Adaptive organization design based on system integration

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Abstract: During the task of projecting an adaptive organizational system whose required output value we know (for instance, a minimized overall loss of a system), we use the method referred to as the integration of subsystems into a control structure. As the suggestion content of this contribution is an application of adaptive system into the area of organizational arrangement of resources, it is primarily necessary to define the elements of this system. The objective of this paper is, consequently, to create, on the basis of system organization of adaptive systems, a methodology for projecting the adaptive organizational systems. Any control and adaptive organizational model could be included into the response of the environment of all situational phenomena or factors which determine or influence the characteristics of an organizational and control system and consequently, in its results, influence an output from the system.

Key words: adaptive organization, system integration, feed-back, organizational optimization

This paper is closely related to the paper entitled "Determination of management capacity", published in the Agrarian Perspectives 2009, 54: 49–55. The paper derives from the working and publication activities from research projects of the MSM 6046070904 and the GACR 11140/1411/114105 focused on Module TM 10 – Knowledge-Based systems Design. There were several themes solved and published in terms of this research projects (besides those in the Agrarian Perspectives proceedings). The initial work was regarding the classification of the factors of organizational systems (represented by the paper "Ontogenesis – Based Organization of Knowledge" Hron 2008), in terms of the above-mentioned project, and the principles of designing organizational systems (represented by the paper "Design of the Diversification Classifier for Agricultural Entrepreneurs Activities", Hron et al. 2009). The claims of the development of a new contemporary process were implicit from that initial classification. These new processes concentrate on the optimisation of the food production control (in analytical and also in set forms) – "Control of Food Products´ Quality" (Hron and Macák 2009). Regarding the present control systems or managerial systems, it is necessary to consider a common attribute of a typical real system – although its output is not always reliably obtained. This was published in a paper regarding the formalised organisational and control diagnostics ("Forecast of Demand trough the Differential Description of their Effects", Hron and Macák 2010). A practical utilization of the basic research outputs is summarized in the monography "Creating consumer value, through control of product quality and uniqueness of product design" (Macak 2010).

Enterprises experienced significant technological and managerial changes over the last decades. The changes have been forced by various events: global competition, workforce changes, new technology, and continuously changing customers' preferences. Enterprises must harmonize their structure and deal with the competition in an increasingly complex and vaguely understood business environment (Temponi 1999). A business organization is considered a society with growth, differentiation, hierarchical order, controls, competition, communications, relationships, etc. The business organization or enterprise is viewed as a socio-cultural system (Von Bertalanty 1968). Managers and leaders should view organizations as flexible work groups with information flow across the business functions, instead of vertically arranged discrete functions with well-defined boundaries Kim (2002) indicated that modelling of organizations in the context of a system involves many difficulties.

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These following problems are given most often in connection with the modelling of organizations in the context of a system:

– Enterprise structures have complex dynamics. Companies are organized by products, processes, hierarchical structures, matrix structures, or hybrids (Malone and Crowston 1999).
– Variables to assess the performance in organizations are difficult to identify and measure, and often they are clouded by the employee and management emotions (Evans and Lindsay 2005).
– The relations between the enterprise components are difficult to identify and quantify. Descriptions are usually qualitative and subjective (Srinivasan et al. 2000).

In the transition from a Newtonian paradigm of control and the equilibrium to one of chaos and disequilibrium, organizations have substantially changed their structures (e.g., moving to the diverse project-based teams, advancing knowledge management, and building innovative cultures), but they have only minimally changed their leadership styles and practices (Tetenbaum and Laurence 2011). The research approach to this Newtonian paradigm of control and equilibrium could be theoretically based on the combined application of control theory, operations research, and agent-based modelling (Ivanov and Sokolov 2010). Another possibility how to model the business decisive processes is the possibility to use the fuzzy logic access (Chen and Wang 2010). Originally, the term "adaptive" signified the quality of a living substance to adapt its behaviour to the changes of the influences of the environment. At the same time, it was observed that each adaptation, as a necessary reaction of the organism to new parameters of the environment. will cause a certain loss which is being increased by repeating the process of adaptation (nevertheless, the rise of a loss does not need to increase) (Cernuzzi and Zambonelli 2011). At the situation when a living substance is not capable of further adaptation (for instance, as a result of the non-existence of resources necessary for covering the adaptations of an originated loss), it consequently disappears. The adaptation, however, does not occur during all manifestations of the environment but only in the case when there is a causal relationship between the responses of the environment and a system loss. This means that, in general, the adaptation is not only useless but also undesirable if the change of parameters of the environment does no cause a system loss (that is, there is no causal relationship between the environment and the loss of the system). That is why the main purpose of any adaptation is minimizing of the overall loss of the system. The adaptation of a system is not practicable, however, whenever there is a need for its realization owing to a rising loss of a system. For the proper function of an adaptive learning system, it is necessary that this system fulfils both the conditions stated bellow (Natter and Mild 2001):

(1) system can change the state of its elements or its structure;
(2) we can influence the state of the system or the output from the system.

OBJECTIVES AND METHODOLOGY

During the task of projecting an adaptive organizational system whose required output value we know (for instance, a minimized overall loss of a system), we use the method referred to as the integration of subsystems into a control structure. As the suggestion content of this contribution is an application of adaptive system into the area of organizational arrangement of resources, it is primarily necessary to define the elements of this system. The objective of this paper is, consequently, to create, on the basis of system organization of adaptive systems, a methodology for projecting the adaptive organizational systems. Any control and adaptive organizational model could be included into the response of the environment of all situational phenomena or factors which determine or influence the characteristics of an organizational and control system and consequently, in its results, influence the output from the system. In other words, time differences of the environment responses cause a spontaneous change of the parameters of influences of the environment (not influenced by the output from the system), as a result which is necessary to modify the behaviour of a learning organizational system. If we kept the conventional marking for the controlled (required) quantity – $\boldsymbol{w}$, and $\boldsymbol{y}$ – for the real output quantity and for the responses of the environment – $\boldsymbol{v}$, we can formulate an adaptive organization in an axiomatic-deductive way. An organizational system is adaptive if:

(1) There is an aggregate of responses of the environment in which the organization is situated $\Omega(v)$
(2) There is an aggregate of pieces of information (aims) about the required behaviour of the organization $\Omega(v)$
(3) There is an aggregate of the (actually reached) output values $\Omega(v)$
(4) And besides these quantities there is an aggregate of decision rules (relations between elements of a system) $\Omega(r)$. These rules have the following specifics: $y = r(v, \alpha)$ where the value of the output

y is determined by a change of the environment of ***v*** and a change of parameters of the system α, whereas the rules ***r*** create relations between the environment and the system.

(5) If the so-called "loss fiction" is defined as: $z = f(v, w, \alpha)$, then the adaptive organization is such a system which, from the aggregate of admissible parameters of the system, seeks for such ones to conform to the target function: $z(v, w, \alpha) \approx MIN$!

The adaptive learning organization receives the information ***w*** of how to behave in relation to the given responses of the environment ***v***. Then it compares the required behaviour ***w*** to the real response of the organization ***y*** to the given responses of the environment ***v*** and tries to minimize the loss function $z(v, w, \alpha)$. This minimization is realized by a suitable change of the parameters of the system α for such a long time until it reaches the minimum of the loss function ***z*** . This formulation results from the requirements of the practice for management of an organization or its organizational units, when these are the scores of time necessary to manage the organizations with an incomplete knowledge of an organizational and control systems and, at the same time, it is required that, after a certain time of "learning", the management as well as the organizational set up may be optimal or close to optimal. The adaptive organization characterized above may be graphically displayed with the assistance of a block diagram in Figure 1.

There can be formulated a task of projecting the adaptive organizational system with the use of systemic integration after a theoretical presentation of methodology. As an illustration, let us suppose that we are able to express the influence of the manifestation of the environment in an aggregated form. This would be possible providing that every partial influence of the environment is a linear function of its value and of a relevant parameter of its weighting function. Under this condition, we can, with the use of the principle of superposition, find out these influences separately from the others and to determine their relevant values, sum them up (to find out the overall (aggregated) influence) with the other influences (Bryant and Temponi 2009) . In the following Table 1, there are presented partial influences for determining the overall influence of the environment and the corresponding regulated quantities (project parameters of a structure).

In terms of preserving the organizational stability, the regulation should be focussed on the attenuation of a control deviation ***e*** between an input value of the manifestation of the environment ***v*** and an output setting of the project parameters α. The control deviation ***e***, nevertheless, equals to the difference between the required value represented by the aggregation of the manifestations of the environment $\sum_{i=1}^{n} v_i \times h_i$ and

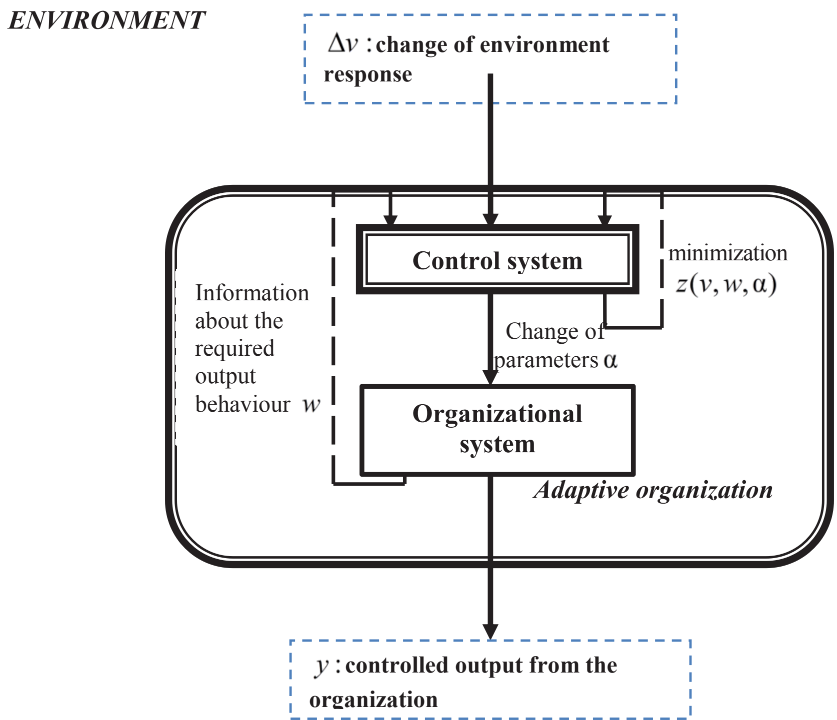

Figure 1. Illustration of adaptive organization principle

Table 1. Partial situational influences and partial project parameters of the Alcan Packaging Ltd. organizational structure

Category	Manifestation of environment			Organizational parameter setting		
Partial manifestation or parameter	dynamicity	complexity	non-isolation	organical nature	decentralization	non-persistence
Manifestation intensity $\in \langle 0,1 \rangle$	v_1 0.75	v_2 0.25	v_3 0.25	α_1 1.00	α_2 0.75	α_3 1.00
Weighting function $h_{i,j} \in \langle 0,1 \rangle$	0.30	0.40	0.30	0.40	0.30	0.30
Aggregated value	$\sum_{i=1}^{3} v_i \times h_i = 0.400$			$\sum_{j=1}^{3} \alpha_j \times h_j = 0.925$		

the real (regulated) quantity, represented here by aggregation of the organizational setting $\sum_{j=1}^{m} \alpha_j \times h_j$.

$$e = \sum_{i=1}^{n} v_i \times h_i - \sum_{j=1}^{m} \alpha_j \times h_j = 0.400 - 0.925 = -0.525 \quad (1)$$

It is obvious that the regulation of the organization is performed by an efficient suggestion of the setting of individual parameters α_j, that is why in the equation (1) we will notice the sums of products α_j h_j. If we transcribe these products $\alpha_j \times h_j$ by the substitution of values from Table 1 and require the minimization of the control deviation, that is $\boldsymbol{e} = 0$, we receive:

$$e = 0 \Rightarrow \sum_{i=1}^{n} v_i \times h_i = \sum_{j=1}^{m} \alpha_j \times h_j = 0.4 = \alpha_1 \times h_1 + \alpha_2 \times h_2 + $$
$$+ \alpha_3 \times h_3 = \alpha_1 \times 0.4 + \alpha_2 \times 0.3 + \alpha_3 \times 0.3 \quad (2)$$

It is obvious from the equation (2) that one (any) of the parameters α_1, α_2, α_3 is linearly dependent on the other two. Let us choose, for instance, a variable parameter α_1, that is: $\alpha_1 = f(\alpha_2, \alpha_3)$. Then the formula (2) will be modified into the form:

$$\alpha_1(\alpha_2, \alpha_3) = 1 - 0.75 \times (\alpha_2 + \alpha_3) \quad (3)$$

In a similar way, we could choose also the other two variables as dependent on the remaining two variables, which is:

$$\alpha_2(\alpha_1, \alpha_3) = \frac{4}{3} - \left(\frac{4}{3} \times \alpha_2 + \alpha_3 \right) \quad (4)$$

$$\alpha_3(\alpha_1, \alpha_2) = \frac{4}{3} - \left(\frac{4}{3} \times \alpha_1 + \alpha_2 \right) \quad (5)$$

To find the admissible values of parameters α_j in the organization, we have opted in the introduction for the equation (3). Further, we know a definition scope of the values of every parameter α_1, α_2, α_3 which is formed by an interval of values from the minimal value possible 0 up to the maximal value possible 1:

$$\alpha_1 \in \langle 0,1 \rangle \quad (6)$$

$$\alpha_2 \in \langle 0,1 \rangle \quad (7)$$

$$\alpha_3 \in \langle 0,1 \rangle \quad (8)$$

By connecting the relations (3) and (6), we receive an area of solutions which are suitable for the parameter α_1. This area of solving the parameter α_1 can be marked, for instance, as $\Omega(\alpha_1)$. The area of solution $\Omega(\alpha_1)$ will be found out in conformity with the synthesis of (3) and (6) during the resolution of the inequality:

$$0 \leq 1 - 0.75 \times (\alpha_2 + \alpha_3) \leq 1 \quad (9)$$

Besides the synthesis of the relations (3) and (6), we can synthesize the definition scopes of parameters α_2 and α_3, consequently, the formulas (7) and (8) and create in this way an area of solutions of these parameters. This area of mutual solutions α_2 together with α_3 can be called $\Omega(\alpha_{2,3})$. Graphically, this method is displayed in Figure 2.

In Figure 2, the area marked $\Omega(\alpha)$ represents an aggregate of the admissible settings of parameters α_1, α_2, α_3 such ones for which the conditions of stability of an adaptive task are fulfilled. This area was created as an intersection of the aggregate of solution of the parameter α_1, that is the area $\Omega(1)$, with the aggregate of the solution of the parameters α_2, α_3 that is the area $\Omega(\alpha_{2,3})$. This area of admissible parametric settings $\Omega(\alpha_{2,3})$ is represented geometrically by a polygon with the vertexes of coordinates of:

$$PP_2, PP_3]: \quad \{ [0,0], [0,1], [\tfrac{1}{3},1], [1,\tfrac{1}{3}], [1,0] \} \quad (10)$$

The aggregate $\Omega(\alpha)$ presented in Figure 2 expresses all possibilities of parametric setting of the organization for which the zero control deviation will be $\boldsymbol{e} = 0$. Each of these settings, however, does not lead to the same value of the loss function $z(v, w, \alpha)$. The aim of the perfective phase is to find out such setting of parameters of the organization, during which a minimal value of loss function will be achieved. Neither the manifestations of the environment $\Omega(v)$ nor the

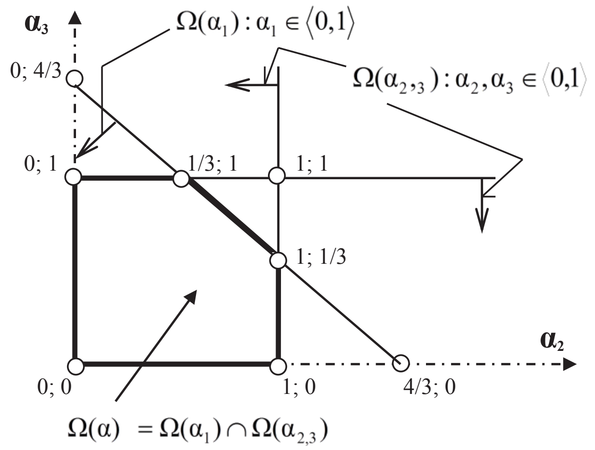

Figure 2. Area of admissible settings of organizational parameters of the adaptive system at the Alcan Packaging Ltd.

required behaviour $\Omega(w)$ can be directly regulated; there remains the option of setting the parameters α. The evaluation of differences between the real and the required properties is, after a prior determination of an admissible aggregate $\Omega(\alpha)$ *p*, realized by measuring of an auxiliary (indirect) quantity – loss function. This loss function consequently measures, in an indirect way, the effectiveness of parametric setting. This effectiveness will grow with athe decreasing progress of the loss function. Recognition of the progress of the loss function is designed with the use of the integration between two separate systems (for instance, planning and organizational ones). The desirable interaction of these systems is ensured by the means of the already mentioned integration. This integration is schematically described in Figure 3 by the means of meeting three necessary conditions of the origin of interaction between the above stated systems. For the practical interpretation (or realization), there are switching contacts inserted into the scheme of Figure 3 which represent the technical side of the realization of the interconnection of model cooperation.

In Figure 3, the planning system (e.g., for the prediction of revenues) is marked as M1 and the model of adaptive organization is marked as M2. To achieve a desirable interaction between both systems, it is necessary to reply positively to three questions:

(1) Is the value of the real achievement distinct for more than is the permitted deviation?

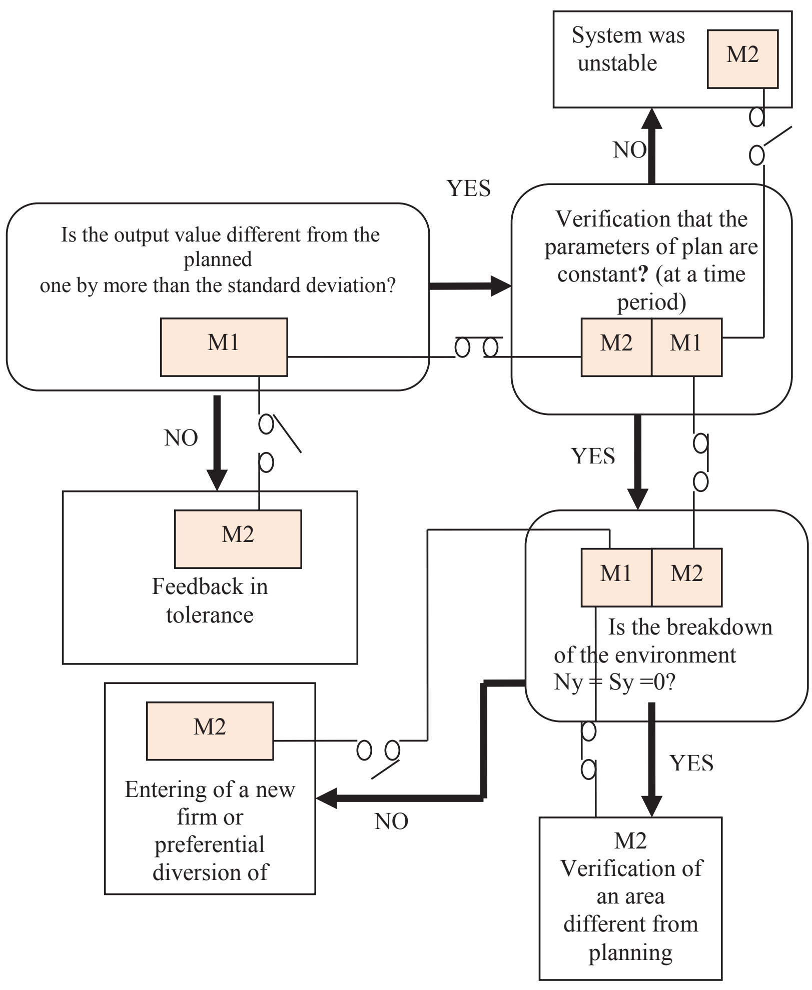

Figure 3. Integration of planning system with a model of adaptive organization at Alcan Packaging Ltd.

(2) Did the particular parameters of influences v_i behave like quasi-constants during the period under consideration?

(3) Did a breakdown of the environment occur during the period under consideration (e.g., preferential diversion of customers, entering of a new competitor, etc.)?

Positive answering of all these three questions represents a necessary condition of the interaction of the integrated systems for planning and adaptive organization of resources. Besides the relations of the inevitable conditions of connectivity of these systems (relations of conditions are represented by arrows), Figure 3 is accompanied by switching and release contacts. These contacts illustrate the mechanism of integration of these two systems. Individual conditions, which must be fulfilled, are connected in the series in the sense from the first system M1 (for planning) to the second one M2 (for adaptive optimization of organizational structure). In case the question is positively answered, there is a switching contact connected between the models, in case of a negative answer, there is a release contact. Individual conditions are connected in the seriatim fashion, they create, consequently, a conjunctional bond. For this reason, a purposeful interaction of these systems is practicable only in the situation when all the contacts are connected.

Based of this interaction between the planning and organizational systems, we can measure indirectly the change of the loss function. This loss function could practically be defined as a financial value of the increase of the error rate (scrap) from which we deduct the change of the value of overproduction owing to a higher productivity of the production process.

$$\Delta Z_i = p_{Zi} \times q_{Zi} - p_{pi} \times q_{Pi} \qquad (11)$$

where: p_{Zi} resp. p_{pi} is an average value of the false output (scrap) resp. the complete overproduct in ***i*** learning period, q_{Zi} is the amount of scraps in ***i*** learning period and q_{pi} is the amount of the complete overproduct in ***i*** learning period.

Figure 4 characterizes the procedure for finding the setting of the operational quantity represented by the values of parameters α_1, α_2, α_3 under the condition that there happened a purposeful integration between the planned system and the system of adaptive organization. For the final setting of parameters represented by the point A_4, it is primarily necessary in the aggregate of the admissible setting to assess $\Omega(\alpha)$ the values of the loss function (see formula (11)), namely in a vertex of the polygon of the aggregate $\Omega(\alpha)$. These experimentally identified values of the loss function are stated in Table 2. After this first step, it is necessary to further limit the area $\Omega(\alpha)$ in the sense of determining of the smallest aggregate of the parametric setting. Providing that the loss function has, between two vertexes, a monotonously increasing/decreasing development, there should be vertexes belonging to this tapered area demonstrating a lower value of the loss function than that of the other vertex at the respective side. If we decide between the vertexes of the base of the polygon, that is, between Z[0; 0] = 0.4 and Z [1; 0] = 0.2, we choose Z [1; 0], because the loss function in it reaches a lower value. If we decide between Z [1; 0] = 0.2 and Z[1; 1/3] = 0.3, we choose again Z [1; 0], pertaining to a tapered aggregate. We apply this procedure to the three remaining parts of the polygon, consequently, we choose Z[1; 1/3], where there is a lower value of loss function and Z[0; 1], where there is a lower value of l the oss function in comparison with the point Z[1/3; 1]. The condi-

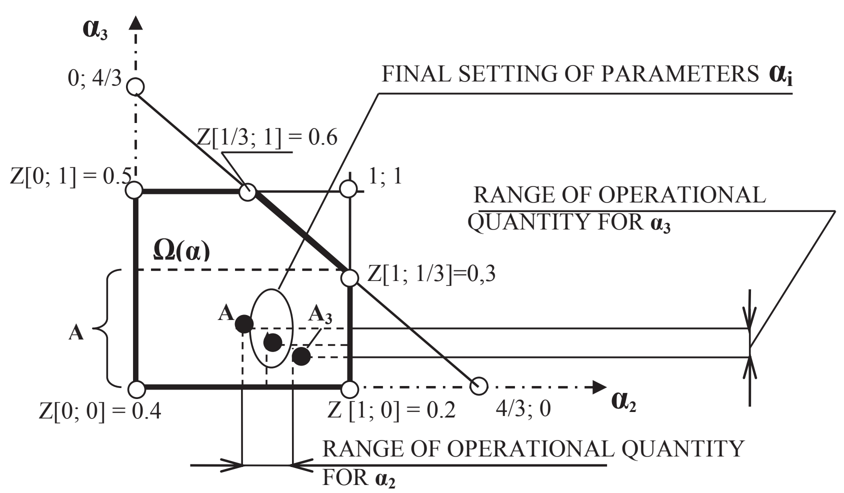

Figure 4. Procedure of setting of parameters in the Alcan Packaging Ltd. adaptive organization

Table 2. Values of the loss function for determining the parametric setting $A_1 – A_4$

Solution areas	Step			
	A_1	A_2	A_3	A_4
α_1	$\alpha_1(\alpha_2, \alpha_3) = 1 - 0.75 \times (\alpha_2 + \alpha_3)$	0.5	0.375	0.4375
α_2	$\alpha_2 \in \langle 0,1 \rangle$	0.5	0.75	0.625
α_3	$\alpha_3 \in \left\langle 0, \frac{1}{3} \right\rangle$	$\frac{1}{6}$	$\frac{1}{12}$	$\frac{1}{8}$
Value of loss function $(v, w, \alpha) \in \langle 0,1 \rangle$	$Z[1; 0; 0] = 0.4$ $Z[0,25; 1; 0] = 0.2$ $Z[0; 1; 1/3] = 0.3$	$Z\left[0.5, 0.5, \frac{1}{6}\right] = 0.25$	$Z\left[0,5,\ 0,5,\ \frac{1}{6}\right] = 0.28$	$Z\left[0.5,\ 0.5,\ \frac{1}{6}\right] = 0.17$

tion of this overall procedure of parametric setting is a purposeful integration between the planning system and the system of adaptive organization. It is so because we perform the parametric setting in the organizational system, whereas the value of the loss function is measured at the output from the planning system.

CONCLUSION

In this paper, there is a suggestion of the integration between two separately working systems, serving during its implementation into planning and organizational tasks as managerial tools at the Alcan Packaging Ltd. In the sense of this paper, adaptation means the capability of the control and organizational system, with the use of its resources, to adapt its behaviour to the changes of the environment where it realizes its transformation processes. Every adaptation represents for the system a certain loss in the form of energy, information or mass (Jenssen, 2009). During the observation of a repeated adaptation as a reaction to the change of the manifestation of the environment, there can occur a phenomenon when we measure the value of a loss of adaptation in a system which is a different form than where we perform the adaptation. In this case, it is efficient to use a systemic integration, the design of which has been introduced in this contribution.

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