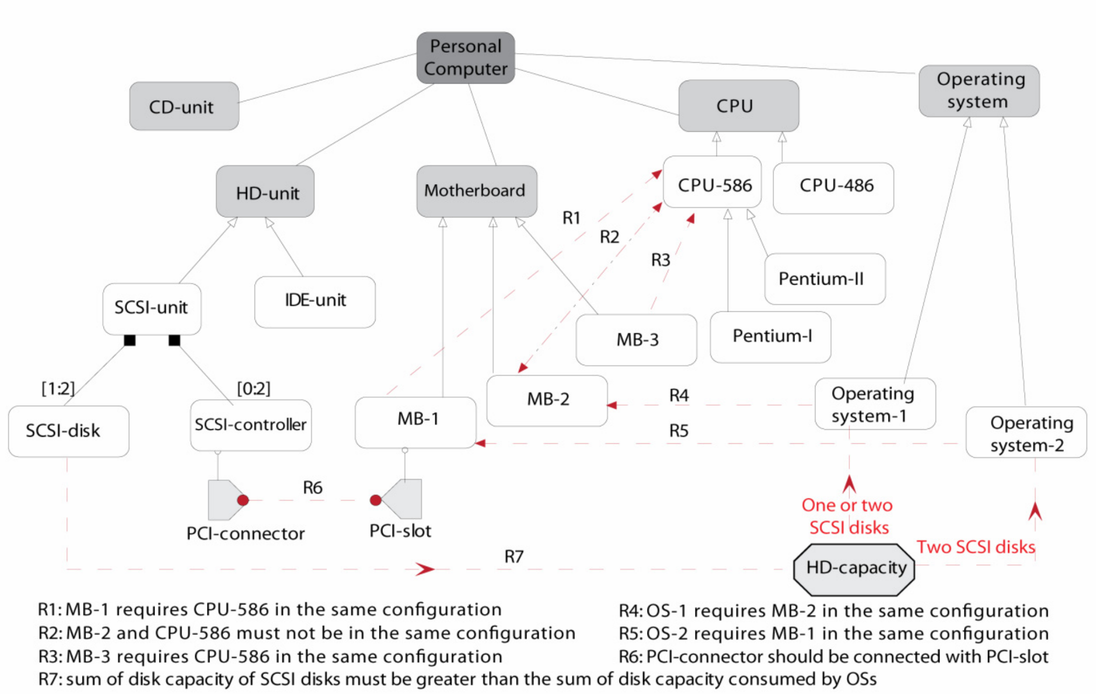


Figure 1. Case of product structure with rules for constraint satisfaction problem (adopted from [22])

in Fig. 2. Number "k" of compulsory optional components (CO) is limited in selection. They are optional, but with minimum and maximum requirements "l" on a selection by customer, where $1 \leq l < k$.

Figure 2. An example of two basic types of product components

Further individual building elements of the MCA are assembly branches of MCA assembly structure. They are important in identification and distribution of possible product configurations within assembly process. Assembly branches can be identified on the highest layer.

For those three types of initial components can be used combinatorial rules in order to calculate all possible number of product configurations. Based on this concept, company decision-makers and managers might be able to decide on the optimal product variety within the existing production structure.

4.2 Description of two possible scenarios

Framework Scenario#1: The basic precondition of any MC assembly (MCA) process is the composition of initial assembly components on entry to assembly node operation. Each such node must consist of at least one stable component and one voluntary component. The group of entry components with one stable component we denote as CL_1 (class of product configurations 1). Two product configurations arising in assembly of single stable and voluntary optional component are considered as available configuration for customer to choose from, while the choice depends on the number of voluntary components. If such a component is not selected, standard assembly is performed on the product without voluntary component. The group of entry components with one optional component we denote as SCL_1 (sub-class of product configurations 1). Such an assembly (CL_1 SCL_1) is in terms of Framework Scenario #1 (FS#1) considered as MCA since basic precondition for such manufacturing strategy has been met.

As it was already presented, FS#1 consists of only stable and of voluntary components, starting with single stable component, and growing number of voluntary optional components. This way, numbers of available product configurations and variations have been determined by Modrak et al. [23] for each relevant initial component setups in a systematic manner according to classes and sub-classes of product configurations.

Furthermore, our previous research works [24], [25] proved that from practical and application standpoint, available product configurations are much more relevant than related number of product variations.

Framework Scenario#2: In order to develop the realistic MCA concept and to employ all necessary elements of MCA, FS#2 has been proposed while taking all theoretical assumptions and preconditions into account. The FS#2 identifies the same numbers of product configurations (without product variations due to their low relevance) within a system of stable, voluntary optional and new – compulsory optional components. Existing rules for generation of all possible product configurations have therefore been extended with rules regarding the conditions for selection from compulsory optional components, which can be expressed according to combinatorial number such that (unlike permutations) the order of selection does not matter.

Focus remains on the growing product variety (number of product configurations) and/or variety induced complexity.

The above presented FS#2 in shows that it is possible to combine practically any class and sub-class with unlimited numbers of VO and CO components. But for the set of CO components with number k, there are three different rules of the selection when identifying product configurations. They are:

- Individual selectivity rule - we may define exact number of „*l*“ of components to be chosen from all „*k*“ of CO components, or

- Maximum selectivity rule - we may define the maximum number „*l*" of CO components to combine within an assembly choice of all „*k*“ of CO components (note that „*l*“ is max. *k-1*), or finally

- Minimum selectivity rule – we may choose / combine at least „*l*“ CO of components from available „*k*“ of CO components (note that „*l*“ is min. 1).

The above presented FS#2 is different from our previously published works as it takes individual selectivity rule into account and identifies available product configurations accordingly.

4.3 Determining total model configurations accepting rules and restrictions

At first, it is useful to start with determination of HD-unit configuration options for customers for case in Fig. 1. Applying simple combinatorial rules, then we obtain six possible HD-unit configurations as allowed combinations of HD components. The components are as follows: HD unit consisting of only IDE-unit, HD-unit with SCSI disk, and SCSI controllers (see model of these combinations in Fig. 3). If SCSI–disk is chosen by the customer, then Rule 7 -resource balancing rule is applied and one or two disks must be selected depending on the Operating system OS_1 or OS_2 (see Fig. 1). Conditions for the disks are that at least one and maximum two disks can be selected. At the same time, selection of SCSI controller is possible, such that one or two controllers may by mount according to SCSI disk selection. No controller selection is also possible with SCSI disks (see configurations 2. and 3. in Fig. 3 below).

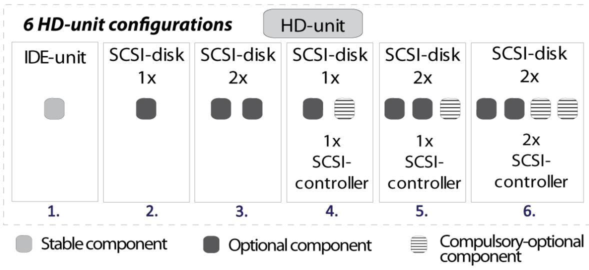


Figure 3. Model of six possible combinations of HD units

Subsequently, it is possible to continue in determining total model configurations. Understandably, there are different ways to enumerate and depict all possible personal computer configurations as component combinations. Rules $R_{1\text{-}7}$ are fully taken into account. The following Fig. 4 depicts one way to identify all possible restrictions and component conflicts (functional or design conflicts). In this figure, available personal computer case model configurations have been divided into six groups according to HD-unit options in Fig. 3 above. Subsequently, all required and restricted rules have been addressed.

The model offers this number of restricted configurations:

$$\sum Conf_{C1} = 5+5+5+2+2+2 = 21 . \qquad (1)$$

4.4 Determining total model configurations without rules and restrictions

In order to provide a relevant benchmarking of the entropy-based variety measures, summary amount of available configurations not respecting the rules $R_{1\text{-}7}$ can be also determined. Here, higher number of personal computer configurations is expected due to less functional and design restrictions.

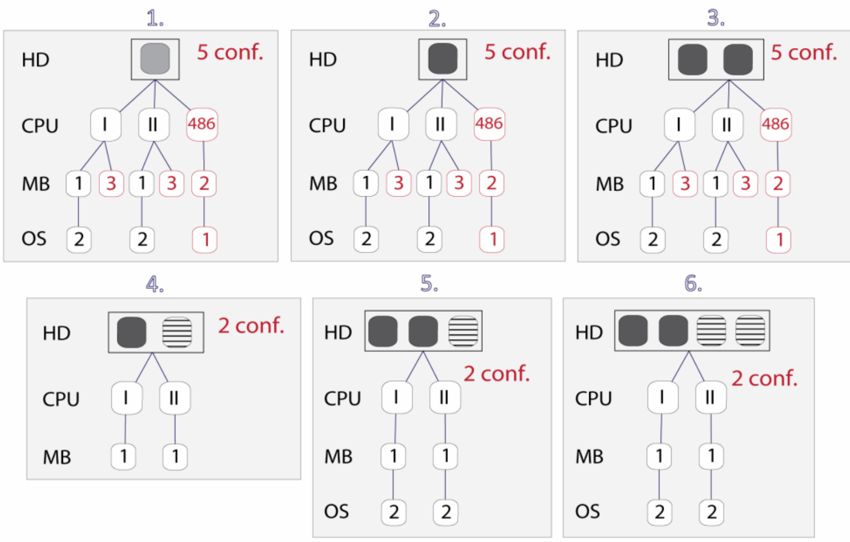


Figure 4. Model of 21 possible product configurations respecting configuration rules

The division of the personal computer options is based on the division in Fig. 1, so all possible CD-drive options (1 possible configuration) can be combined with all possible HD-unit options (6 configurations), then with Motherboard (3 configurations), CPU (3 configurations) and Operating system options (2 system configurations). Finally, the summary value of all available personal computer customer options would be as follows:

$$\sum Conf_{X1} = 1*6*3*3*2 = 108 . \quad (2)$$

4.5 Determining configuration options of optimized component structure design

In order to catch the effect of design optimization with regards to waste entropy, an execution of selected component must be performed on the case model. Such component is then not part of the model variety anymore. All previously identified product configurations will not include this component.

For this reason, e.g. one of motherboards, namely Motherboad_2 has been selected for execution in the first step. Then, total number of model configurations can be determined accepting the rules and restrictions. The number of available restricted product configurations will decrease. Excess entropy defined by Krus [26] might be also decreased, and should be completely avoided.

As seen in Fig. 4, component MB_2 (in red) is executed, which results in reduction of exactly three personal computer configurations. The number of available restricted configurations is then 18:

$$\sum Conf_{C2} = 5+5+5+2+2+2 = 18 . \quad (3)$$

The execution of the MB_2 has been performed for the identification of product configurations when rules R_{1-7} are not taken in to account. Under this consideration, we refer to the Section 4.4 where 108 configurations have been identified. Configurations with MB_2 are not counted, and then the number of product alternatives decreased to 72, as follows:

$$\sum Conf_{X2} = 1*6*2*3*2 = 72 . \quad (4)$$

4.6 Total model configurations without MB_2 not accepting rules and restrictions

In order to present and describe decreasing trend of available product configurations of the model in Fig. 1, other two components have been withdrawn from a range of components.

Such elimination of selected components results with further decrease in number of total available and restricted product configurations.

For the second case product portfolio elimination, CPU486 and all related configurations have been withdrawn for selection. We then obtained 48 configurations in total and restricted product configurations remained at value 18, since no computer can operate without a motherboard.

The last elimination of the product structure removes also MB_3 and all related configurations. In summary we obtain 24 non-restricted and only 12 configurations respecting configuration rules R_{1-7}.

5. THE ADOPTION OF INFORMATION THEORY FOR DESIGN SOLUTION

5.1 Design space for modular design

The classical information theory of communication was founded in 1948 by C.E. Shannon [20]. Subsequently it has been recognized that information is a key property of design, and for describing and analyzing the design process. The notion of information is used in the second axiom of N.P. Suh´s Axiomatic design, which states that the information content in a design should be minimized. Design information entropy can also be used as a measure of information needed to define a particular design relative to a design space [26]. The definition of the Information entropy for n discrete states with probabilities P_i has been defined by Shannon as follows [20]:

$$H = \sum_{i=1}^{n} P_i \log_2 P_i . \quad (5)$$

Here the system can be in n different states with probabilities p_i for each of them. In case of the general multivariable case, entropy of the design can be expressed as follows [26]:

$$H = \log_2 \frac{S}{s} . \quad (6)$$

where S is the size of the design space and s the region of uncertainty for the final design.

In fact, the introduction of standardized components means that a much smaller design space is needed to create useful design, since large design spaces for the individual component are effectively removed. In addition to design information, it is here useful also to introduce information entropy to describe the diversity in the functional space. The simplest would be a simple function of the number of different product variants n_v (with different functional characteristics).

$$H = \log_2 n_v . \quad (7)$$

where n_v is the number of available configurations within a model.

One useful measure for the quality of a modular design would be the relative size of the part of the design space that is outside the constrained design space. That can be formulated as wasted design information entropy H_w as:

$$H_W = H_X - H_C . \quad (8)$$

where H_X is the entropy of the design space, and H_C is the constrained design space.

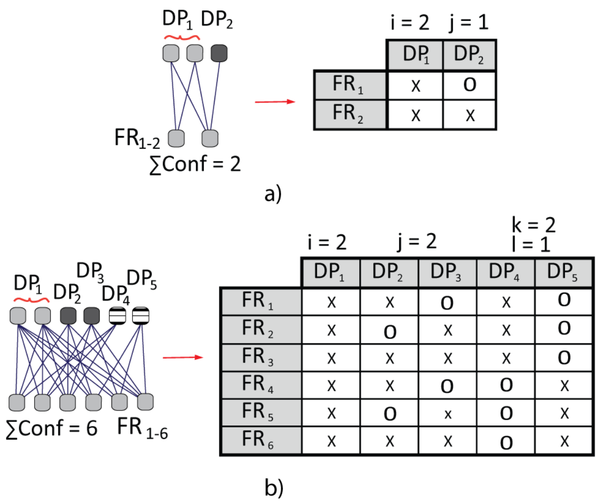
5.2 Design solutions by the use of Axiomatic design theory

In order to apply the complexity measure of the case design solution of personal computer assembly and for quantification of product variety induced complexity, we firstly need to describe the way to transform combinatorial complexity as the sum of product configurations into an axiomatic design matrices.

According to Axiomatic design definition [7], design process is present in four main domains: customer, physical, process and functional. After several iterations, design process transforms customer needs into functional requirements (*FR*) and constraints, which are later transformed into design parameters (DP). Within a design hierarchy, the dependencies between the FRs and DP can be represented by the following equation:

$$FR = [A]DP \,. \tag{9}$$

where each element of the matrix [*A*] can be expressed as *A=FR/DP* meaning that each DP affects its associated FR e.g., $A_{11}=X$ indicates that DP_1 affects FR_1. Equation 9 can be understood as choosing the right set of DPs to satisfy given FRs. Therefore each *A* element of the matrix indicates dependency of FR on DP. If the value of any element *A* refers to „*0*" then FR does not depend on the DP, and vice versa for „*X*". In our approach we are able to transform each possible individual non-modular assembly structure, or architectural design into such design matrix as shown in Fig. 5(a) and 5(b). Example of the design matrices for product classes CL_2 SCL^0_1 and CL_2 SCL^2_2 presents a way to transform any assembly node as dependency of FR on DP.



	DP1	DP2
FR1	x	o
FR2	x	x

	DP1	DP2	DP3	DP4	DP5
FR1	x	x	o	x	o
FR2	x	o	x	x	o
FR3	x	x	x	x	o
FR4	x	x	o	o	x
FR5	x	o	x	o	x
FR6	x	x	x	o	x

Figure 5. An example of transformation of possible customer choices into AD matrices (a) for two types of components; (b) for three types of components

Obtained design matrices represent coupled designs, for which is characteristic that matrix contains mostly non-zero elements and thus the FRs cannot be satisfied independently.

5.3 Adoption of the concept of entropy and disorder to quantify product variety induced complexity

According to Martin et al. [27], the concepts of entropy and disorder are inherently linked, but disorder is only a metaphor for entropy, not the definition.

Guenov [28] introduced a complexity indicator for architectural design, which is relatively simple and easy to apply, and it is sufficiently accurate for the early stages of systems design. The indicator, denoted by authors as Systems Design Complexity (SDC) is expressed in bits as follows:

$$SDC = \sum Nj \ln Nj \,. \tag{10}$$

where the volume is assumed equal to unity and „N_j„ is interpreted as number of interactions per single DP of measured designed matrix.

Compared to (7) this definition considers that different solutions do not require the same amount of information. I.e. the final solution does not have to be specified with the same precision. This is to say that the final design space *s* can be larger in (6) relative to initial design space *S*.

5.4 Verifying the proposed entropy measures

After the identification of all personal computer modelled options before and after components withdrawal respecting and not respecting configuration rules, calculation of entropies described in Sections 5.1 and 5.2 can be performed on case assembly in Fig. 5(a) and 5(b).

While in case (a), we obtained exactly 2 product configurations, here Equation 7 is applied:

$$H_a = \log_2 n_v = \log_2 2 = 1bit \tag{11}$$

Entropy always equals 1 in case of 2 options which is in compliance with statement of Coletti and Aichner [1] about coin toss. AD-based entropy for the case in Fig. 5(a) applies Equation 10 as follows:

$$SDC_a = \sum Nj \ln Nj = 2\ \ln 2 + 1\ \ln 1 = 1{,}386\, nats \tag{12}$$

The same quantification can be applied for case in Fig. 5(b) with 6 possible customer options or configurations applying Equations 7 and 10:

$$H_b = \log_2 n_v = \log_2 2 = 1bit \tag{13}$$

$$SDC_a = \sum Nj \ln Nj = 6\ \ln 6 + 4\ \ln 4 + 4\ \ln 4 + 3\ \ln 3 + 3\ \ln 3 = 28{,}433\, nats \tag{14}$$

Both entropy based methods are applicable in terms of hierarchical design structures at MC. They may now be applied for determination of waste entropy of the case model of this paper in Fig. 1.

6. EXPRESSING WASTE ENTROPY OF THE CASE MODEL

In the final step, case model of MC assembly of computers will become a subject to entropy quantification. Two individual approaches will determine level of entropy for the system before optimization and after execution of single components, as presented in Sub-section 4.6. Thus, we will further benchmark the two approaches to catch the effect of configuration conflict on waste entropy. For this purpose, we will compare these two approaches against relative number of infeasible configurations.

As seen in Table 1, approach based on Shannon's entropy returns values of H_x=6,75 bits for 108 configurations and H_C=4,39 bits for 25 originally restricted configurations. The amount of waste entropy

Table 1. Computational results of waste entropy for different numbers of product configurations

Approach	Indicator	Before reduction of components	After withdrawal of MB_2	After withdrawal of MB_2, CPU486	After withdrawal of MB_2, CPU486, MB_3
Design space-based approach	Entropy of design space (*without constraints*)	$H_x=\log_2 n_v$ [bit] $n_v=108$ $H_x=6,75$ bits	$H_x=\log_2 n_v$ [bit] $n_v=72$ $H_x=6,2$ bits	$H_x=\log_2 n_v$ [bit] $n_v=48$ $H_x=5,58$ bits	$H_x=\log_2 n_v$ [bit] $n_v=24$ $H_x=4,58$ bits
	Entropy of constrained design space	$H_C=\log_2 n_v$ [bit] $n_v=21$ $H_C=4,39$ bits	$H_C=\log_2 n_v$ [bit] $n_v=18$ $H_C=4,17$ bits	$H_C=\log_2 n_v$ [bit] $n_v=18$ $H_C=4,17$ bits	$H_C=\log_2 n_v$ [bit] $n_v=12$ $H_C=3,58$ bits
	Waste entropy	$H_w=H_x-H_c=2,36$ bits	$H_w=H_x-H_c=2,03$ bits	$H_w=H_x-H_c=1,4$ bit	$H_w=H_x-H_c=1$ bit
	Waste entropy ratio	$H_w/H_x=34,9\%$	$H_w/H_x=32,7\%$	$H_w/H_x=25,3\%$	$H_w/H_x=21,7\%$
AD-based approach	SDC of desing space (*without contraints*)	$SDC_x=2650,4$ nats	$SDC_x=1616,1$ nats	$SDC_x=976,8$ nats	$SDC_x=402,5$ nats
	SDC of constrained design space	$SDC_C=266,0$ nats	$SDC_C=227,8$ nats	$SDC_C=227,8$ nats	$SDC_C=152,9$ nats
	Waste SDC	$SDC_w=SDC_x-SDC_c=2384,4$	$SDC_w=SDC_x-SDC_c=1388,3$	$SDC_w=SDC_x-SDC_c=749,0$	$SDC_w=SDC_x-SDC_c=249,6$
	Waste SDC ratio	$SDC_w/SDC_x=90,0\%$	$SDC_w/SDC_x=85,9\%$	$SDC_w/SDC_x=76,7\%$	$SDC_w/SDC_x=62,0\%$
Absolute configuration number-based approach	All possible number of configurations (*without contraints*)	*108 conf.*	*72 conf.*	*48 conf.*	*24 conf.*
	Feasible product configurations (*assuming contraints*)	*21 conf.*	*18 conf.*	*18 conf.*	*12 conf.*
	Relative number of infeasible product configurations	80,6%	75,0%	62,5%	50,0%

decreased from 2,36 bits to 2,03 bits after execution of component MB_2. A ration of waste entropy H_W/H_X decreased from 34,9% to 32,7%. Other calculation results are available in Tab. 1.

This amount and behaviour of waste entropy is also visible in the approach based on SDC measure. Axiomatic design-based measure SDC indicates that the ration of waste entropy H_W/H_X is higher and decreased from 90% to 85,9%.

7. CONCLUSIONS

Effective and accurate execution of low-selling components may bring huge decrease of waste entropy as well as infeasible configurations within product design structures as can be seen in Table 1, where CPU_486 and MB_3 have been eliminated in the second and third run.

Thus, we can preliminarily state, that both entropy indicators can be effectively used for measurements of variety induced complexity of MC product designs and bring more-less comparable results as the relative number of infeasible product configurations.

Our research also proved the above mentioned statement in the Section 2 „system complexity is proportional to the risk that the functional requirements cannot be satisfied" is not only theoretically pronounced but it is highly practical and advisable.

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ПРИСТУПИ УПРАВЉАЊУ ВАРИЈАНТНОСТИ ПРОИЗВОДА СА ПРЕТПОСТАВКОМ ПРОБЛЕМА КОНФЛИКТА У КОНФИГУРАЦИЈИ

В. Модрак, П. Крус, С. Беднар

Проблеми комплексности у производњи типа "масовне индивидуализације" према индивидуалним захтевима купаца се често разматрају и анализирају у циљу изналажења погодних метода за оптимизацију обима варијантности производа. Осим тога, пројектанти производа морају да имају у виду и проблеме задовољења ограничења, јер се могу појавити озбиљни конфликти када се захтеви купца одређују на основу великог портфолија модула или компонената и када се дате конфигурације не могу пронаћи. Главни домен рада је да се истраживање могућности коришћења аксиоматске теорије пројектовања и мера заснованих на ентропији за квантификацију комплексности индуковану варијантношћу производа. У том циљу биће примењена два приступа на реалним случајевима. Затим ће бити приказано поређење и анализа добијених резултата. Компјутерски изведени експерименти показују да предложени приступи нуде упоредиве резултате и да се могу ефективно искористити за квантификовање комплексности индуковане варијантношћу производа са аспекта производње типа "масовне индивидуализације" према индивидуалним захтевима купаца.