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Overview of existing methodologies for clustering on the basis of one or more criteria

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1. Aims of clustering in the context of Data Mining.

1.1. Aims and tasks of clustering as a means of improving the ability for innovation and competitiveness of enterprises.

The business sphere in which present day economics develops is characterized by integration of business relations, globalization and strengthening the role of competitiveness. This means a new approach to management and managerial decisions. Most efforts are now focused on balancing internal and external influences.

In our current situation, we find ourselves in need of new approaches and instrumentarium to make decisions. The analysis of world experience shows that developing a competitive organizational structure based on integration is a viable solution.

This approach fundamentally changes an organization's model, as well as its characteristics. It contributes to the activation of its investment processes and intellectual potential by means of attracting additional internal sources of competitive and innovative growth.

A major problem in the solution of a management problem of small and medium-sized enterprises is the formulation of contemporary innovation infrastructure. World experience offers two main approaches:

- *Creation of an innovation infrastructure based on public-private partnership*.

On one hand, this approach has several significant advantages such as a guaranteed, continuously improving level of innovational infrastructure and the possibility for oversight by the government. On the other hand, it requires substantial resources and offers little returns. However, this approach is unlikely to be employed in a state of crysis.

- *Voluntary clustering of enterprises on a regional or sectoral principle aimed at creating sustainable competitiveness on internal and external markets*.

Sustainable competitiveness can be ensured by combining the strong positions of successfully developing enterprises with those of less success, but technologically connected and ready to interact with others in the cluster. (Porter, 1998).

According to Porter's definition, a cluster is a geographical proximate group of interconnected economical agents (such as companies and associated institutions in a particular field, suppliers, producers, elements of the infrastructure and research organizations) which gain added value. This added value guarantees growth of competitiveness and improvement of sustainable manufacturing of each element. In other words, this is a group of enterprises brought together by strong economical, political and social relations, and are not defined by organized membership.

The strategic purpose of the cluster is to increase the amount of knowledge used (informational clusters) and to create new networks for cooperation and development of products / services. The advantage of such organization is the direct stimulation of development of the competitiveness of integrated enterprises. This approach is mainly realized at the regional level. It's downside is that there is a strong dependency on the effectiveness of the clusters of stable national policy in regards to the development of small and medium-sized enterprises.

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The first approach to building an innovation infrastructure can be realized with the financial aid of the state and the various municipalities. The second approach is aimed at increasing the productivity of each enterprise, finding new and broadening existing markets, increasing the competitiveness of products / services in accord with existing market requirements and the effects of synergy [1]as a consequence of clustering.

According to (Bergman, E.M. and Feser, E.J., 1999), (Porter, 1998), (Copland, T., Koller, T., Murrin, J., 2002) association on various technological networks for production and realization of products / services is one of the most effective instruments for management. This approach allows effective usage of synergy - a strategic match which is defined as an opportunity for separate expenses to be transformed into one another.

Economic integration, or the association of economic agents in clusters, Is widely acknowledged to be one of the most effective instruments for this. Effective management of this process requires new instruments and approaches in line with the specifics of economic agents built upon the use of synergistic effect - an increase in effectiveness as a consequence of integration, merger, consolidation of resources into a unified system in the so-called system effect. The accent here fall on the application of new business models and the voluntary association of SMEs into chains for the creation of use values.

1.2. Definition of fundamental concepts and processes.

Economic agent, agent	Independent economic subject who defines himself as an operating unit, subject to analysis and planning, capable of creating a specific aggregate of products / services, which are not sold on certain markets.
Economic cluster, cluster	A group of enterprises, united by lasting economic, political and social relations, which are not determined by organised membership.
Economic clustering	A practical step towards business cooperation, an incentive for the development of assets, technology, infrastructure, joint investment (things that are not achievable when working alone) and innovations.

[1] Synergy - synergistic effect - from Greek - synergos (acting together) - increase in activity effectiveness as a consequence of integration, merger, combination of separate elements in a unified system at the expense of the so- called system effect. Synergy is positive when elements with similar state of development are integrated. Synergy is negative when trying to integrate elements with different states of development.

Investment attractiveness	An Integral assessment of cluster structure, which characterizes prospects for its development, profitability of investments, the effectiveness of invested assets and interaction with the external medium (markets, suppliers, clients, etc.)
Key indicators	A system of indicators which measure the state of critical factors of success.
Consolidated budget	A budget ensuring the functioning of a cluster structure and combining separate strategic budgets with the accounting of financial and non-financial resources.
Critical factors of success	A composition of a limited number of indicators which reflect the internal connections between factors, ensure the realization of activities and common goals.
Network structure	An open, flexible, vertically organized network of equal independent partners fulfilling different functions and roles and possessing specific limited resources.
Development stage assessment	Integral assessment of the state of development of an economic agent.
Assessment of sustainable development	An integral assessment of the sustainable competitiveness of an economic agent.
Polygon of sustainable development.	A two-dimensional space which connects synthetic indicators for economic creativity and growth through competitiveness and is used as an instrument, which enables the definition of a cluster structure based on a system of criteria and consisting of similarly developed agents.
Synergy	Synergy - effect of synergy - from Greek “synergos”, which means acting together. An increase in activity effectiveness due to integration, merger, or the combination of different elements into a unified system. When integrating similarly developed elements, synergy is positive. When trying to integrate elements whose stages of development are different there is a chance that there will be negative synergy.
System of balanced indicators	A system for strategic management relying on measuring and assessing effectiveness on the basis of optimally chosen indicators, which describe both financial and non-financial aspects of an activity.
Strategic goal of a cluster	The desired result for which a cluster structure aims. It is described in a mission. A mission is a

	brief and clear document that defines the aim of the structure, its tasks and fundamental values. Mission activities have to adhere to the principles laid out in it.
Strategic matters of a cluster	The direction of cluster activities, which ensures the realization of its strategic goal.
Strategic matter "Internal business processes"	Sequential chain of activities directed towards the satisfaction of customer needs. They unite three main processes: innovations, operations and after-sales services.
Strategic matter "Knowledge and development"	Dynamic system approach to the definition of mechanisms for efficiency, which include change measurements, the factors causing change and constant training.
Strategic matter "Markets"	Market and customer share necessary for the implementation of internal business processes.
Strategic matter "Finances"	Return on investments and economic added-value.
Strategy	Complex management of a given business structure that determines the main action guidelines, the mechanisms for decision making, the guidelines and principles for work development and structuring.
Cluster structure	Union of economic agents (suppliers, manufacturers, infrastructural elements, research and development organizations) that are connected while forming the added-value which provides the growth of competitiveness in the environment of stable increase of the productivity of each element.
Technological network	Business structure which - by means of cause-and-effect relationships - connects suppliers, manufacturers, traders, financial institutions, research and development institutes and other potential participants in the design, manufacturing and imimplementation of a product/service.

2. Overview of mathematical methods and decision making approaches that are applicable to the clustering of enterprises.

Various tasks for planning, analysis and management in economics, transport, industrial production, education, ecology, and other areas, can be classified as multicriteria decision-making tasks. They can be divided into three classes depending on their formal makeup.

The first class is made up of a number of finite alternatives clearly defined and in the form of a matrix. These tasks are called multicriteria decision-making for discrete alternatives or multicriteria analysis.

The second class is made up of number of clearly set limitations in the form of functions which define an infinite number of viable alternatives. These tasks are called decision-making tasks with multiple alternatives or tasks for multicriteria optimization.

The third class is made up of multiple alternatives, multiple criteria and three main sources of ambiguity (Roy, 1989):

- inaccuracy due to the difficulty of defining a multitude of alternatives and criteria;
- limitation due to the fact that the assessment methods come from a fairly random choice of various methods;
- ambiguity, since alternatives change in time.

These are multicriteria tasks that utilise the theory of fuzzy sets. This is a fairly new area in information technologies - soft computing - which deals with cases of fuzziness in both source information and at every stage of decision¬making.

During the analysis of literary sources for the developments of algorithms hand models for multicriteria choice it was established that the programming environment for realisation are the first two classes is well developed. This, however, does not apply to the third class that is relatively less developed and that creates certain difficulties in the solution of relevant tasks. This is one of the reasons the main focus to fall on the first two classes

While performing multicriteria analysis and optimization, several criteria simultaneously optimize sets of acceptable alternatives. In the general case, there is no one alternative that is optimal for all criteria, but there does exist a set of alternatives characterized by the following: Every similarity in the value of one of the criteria leads to a reduction in value of another criterion. This set of alternatives is called a set of non-dominant (Pareto-optimal) alternatives (solutions) (В.И.Данаилов-Данильян, 2003). Every set alternative from Pareto's set can be a solution to a multicriteria problem. In order for an alternative to be chosen, it is necessary to have additional information provided by the so called "decision-making person" (DMP). The information provided by DMPs reflects their preferences (bearing in mind the qualities of the desired alternative).

2.1. Analysis of algorithms for multicriteria decision making.

2.1.1. Multicriteria decision analysis algorithms

There are many different methods for solving multi-criteria analysis problems. Most of these algorithms can be categorized in three classes (Vincke, 1992). The first class of algorithms (Dyer, 2004) includes multi-attribute utility (such as the compromise algorithm by Keeny and Raiffa, MACBETH, UTA, the direct weight algorithm) and the Analytic hierarchy process (AHP) weight algorithms. The two subclasses of these algorithms differ in the way DMPs' preferences are aggregated. A generalized functional criterion is synthesized in the first subclass, whereas in the second subclass (weight algorithms), such a criterion (adaptive form) is indirectly synthesized. Both algorithms, however, are based on the supposition that the DMP's ability to differentiate between the alternatives. Using the binary relations for strong preference P (non-reflexive, symmetric and transitive) and indistinguishability I (reflexive, symmetric and transitive) we can express the alternative preferences of DMPs.

The second-class algorithms are the outranking algorithms (ELECTRE algorithms (Roy, 1996)), algorithms PROMETHEE (Brans, 1994), algorithms TACTIC (Vansnick, 1986), etc.), and are based on the assumption that a limited comparability between the alternatives is possible. Initially, these algorithms create (an) outranking relation(s), which reflect(s) the preferences of the DMP(s). The outranking relation is then used to aid DMPs come to a solution when resolving multicriteria analysis. When comparing two alternatives, they use four binary relations: of indistinguishability ***I*** (reflexive and symmetric), of weak preference ***Q*** (non-reflexive and asymmetric), of strong preference P (non-reflexive and asymmetric) and of incomparableness ***R*** (non-reflexive and asymmetric). The outranking relation covers these four relations. Most outranking algorithms assume that DMP is incapable of or lacking desire to clearly distinguish between the four relations, therefore DMP defines its preferences by setting inter- and intra criteria information. Inter-criteria information is represented in the form of weights and veto-thresholds while intra criteria information - in the form of indistinguishability and preference.

Interactive algorithms (such as VIMDA, aspiration levels algorithm, InterQuad, LBS, CBIM, etc.) fall under the third category. They are optimization motivated and targeted at the resolution of problems during multicriteria analysis when there are many alternatives and few criteria. The first and second algorithms use the first model of DMP preference assignment and DMPs must define desire or acceptable values of criteria during every integration. The fourth and fifth algorithms use the second model of DMP preference assignment and DMPs must not only define desire or acceptable values of criteria but also inter- and intra criteria information during every integration.

2.1.2. Tasks of multicriteria analysis

The problem of multicriteria analysis can be described through the alternative's matrix A (n x k), which can be put in two ways (Василев, 2005):

Alternatives matrix variant 1

k_j / a_i	$k_1(.)$	$k_2(.)$	...	$k_j(.)$	...	$k_k(.)$
a_1	a_{11}	a_{12}	...	a_{1j}	...	a_{1k}
...	...	...	...	...	...	...
a_i	a_{i1}	a_{i2}	...	a_{ij}	...	a_{ik}
..	...	...	...	...	...	...
a_n	a_{n1}	a_{n2}	...	a_{nj}	...	a_{nk}

Alternatives matrix variant 2

f_k / a_i	$f_1(.)$	$f_2(.)$	...	$f_j(.)$	...	$f_k(.)$
a_1	$f_1(a_1)$	$f_2(a_1)$	...	$f_j(a_1)$	...	$f_k(a_1)$
a_2	$f_1(a_2)$	$f_2(a_2)$	...	$f_j(a_2)$	...	$f_k(a_2)$
...	...	...	...	...	...	...
a_i	$f_1(a_i)$	$f_2(a_i)$	...	$f_j(a_i)$	...	$f_k(a_i)$
..	...	...	...	...	...	...
a_n	$f_1(a_n)$	$f_2(a_n)$	...	$f_j(a_n)$	...	$f_k(a_n)$

where :

– a_i is an alternative with an index i, $i=1,\dots,n;$

– k_j (.) или f_j(.) is an criterion with an index j, $j=1,\dots,k.$

The set of the indices of alternatives is marked as I, while the index set of criteria is marked as J.

The assessment of all criteria in relation to the *i-th* alternative is done according to the vector-row $(a_{i1}, a_{i2}, ..., a_{ik})$ or $(f_1(a_i),..., f_k(a_i))$.

The assessment of all criteria in relation to the *j-th* alternative is done according to the vector-column $(a_{1j}, a_{2j}, \ldots, a_{nj})^T$ or $(f_j(a_1), \ldots, f_j(a_n))^T$.

Three main types of tasks can be formulated on the basis of the alternatives matrices A:

Task 1. Picking the best alternative for DMP according to their preference (multicriteria decision task).

Task 2. Sorting all alternatives in ascending or descending order (multicriteria arrangement task, etc.)

Task 3. Division of alternatives into groups (multicriteria classification problem or multicriteria sorting)

Definition 1. The acceptable alternative indexed i' is designated as a Pareto-optimal alternative if no other alternative indexed i exists, for which the following rules apply: $a_{ij} \geq a_{i'j}$, $j = 1,\dots,k$ and at least for one index $j = s$ the condition $a_{is} > a_{i's}$ holds.

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Definition 2. The acceptable alternative indexed i is designated as satisfactory if the condition $a_{ij} \geq \overline{a}_j,\ j = 1,\ldots,k$ holds, where $\overline{a}_j$ is an aspirational level of the criterion indexed j, $j= 1,\ldots,k$.

Definition 3. The alternative l^* is designated as ideal alternative if the following condition is met: $l^* = (a_1^*, a_2^*, \ldots, a_n^*)$, where $a_j^* = \max_{1 \leq i \leq n} a_{ij}$.

In the general case, an ideal alternative does not exist.

Definition 4. A Pareto-optimal alternative is the most prefered one if it best reflects the preferences of DMP.

2.2. Analysis of algorithms for multicriteria optimization.

2.2.1. Algorithms for multicriteria optimization

Currently, there are two main approaches to multicriteria optimization problem solving: the scalarization method (Miettinen, 1999) and the approximation method (Ehrgott, M., Wiecek M., 2004). The main representatives of scalarization are the interactive methods (Wierzbicki, 1980), (Steuer R. ,1986), (Vassilev, 1993), (Narula, S. C. and Vassilev, V., 1994), (Gardiner, 1997), (Korhonen,1987), (Miettinen, K. and Makela M.M., 2002). These methods treat multicriteria optimization tasks as decision-making tasks. They focus on the actual participation of DMP in the process of decision-making.

Interactive algorithms are the most advanced and widely used due to their main advantages:

- Only a small number of Pareto-optimal decisions have to be generated and evaluated by DMPs.
- DMPs learn in the process of solving multicriteria problems.
- DMPs can be more confident in the validity of the end result.

Each interactive algorithm usually has two procedures - optimization and assessment, which are executed cyclically until conditions for task completion are met. During the assessment procedure DMPs assesses the current Pareto- optimal decision(s) and chooses their preference(s) for seeking new solutions. A scalarization task is then formulated on the basis of these preferences and it is decided in an optimization procedure. With its aid, a new Pareto-optimal decision is made and then presented to DMP(s) for assessment. A fundamental feature of each scalarization task is that every optimal decision is considered a Pareto-optimal (weak Pareto-optimal) decision of a given multicriteria optimization task. Scalarization tasks are single criteria tasks for optimization, which allows single criteria optimization theories and algorithms to be employed. Each interactive algorithm for resolution of multicriteria optimization tasks of various classes so far has its pros and cons, which are mainly related to the type of information presented to DMP(s) and reflecting their global and local preferences, as well as the manner of extraction and resolution of tasks and their type. Interactive algorithms are especially suitable for the resolution of linear and convex nonlinear tasks of multicriteria optimization. The time for scalarization task solution (the time necessary for generation of a new solution) bears no major significance. In NP- tasks (integer, discrete, combinatorial, non-convex, nonlinear multicriteria tasks) the performance time might substantially increase, thus hindering DMP(s) work. In some of these tasks, for example

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multiple-objective integer linear tasks such as (Narula, S. C. and Vassilev, V., 1994), (Karaivanova, J., Korhonen, P., Narula, S., Wallenius, J., Vassilev, V., 1995), many different strategies for reduction of response wait time of new decisions have been proposed. DMP are given an integer Pareto-optimal (weak Pareto-optimal) decision in the learning phase of a given integration, an approximated Pareto-optimal (weak Pareto-optimal) decision or a Pareto-optimal decision for linear relaxation task (in this case uninterrupted). Iterative algorithms (direction) and classification-oriented interactive algorithms (Miettinen, 1999) are the most widely used algorithms for multicriteria optimization problem solving. Despite the fact that iterative algorithms still dominate, classification-oriented algorithms give better solutions to some of the main problems in communication with DMP(s) related to the definition of time preferences (the time necessary to generate new non-dominated decisions for assessment and choice).

Algorithms of various types, which approximate Pareto-optimal decision sets, have also been developed (Coello, C.A.C., Veldhuizen, D.A.V., Lamont, G.B., 2002), (Ehrgott, M., Wiecek M., 2004). Most of them are interactive and generate points or objects, which approximate those sets. Some algorithms (Ehrgott, M., Wiecek M., 2004) have been precisely grounded in terms of theoretical facts and optimality, while others (Coello, C.A.C., Veldhuizen, D.A.V., Lamont, G.B., 2002) are heuristic and often have no theoretical rationale. In most multicriteria optimization tasks it is difficult to describe Pareto-optimal decisions accurately, which usually involves lots, if not an infinite amount, of points. Even if it were theoretically possible to find all these points, it would require a tremendous amount of resources (both financial and processing).

Good examples of heuristic algorithms are multicriteria genetic (evolutionary) algorithms such as (Coello, C.A.C., Veldhuizen, D.A.V., Lamont, G.B., 2002), (Goldberg, 1989). These algorithms treat multicriteria optimization tasks more like a vector optimization one than a decision-making one and they focus on finding subsets of potential Pareto-optimal decisions, which approximate the whole Pareto set. This is achieved by maintaining a population of candidates for the approximation process throughout the whole optimization set. This population improves with each iteration through the help of various operations which model (shape) the main processes in genetics/genetic operators - selection, recombination and mutation. Modifications of these operations are used in genetic algorithms, as well as various population models for improvement of their compatibility with Pareto-optimal sets. Different mechanisms for dispersion of population are employed, which guarantees good approximation of the whole Pareto set.

Genetic algorithms are algorithms with a built-in parallelism, which allows them to overcome many difficulties (presence of a set of local optima, set of decisions, etc.) when resolving single- or multicriteria combinatorial and non-convex nonlinear tasks. The biggest cons of these algorithms are related to the inadequate use of certain specifics for problem solving. They require a lot of processing power and lack conditions for optimality. Hybrid genetic algorithms (Ishibuchi, H., Murata, T., 1998) have been developed, which use the specifics for problem solving to improve local populations. The procedures for making new decisions have been modified and several new mechanisms for dispersion of populations have been included.

Decisions, which have been reached with the aid of genetic algorithms, in the general case are closer to Pareto- optimal decisions. During the selection process of an approximating set the DMP(s) is/are isolated, while at the same time, they are presented with too many decision sets for assessment and decision-making (this is a fairly difficult problem to resolve in multicriteria analysis). A big part of these decisions are not necessary for DMP to make and the best decision might even never be found.

2.2.2. Tasks of multicriteria optimizzation

A decision consists of the following: looking for target variables, which meets the imposed restrictions and optimizes vector function, and the elements which correspond to target functions. These functions (being contradictory by definition) form a mathematical description of an integral criterion. Optimization in solving problems of this class means finding a solution whose target functions satisfy the person(s) formulating the task. Reference points (“ideal point”, “utopian point” and “nadir”) are taken into consideration in order to assess the quality of a given decision in the area of target function values. Sometimes, these points can also be solutions to a problem.

The most common formula for multicriteria optimization tasks is:

An integer linear multicriteria optimization task (we will be designated it as task (*I*)) can be formulated in the following manner:

(1) $\text{"max"}\{f_k(x), k \in K\}$

with the following restrictions:

(2) $\sum_{j \in N} a_{ij} x_j \leq b_j, i \in M,$

(3) $0 \leq x_j \leq d_j, j \in N',$

(4) $x_j - integer, j \in N', N' \subset N.$

where:

- the symbol “max” means that all criteria must be maximized simultaneously (target functions);
- $K = \{1, 2,..., p\}$, $M = \{1, 2,..., m\}$ and $N = \{1, 2,..., n$ are the index sets - respectively of linear criteria, linear restrictions and variables;
- $f_k(x)$, $k \in K$ are the linear criteria (target functions);:
    - $f_k(x) = \sum c_j^k x_j$;
    - $j \in N$
    - $x = (x_1, x_2,..., x_j,..., x_n)^T$ is the vector of variables.

Restrictions (2) - (4) determine the admissible set of integer variables. This set will be designated as X_1.

Task (1) - (3) is a linear multicriteria optimization task. It will be marked as task (P). The admissible set of uninterrupted variables will be designated with X_2. Task (P) is a relaxation of task (I).

Definition 5: The admissible vector x is called an effective solution to problem *(I) or (P)*,) if no other admissible vector $\bar{x}$, exists so that the following inequalities hold:

$f_k(\bar{x}) \geq f_k(x)$, for every $k \in K$ and

$f_k(\bar{x}) > f_k(x)$, for at least one index $k \in K$.

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Definition 6: The admissible vector x is called a weak effective solution (weak solution) to problems (I) or (P) if no other admissible vector $\bar{x}$, exists so that the following inequalities are true:

$f_k(\bar{x}) > f_k(x)$, for every $k \in K$.

Note 1: The set of effective solutions to (I) or (P) is a subset of the respective problem's weak effective solutions set.

Definition 7: The admissible vector x is called a weak effective solution to (I) or (P) if x is a weak effective or effective solution to the respective problem.

Definition 8: Vector $f(x) = (f_1(x),..., f_p(x))^T$ is considered a (weak) non-dominated solution of problems (I) or (D) in criterial space if x is a weak effective solution of the respective problem in the space of random variables.

Problems (I) and (P) do not have an optimal solution (in the traditional sense of single criteria problems). This is why it is necessary to choose a weak non-dominated or non-dominated solution, which corresponds best to the global preferences of DMPs. This decision is subjective and depends entirely on DMPs.

Criteria for optimality

Pareto criterion

Vector solutions $\vec{x} \in S$ c are called Pareto-optimal if there is no $\vec{x} \in S$, such that $f_i(\vec{x}) \leq f_i(\vec{x}')$ for every $i = 1, \ldots, k$ and $f_i(\vec{x}) < f_i(\vec{x}')$ for at least one i. A set that is optimal according to Pareto may be designated as $P(S)$. A target vector is optimal according to Pareto if its respective vector from the acceptable area is also optimal according to Pareto.

The Pareto-optimal set of vectors is a subset of weak Pareto-optimal vectors. Vector $\vec{x} \in S$ is a weak Pareto-optimal one when there is no vector $\vec{x} \in S$, such that $f_i(\vec{x}) < f_i(\vec{x}')$ for every $i = 1, \ldots, k$.

The set of Pareto-optimal solutions in the range of acceptable values gives useful information about the researched problem if the target functions are restricted to the area of definition. Beneath the bar of Pareto-optimal sets is the "ideal target vector" $\vec{z} \in R^k$. Its components z_i have been derived from minimization of each target function within the acceptable area.

The set of Pareto-optimal solutions is also called a Pareto-frontier.

Lexicographic order

If some target functions are more important than others, the criteria for optimality may be defined in lexicographic order.

The relation of the lexicographic line $<_{lex}$ between vectors $\vec{a}$ and $\vec{b}$ is true if $a_q < b_q$, where $q = min\{k: a_k \neq b_k\}$. Namely, the first component q of vector $\vec{a}$ is smaller than the that of vector $\vec{b}$, but the components $q + 1$ (if any) are equal. The lexicographic order is linear when it comes to real numbers.

Vector $\vec{x} \in X$ is a lexicographic solution if there is no vector $\vec{x} \in X$, such that $f_i(\vec{x}') <_{lex} f_i(\vec{x})$.

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Since the relation of a lexicographic order is linear, it can be proven that vector $\vec{x}$ is a lexicographic solution if for all $\vec{x} \in X$ the following inequality is true:

$\vec{f}(\vec{x}) <_{lex} \vec{f}(\vec{x}')$.

The main difference of lexicographic lines is the fact that you can choose between various criteria. Lexicographic order requires criteria to be sequenced in such a way that optimization of f_k is possible only when the optimum for previous criteria is reached. This means that the first criterion has the highest priority. In case there is more than one solution, the algorithm initiates a new search based on the other criteria. The existence of hierarchy allows for sequential lexicographic problem solving (step by step, going down the chain of criteria and utilizing the optimal values of criteria as guidelines/restrictions).

Multicriteria optimization tasks can be classified as linear, non-linear, integer, network, etc. based on the type of their criteria, restrictions and variables.

The most used approach to their resolution is scalarization.

Existing algorithms for multicriteria optimization task resolution can be divided into four classes based on the time and place of information provided by DMPs (Fig. 1): apriori algorithms (previously known information), interactive algorithms, a posteriori algorithms and algorithms that do not require information from DMPs.

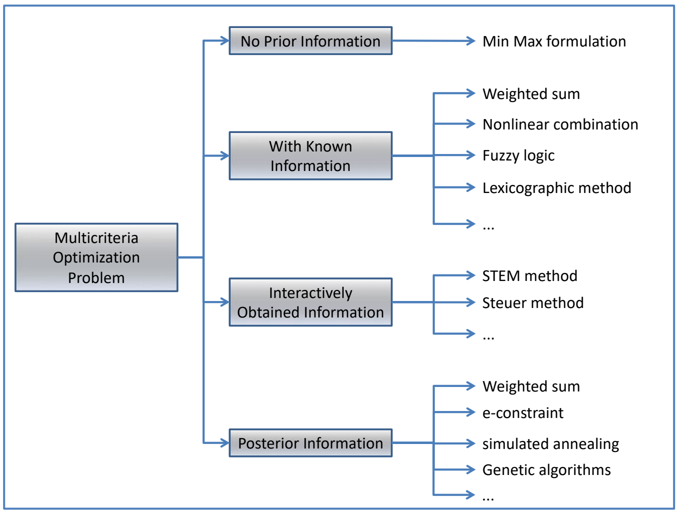

Fig. 1. Classification of some methods for multicriteria optimization

The information provided by DMPs expresses their preferences for target (sought) solution.

<u>In apriori algorithms</u>, all preferences are known from the onset of the decision-making process. Employed techniques are aimed at finding Pareto-sets or subsets through the use of apriori articulation of preferences. The most popular algorithms from this group are those for target programing.

<u>Interactive algorithms</u> produce Pareto-optimal solutions on the basis of DMPs' preferences during the decision-making process. DMPs can express their preferences between the various Pareto-optimal solution based on the values of a scalarization task's parameters. DMPs have to reach an

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(most desirable) end solution and are responsible for their choices.

A posteriori algorithms generate a set of all Pareto-optimal solutions for a particular task, after which the set is analyzed according to DMP's preferences.

2.2.3. Interactive algorithms

Interactive algorithms are the most often used for multicriteria problem solving. Interactive (dialog) in this case means a process of choosing a solution, which is based on an indirect and sufficiently quick exchange of information between two subjects and a constant swapping of roles (informer-informant subject). If such a role swap does not exist (or is impossible), the process is unilateral and is typical for traditional information systems. In this case the term dialog refers to the contact between computer and user. The main advantages to dialog systems are:

- The possibility to apply knowledge of a higher rank (semantic networks, distributed knowledge bases, etc);
- The possibility to trace the process of choosing of solutions in detail (a more perfect mechanism for explaining);
- The possibility to apply non monotonous logical conclusions;

By default, mathematical modeling of real processes and systems leads to multicriteria problems. In order to solve them, interactive algorithms are most often used. This is due to their advantages - a small part of Pareto-optimal solutions have to be generated and assessed by DMPs. In the process of multicriteria problem resolution, DMPs can learn with respect to the problem. DMPs can change their preferences during resolution. DMPs also feel more confident in their final solution preferences.

Each of the aforementioned interactive algorithms for various class problems solution of multicriteria optimization has its pros and cons in regards to the manner of processing and the type of information extracted by DMPs about their global and local preferences, the type and ways of scalarization problem resolution, as well as the type of information provided to DMPs. These algorithms can be classified into five groups depending on the type of information about a DMP's search preferences for new solutions.

№	Type of assigned information about DMP's preferences	Interactive algorithm
1	Weight factors (priorities) for each criterion.	1) Chebishevsky algorithm 2) Weight algorithm
2	Selection of a criterion for optimization and transformation of other criteria (setting a lower limit for variation for each criterion).	1) the ε-restrictions algorithm

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3	Aspirational levels of each criterion.	1) the STEM algorithm 2) the STOM algorithm 3) the reference point algorithm RP 4) the GUESS algorithm 5) the modified reference point algorithm MRP
4	Aspirational levels of each criterion and parameter for initial path selection.	1) the initial path algorithm RD1 2) the initial path algorithm RD2
5	Desired and acceptable levels, directions and (partial) criteria change intervals.	1) the classification-oriented algorithm NIMBUS 2) the classification-oriented algorithm DALDI

Interactive methods for multicriteria optimization problem solving are the main representatives of the scalarization approach.

In order for a single criteria problem to be a scalarization problem of output multicriteria problem, it must meet two requirements:

- Each Pareto-optimal solution of a multicriteria problem has to be found by changing the values of a scalarization problem's parameters;
- Appropriate values of a scalarization problem's parameters must be found for each Pareto-optimal solution, so that its optimal solution is the exact same as the Pareto-optimal solution of the multicriteria problem.

The fundamental steps of an interactive algorithm are the following:

Step 1. Finding an initial acceptable solution.

Step 2. Initiating a dialog with DMPs - providing DMP with found solution and receiving information about their relation to given solution. If the solution satisfies DMPs, STOP.

Step 3. Finding a new solution. Transition to step 2.

Interactive methods differ from each other depending on the type of:

- information provided by DMPs;
- information received by DMPs;
- scalarization problem;

The information that a DMP requests from the various interactive methods may include:

- importance or weight of criteria;
- the compromises a DMP makes;
- criteria indices which can worsen in order for other criteria to improve;
- criteria indices which can worsen, as well as information about how much they can worsen;

- Desired or acceptable levels, directions and intervals of change of separate criteria;

The information DMPs receive consists of one or several Pareto-optimal (weak Pareto-optimal) solutions. The various interactive algorithms are based on scalarization problems. These problems define the type of information that DMPs have to provide, as well as the type and number of Pareto-optimal or weak Pareto-optimal solutions to be received. Some of them are oriented at solving only linear problems, while others - linear and nonlinear, while still others integer and discrete problems.

Decision making is not a single, isolated act. This is a process that consists of several stages in time. Each process in nature - physical, chemical, social, intellectual, etc, provided to itself, evolves and is controlled by specific laws. This process, however, is affected by other processes and it affects others as is the law of interconnectedness in nature. This leads to a deviation from the initial development of the process, meaning that it runs its course according to more complicated regularities.

All external influences can be divided into two groups - random and controlling influences. Random influences are the result of interaction between said processes, while the controlling ones change the direction of the process to a more desirable one. In this regard, there must be a body of some sort, which should systematically (or at least when necessary) generate controlling influences. This kind of body is called a management system.

In the general case, system means an objective unity of regularly interconnected objects and phenomena in nature and society. The characteristics of the system are usually defined as characteristics of the system’s building blocks, as well as characteristics of their relations.

The quality and effectiveness of the system’s work is assessed based on effectiveness criteria, which evaluate the process of achieving a desired goal. Decision-making problems arise only when there are difficulties in achieving the necessary goals.

The system has to have means of guaranteeing the application of chosen controlling influences during the decision¬making process. The decision-making process begins with becoming aware of the state or situation in which DMPs act.

This first stage can be considered as preceding the decision-making process. It reveals either satisfaction or dissatisfaction from the state of the system.

During the second stage, a desire for change or maintaining the current state of the system in some way emerges (meaning that a decision goal is set).

During the third stage, all possible means and ways of achieving a goal or transitioning to a desired state are identified.

During the fourth stage, an effective decision is chosen (from the perspective of finding a desired goal) if certain rules for choosing are upheld. The result of this phase is the single decision. This is the main stage but it is impossible to reach it, unless the system has gone through the first three stages.

The whole process of decision-making concludes with stage five, in which the decision is executed.

The main representatives of the scalarization approach are interactive algorithms which are used for multicriteria optimization problem solution. Scalarization means to transform a

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multicriteria optimization problem into one or several single criteria problem(s). Their transformation allows for the utilization of single criteria optimization theory and methods in multicriteria problem solving. The basis for such a transformation is that each multicriteria optimization problem's Pareto-optimal solution may be an optimal solution for the scalarization problem.

The methods of multicriteria optimization utilize various scalarization problems as a weighted sum problem - the e- restrictions problem, initial point problem, classification-oriented problems, etc. (Василев, 2005). Despite the fact that scalarization problems define these methods to a huge extent, one can come across methods for comparative analysis more often and seldom for scalarization problems (Miettinen, K. and Makela M.M., 2002). Analogically, in the specialized literature one can read more about various attempts to merge different methods than to summarize different scalarization problems.

Some of the more popular scalarization problems of multicriteria optimization have been reviewed. These problems approximate a whole set of popular scalarization problems. The values of criteria of a current solution of a scalarization problem do not match the parameters of a scalarization problem perfectly, despite the fact that DMPs set their values in scalarization problems. When talking about classification-oriented scalarization problems one must consider that the values of criteria in a solution are parameters of the scalarization problem. In the weighted sum method, DMPs set their preferences by using weight values of criteria, whereas in scalarization problems of e- restrictions, by choosing a maximization function and setting a lower limit for criteria. The reference point is determined by the aspirational levels of criteria, which are either desired by DMPs or are considered acceptable in the new solution. These aspirational levels of criteria are parameters for reference-point scalarization problems. In classification-oriented scalarization problems, the parameters of a task can not only be aspirational levels, but also directions and intervals of change in the values of criteria, which DMPs desires or is willing to accept in a new solution. The parameters of a scalarization task can the values of criteria in their current solution. DMPs indirectly classify divide criteria into groups by setting the desired or acceptable changes in the values of the current solution's criteria.

The following definitions are introduced for the purposes of the analysis:

Definition 1. Vector $z^* \in R^p$ is called an ideal vector if each of his components $z_k^*,\ k = \overline{1,p}$ can be created by individually optimizing the $f_k,\ k = \overline{1,p}$ criterion over the acceptable set *X*.

Definition 2. Vector $z^{**} \in R^p$ is called a utopic vector if each of his components $z_k^{**}, k = \overline{1,p}$ meets the condition $z_k^{**} = z_k^* + \varepsilon_k$, $k = \overline{1,p}$, where ε_k is a small positive number.

Definition 3. Vector $z^{nad} \in R^p$ is called a nadir vector if each of his components $z_k^{nad},\ k = \overline{1,p}$ is obtained through individual criterion minimization of $f_k,\ k = \overline{1,p}$ over the acceptable set *X*. The nadir vector $z^{nad} \in R^p$ represents the lower limit of the Pareto-optimal set. An easy-to-use constructive method for definition of components of a nadir vector has not yet been found, but they can be assessed, at least to some extent, by the so called pay-off table (Miettinen, K. and Makela M.M., 2002). (Miettinen, K. and Makela M.M., 2002).

Definition 4. The current preferred solution $z = (f_1,..., f_k,..., f_p)$ is a weak Pareto-optimal or a Pareto-optimal solution in the criteria space chosen by DMPs in the current iteration.

Definition 5. A reference point or a reference vector $\bar{z} = (\bar{z}_1,..., \bar{z}_p)^T \in R^p$ is the vector whose criteria values match the desired or acceptable values defined by DMPs. These aspirational values might or might not be reached/surpassed. The reference point can be a randomly chosen from the space R^p.

Definition 6. The reference direction (Korhonen, P. and Laakso, J., 1986) is based on the difference between the reference point set by DMPs and the the currently prefered solution.

Definition 7. Classification of criteria (Benayoun, R., de Montgolfier, J., Tergny, J. and Larichev, O., 1971) is the separation of criteria by DMPs into classes depending on the change in the values of criteria, which they desire to receive in contrast to the respective values of the criteria in the current solution.

Method of the weighted sum

The scalarization problem of the weighted sum (OSP1) was first used in the weighted sum method for linear and nonlinear multicriteria problems. DMPs have to define a weight factor ω_k for every criterion. The scalarization problem is:

To maximize $\sum_{k \in K} \omega_k f_k(x)$ under the restriction $x \in X$,

where: $\omega_k \geq 0,\ k \in K, \sum_{k \in K} \omega_k = 1$.

Method OSP2 - a scalarization problem of ε -restrictions

This scalarization problem's first appearance was in the e-restrictions method for resolution of nonlinear multicriteria problems (Haimes, 1971). A criterion is chosen for optimization, while the others are transformed into restrictions and a lower limit is set for each of them. A set chosen by these restrictions cannot be an empty one. The scalarization problem looks like this:

$f_l(x)$ has to be maximized and has the following restrictions $f_k(x) \geq \varepsilon_k, k \in K, k \neq l, x \in X$.

Method OSP3 - Chebyshev's scalarization problem

Chebyshev's scalarization problem is used in Chebyshev's method (Steuer R. E., 1989), (Steuer R. E., 1983). Its purpose is to aid the resolution of linear and nonlinear multicriteria problems. Weight values are automatically generated in this method so that a subset of various Pareto-optimal solutions can be created. The scalarization problem looks like this:

$\max_{k \in K} \left(\omega_k \left(z_k^{**} - f_k(x) \right) \right)$ has to be minimized and has the following restriction: $x \in X$.

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Method OSP4 - STEM scalarization problem

This scalarization task is used in the STEM method (Benayoun, R., de Montgolfier, J., Tergny, J. and Larichev, O., 1971) for resolution of linear multicriteria problems. DMPs must classify the criteria into two groups: $K^{\le}$ and $K^{>}$. To be more precise, they determine which criteria can be degraded, as well as the maximum value of degradation. The rest must be improved. The STEM scalarization problem looks like:

To minimize $\max\limits_{k\epsilon K^{>}} \left[\frac{e_k}{\sum_{j\in K^{>}} e_j}\left(z_k^* - f_k(x)\right)\right]$

under the restrictions $f_x(x) \ge f_k - \Delta_k$, $k \in K^{\le}$, $f_k(x) \ge f_k$, $k \in K^{>}$, $x \in X$,

where:

- $e_k = \frac{z_k^{nad} - z_k^*}{max(|z_k^{nad}, z_k^*|)}$,
- Δ_k is an acceptable degradation value of the criterion indexed k.

Method OSP5 - STOM scalarization problem

The STOM scalarization problem is used in the satisfactory compromise method. It is designed to solve nonlinear multicriteria problems. DMPs separate criteria into two groups $K^{\ge}$ and $K^{\le}$ and define the desired or acceptable levels of criteria in reference point $\bar{z}$ based on the values of a current solution. There are, however, different definitions for STOM scalarization problems. For example:

To minimize $max\left(\max\limits_{k\in K^{\ge}} \frac{z_k^{**} - f_k(x)}{z_k^{**} - \bar{z}_k}, \max\limits_{k\in K^{\le}} \frac{z_k^{**} - f_k(x)}{z_k^{**} - \bar{z}_k}\right)$

under the restriction $x \in X$,

where:

- $\bar{z}_\kappa$ is κ-th reference point component,
- z_k^{**} is κ-th component of the utopic point and $\bar{z}_k < z_k^{**}, k \in K$.

Method OSP6 - reference point scalarization problem

This type of problem is used in the reference point method (Wierzbicki, 1980) to resolve linear and nonlinear multicriteria problems. DMPs must set the aspirational levels of criteria in point $\bar{z}$ without taking into consideration the values of criteria at that particular stage. The comparison of the aspirational levels of criteria and their respective values leads to the division of criteria into two groups $K^{\ge}$ and $K^{\le}$ or to the first of them. Consequently, the scalarization problem could look like:

To minimze $max\left(\max\limits_{k\in K^{\ge}} \frac{(\bar{z}_k - f_k(x))}{|\bar{z}_k|}, \max\limits_{k\in K^{\le}} \frac{(\bar{z}_k - f_k(x))}{|\bar{z}_k|}\right)$

under the restriction $x \in X$.

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Method OSP7 - GUESS scalarization task

A GUESS scalarization task is used in the GUESS method (Buchanan, J. T., Corner, J. T., 1997) for linear multicriteria problem resolution. DMPs must set the values of the nadir point components and the reference points - z^{nad} and $\bar{z}$ without taking into account the values of criteria at the current stage. The comparison of reference and current point criteria values leads to division of criteria into two groups $K^{\geq}$ and $K^{\leq}$ or the first of the two. Sample scalarization problem:

To minimize $max\left(\max_{k\in K^{\geq}}\frac{\left(z_k^{nad}-f_k(x)\right)}{\bar{z}_k-z_k^{nad}},\max_{k\in K^{\leq}}\frac{\left(z_k^{nad}-f_k(x)\right)}{\bar{z}_k-z_k^{nad}}\right)$

under the restriction $x \in X$. Aspirational levels should be higher than the respective values of criteria in the nadir point.

Method OSP8 - MRP scalarization problem.

The scalarization problem of modified reference point MRP is used for resolution of convex integer multi-criteria problems in the reference direction method. DMPs separate criteria into three groups - $K^{\geq}$, $K^{\leq}$ and $K^{=}$ depending on their values in the current solution and set their preferences or acceptable levels of criteria in reference point $\bar{z}$, where for $k \in K^{=}$, $\bar{z}_k = f_k$. The formulation of this scalarization function is as follows:

To minimize $max\left(\max_{k\in K^{\geq}}\frac{\left(\bar{z}_k-f_k(x)\right)}{|\bar{z}_k-f_k|},\max_{k\in K^{\leq}}\frac{\left(\bar{z}_k-f_k(x)\right)}{|f_k-\bar{z}_k|}\right)$

under the restrictions $f_k(x) \geq f_k$, $k \in K^{=}$, $x \in X$.

Methods OSP9-OSP11 - scalarization problems of reference directions

Scalarization problem RD1 (OSP9.1) that has been used in the so-called visual interactive method of Korhonen (Korhonen, 1987), (Korhonen, P. and Laakso, J., 1986), is now used for resolution of linear multicriteria problems. DMPs must set the aspirational levels of criteria in reference point $\bar{z}$ at each iteration without taking into account the value of criteria in the current point. The comparison of aspirational levels of criteria with their respective values in the current point separates criteria into two groups $K^{\geq}$ and $K^{\leq}$. For each iteration, DMPs receive more than one solution. This scalarization problem is a parametric modification of a reference point scalarization problem and can be expressed as follows:

To minimize $max\left(\max_{k\in K^{\geq}}\frac{\left(\bar{z}_k-f_k(x)\right)}{\omega_x},\max_{k\in K^{\leq}}\frac{\left(\bar{z}_k-f_k(x)\right)}{\omega_x}\right)$

under the restrictions $\bar{z}_k = z_k + td_k$, $k \in K^{\leq} \cup K^{\geq}$, $x \in X$,

where:

- ω_k is a weight factor of criterion indexed κ,

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- z_k is the value of criterion indexed k in the current solution,
- $d_k = \bar{z}_k - z_k$,
- t is a parameter: $t = 1,2,...,\infty$.

Scalarization problem RD2 (OSP10)

Scalarization problem RD2 (Vassilev, 1993) is the basis of the interactive method for linear integer multicriteria problems. On the basis of criteria values in the current point, DMPs separates criteria into three groups $K^{\geq}$, $K^{\leq}$ and $K^{=}$ and sets the desired or varying levels of criteria in the reference point $\bar{z}$, where $\bar{z}_k = f_k$ за $k \in K^{=}$. A scalarization problem of this type may be formulated as follows:

To maximize $\min_{k \in K^{\geq}} \left(\frac{f_k(x) - f_k}{\bar{z}_k - f_k} \right)$

under the restrictions $f_k(x) \geq \bar{z}_k + \alpha(\bar{z}_k - f_k)$, $k \in K^{\leq}$, $f_k(x) \geq f_k$, $k \in K^{=}$, $x \in X$,

where α is a parameter: $\alpha > -1$.

Scalarization problem RD3 (OSP11)

Scalarization problem RD3 (Narula, S. C. and Vassilev, V., 1994) is used in the interactive method for solving non-linear multicriteria problems. One way to express this type of problem is:

To minimize $\max_{k \in K^{\geq}} \left(\frac{f_k(x) - f_k}{f_k - \bar{z}_k} \right)$

under the restrictions $f_k(x) \geq \bar{z}_k + \alpha(f_k - \bar{z}_k)$, $k \in K^{\leq}$, $f_k(x) \geq f_k$, $k \in K^{=}$, $x \in X$,

where α is a non-negative parameter, $0 \leq \alpha < 1$.

Method OSP12 - scalarization problem NIMBUS

Scalarization problem NIMBUS is used in the classification-oriented method NIMBUS (Miettinen, K. and Makela M.M., 2002). Its purpose is to resolve nonlinear multicriteria problems. DMPs have to separate criteria into five groups - $K^{>}$, $K^{\geq}$, $K^{=}$, $K^{\leq}$ and K^{0} depending on the desired change of criteria values in relation to the values of criteria in the current solution. In this method there are several versions of a scalarization problem. A sample one would look something along these lines:

To minimize $max \left(\max_{k \in K^{\geq}} \frac{(\bar{z}_k - f_k(x))}{|z_k^*|}, \max_{k \in K^{>}} \frac{(z_k^* - f_k(x))}{|z_k^*|} \right)$

under the restrictions

$f_k(x) \geq f_k$, $k \in K^{>} \cup K^{=}$,

$f_k(x) \geq f_k - \Delta_k$, $k \in K^{\leq}$, $x \in X$.

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Methods OSP13 Classification-oriented scalarization problem DALDI

This classification-oriented scalarization problem (V assileva, 2000) is used in a method for linear and linear integer multicriteria problem resolution. DMPs have a broad range of possibilities when setting their preferences for criteria value changes in comparison to the values of criteria in the current solution. These criteria can be separated into seven or less than seven classes based on these preferences. The scalarization problem can be expressed as follows:

To minimize

$$max\left(\max_{k\in K^{\geqq}}\frac{\left(\bar{f}_k - f_k(x)\right)}{\left|f'_k\right|}, \max_{k\in K^{\leqq}}\frac{\left(f_k - f_k(x)\right)}{\left|f'_k\right|}, \max_{k\in K^{<}}\frac{\left(f_k - f_k(x)\right)}{\left|f'_k\right|}\right) + \max_{k\in K^{>}}\frac{\left(f_k - f_k(x)\right)}{\left|f'_k\right|}$$

under the restrictions

$f_k(x) \geq f_k,\ k \in K^{=} \cup K^{>},\ f_k(x) \geq f_k - \Delta_k,\ k \in K^{\leqq},$

$f_k(x) \geq f_k - t_k^{-},\ k \in K^{><},\ f_k(x) \geq f_k - t_k^{+},\ k \in K^{><},\ x \in X,$

where: $-f'_k = \begin{cases} \varepsilon, if\ |f'_k| \leq \varepsilon, \\ f_k,\ otherwise. \end{cases}$, ε is a small positive number.

In some of the relatively older interactive methods, in which scalarization problems OSP1 and OSP2 are still used, it is theorized that there is an implicit target function of DMPs. These methods are search oriented and their processes are terminated when the mathematical end checks are met. The interactive methods using scalarization problems OSP3 through OSP13 were developed in applications that are only concerned with the general structure of DMPs' preferences. The application is such that for DMPs, larger is the prefered to the smaller. This is equal to the requirement for the implicit target function of DMPs to be strictly increasing. These methods are directed at learning and their work ceases when DMPs are satisfied with the solution they are provided.

Outranking methods

Outranking methods that include TACTIC (Vansnick, 1986), the PROMETHEE methods (Brans, 1994), the ELECTRE methods (Roy, Multicriteria Methodology for Decision Aiding, 1996), etc, utilize the fact that there is a limited comparability between alternatives. The first step in these methods is the creation of one or several outranking relations which reflect the global preferences of DMPs. Next, this relation is used to aid DMPs in solving multicriteria analysis decision-making problems. Four types of binary relations are used when comparing the two alternatives:

- Of indistinguishability ***I*** (reflexive and symmetric);
- Of weak preference ***Q*** (non reflexive and asymmetric);
- Of Strong preference ***P*** (non reflexive and asymmetric);

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– Of comparability ***R*** (non reflexive and asymmetric);

The outranking relation 'covers' these four relations. In most outranking methods it is considered that DMPs are either incapable of or unwilling to make an expressly distinction between these four relations and this is why they choose to set a more general inter- and intra criterial information. Intercriterial information is expressed in weights and veto thresholds, while intracriterial - as indistinguishability thresholds and preference.

Outranking methods and methods based on the multiattribute utility theory are traditionally used for resolution of a broad class of multicriteria analysis problems. Currently, these methods have no viable (competitive) alternative in resolving problems with many criteria and few alternatives.

2.3. Intelligent techniques for decision-making analysis

This will be a brief introduction to intercriteria analysis, which is a new approach to aiding the decision-making process that has a wide range of applicability in various spheres, objects and problems (including economics). This instrument is widely acknowledged and shows lots of promise in the area of Data Mining.

The concept of intercriteria analysis is based on the apparatus of indexed matrices IM (Atanasov K., 2014) and intuitionistic fuzzy sets (Atanasov K., 2012). This approach is especially designed for multicriteria decision-making situations, where, according to certain criteria, measurement and assessment can be slow, expensive, resource-consuming, etc. In these cases, it is of great importance for DMPs to be able to ignore all or part of the unfavorable criteria without much loss of accuracy. To this end, a sufficiently high and predictable correlation between said "unfavorable" criteria and others, among those in the available set of criteria, which are faster, cheaper and easier to measure or evaluate, is sought. There is a hypothesis that overlooking some criteria (without a significant drop in accuracy) during decision making on the basis of an established correlation between them and other criteria may significantly increase or decrease the costs of the decision-making process.

Intuitionistic fuzzy sets (IFS) are among the most popular add-ons to Zade's fuzzy sets concept. Fuzzy sets build upon the traditional by introducing the function of membership. They allow for the assessment of membership to a set with interval values between [0; 1]. IFS expand on the concept of fuzzy sets by introducing an additional function for nonmembership, which is assessed in the same interval, but with the requirement of two memberships and their sum to be in the same interval.

IFS are used as mathematical instruments for treatment of uncertainty. The purpose of these is to create a matrix (as a result of coupled comparisons of objects and criteria) with parameters n x n, which stores the measurements/assessments of m assessed objects on n assessment criteria and sets in the form of intercriterial pairs the correlations between each two,

A high enough correlation between DMP designated unfavorable and favorable criteria exists when the respective value of these two criteria (row and column) in the matrix is higher than the previously defined threshold for IF membership and lower that the previously defined threshold for IF nonmembership (the thresholds are in the interval between [0, 1]).

IFS are used in pair comparisons and assessment of behavior of objects based on criteria, as well as for definition of values of thresholds of correlation between the criteria and thresholds for permissible error necessary for the decision-making process.

Indexed matrices are the fundamental instrument of the method. WIth their aid, input arrays with set values of objects relative to set criteria, as well as input matrices with the calculated degree of correlation between each criteria pair are described.

In brief, IFS can be defined as $A = \{\langle x, \mu_A(x), \nu_A(x)\rangle, x \in E\}$, where $\mu_A(x)$ is the membership of the element x in set A, calculated in the interval [0; 1]; $\nu_A(x)$ nonmembership of the element *x* in set *A*, where $\mu_A(x) \in [0;1], \nu_A(x) \in [0;1]$ and $\left(\mu_A(x) + \nu_A(x)\right) \in [0;1]$.

The comparison of two IFS elements includes the comparison in pairs between the degree of membership and nonmembership of these elements.

Let there be indexed matrices with elements $\mathrm{a}_{p,q}, p = 1, \dots, m, q = 1, \dots, n,$

$$M = \begin{array}{c|ccccccc} & O_1 & \cdots & O_k & \cdots & O_l & \cdots & O_n \\ \hline C_1 & a_{C_1,O_1} & \cdots & a_{C_1,O_k} & \cdots & a_{C_1,O_l} & \cdots & a_{C_1,O_n} \\ \vdots & \vdots & \ddots & \vdots & \ddots & \vdots & \ddots & \vdots \\ C_i & a_{C_i,O_1} & \cdots & a_{C_i,O_k} & \cdots & a_{C_i,O_l} & \cdots & a_{C_i,O_n} \\ \vdots & \vdots & \ddots & \vdots & \ddots & \vdots & \ddots & \vdots \\ C_j & a_{C_j,O_1} & \cdots & a_{C_j,O_k} & \cdots & a_{C_j,O_l} & \cdots & a_{C_j,O_n} \\ \vdots & \vdots & \ddots & \vdots & \ddots & \vdots & \ddots & \vdots \\ C_m & a_{C_m,O_1} & \cdots & a_{C_m,O_k} & \cdots & a_{C_m,O_l} & \cdots & a_{C_m,O_n} \end{array}$$

where C_p is a criterion which participates in the assessment; O_q is the assessed object; $\mathrm{a}_{p,q}$ Is the assessment of the q-th object by the p-th criterion and is defined as a real number or a different object, which is comparable by relation *R* to all other elements of the indexed matrix *M*, so that the relation $\left(R\left(a_{C_k,O_i}, a_{C_k,O_j}\right)\right)$ is valid for every *i*, *j*, *k*.

The relation *R* has a double link $\bar{R}$, which is true for the cases when *R* е "false" and vice-versa.

If the number of cases for each relation $\left(R\left(a_{C_k,O_i}, a_{C_k,O_j}\right)\right)$ and $\left(R\left(a_{C_l,O_i}, a_{C_l,O_j}\right)\right)$ are simultaneously satisfied for $S_{k,l}^{\mu}$ and the number of cases when the relations$R\left(a_{C_k,O_i}, a_{C_k,O_j}\right)$ and their pair $\bar{R}\left(a_{C_k,O_i}, a_{C_k,O_j}\right)$ are simultaneously satisfied for $S_{k,l}^{\upsilon}$, then

$$0 \le S_{k,l}^{\mu} + S_{k,l}^{\upsilon} \le \frac{n(n-1)}{2},$$

while the total number of pair comparisons between objects is $\frac{n(n-1)}{2}$.

For each *k*, *l* such that $1 \le k \le l \le m$ and for ≤ 2 , we define two numbers:

$$\mu_{C_k,C_l} = 2\frac{S_{k,l}^{\mu}}{n(n-1)}, \upsilon_{C_k,C_l} = 2\frac{S_{k,l}^{\upsilon}}{n(n-1)},$$

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$$0 \leq S_{k,l}^{\mu} + S_{k,l}^{\nu} \leq \frac{n(n-1)}{2}.$$

The pair formed from these two numbers plays the role of intuitionistic fuzzy assessment of relations, which can be established between any two criteria C_k and C_l. In this case, the indexed matrix M, which is related to the assessed objects' criteria, can be transformed into another Matrix M^*, which gives the following relations between the criteria:

$$M^* = \begin{array}{c|ccc} & C_1 & \cdots & C_m \\ \hline C_1 & \langle \mu_{C_1,C_1}, \nu_{C_1,C_1} \rangle & \cdots & \langle \mu_{C_1,C_m}, \nu_{C_1,C_m} \rangle \\ \vdots & \vdots & \ddots & \vdots \\ C_m & \langle \mu_{C_m,C_1}, \nu_{C_1,C_m} \rangle & \cdots & \langle \mu_{C_m,C_m}, \nu_{C_m,C_m} \rangle \end{array}$$

It is more convenient to work with two indexed matrices M^{μ} и M^{ν} than the indexed intuitionistic fuzzy pair matrix M^*.

The last step of the algorithm requires the definition of limit values for membership and nonmembership, for which the accuracy of ICDM is being assessed. It is assumed that these two criteria of membership and nonmembership are either in "positive consonance", in "negative consonance" or in "dissonance" depending on the comparisons of their intercriteria couples with the two defined limit values.

Let $\alpha, \beta \in [0; 1]$ be limit values, by which the values of μ_{C_k,C_l} and υ_{C_k,C_l} are compared. We also assume that criteria C_k and C_l are in:

- (α, β) - „positive consonance", if $\mu_{C_k,C_l} > \alpha$ and $\upsilon_{C_k,C_l} < \beta$;
- (α, β) - „negative consonance", if $\mu_{C_k,C_l} > \beta$ and $\upsilon_{C_k,C_l} > \alpha$;
- (α, β) - „dissonance", otherwise.

There are a lot of accumulated results from intuitionistic fuzzy set research and indexed matrices into intercriteria analysis and methodology of its applications.

This approach is applicable to data analysis of competitiveness at the macroeconomic level (Atanassova, Doukovska, De Tre, & Radeva, 2017), it gives the opportunity to isolate especially strong correlating criteria and it allows for research of their behavior under changing threshold values, as well as in different points in time. Bearing in mind that economic data is inherently strongly correlated, the possibility of reducing assessment criteria has its reasons (when researching problems in economics). The analysis also allows for discovery of strongly correlating criteria, for which it can be hypothesized that they can play the part of "economic multilicatiors", meaning that investing in them and improving their ratings may lead to realizing higher investment returns.

This approach is also applicable for data of micro, small, medium and large enterprises, rated on various economic indicators (number of enterprises, people hired, turnover, added value, etc.) (Doukovska, Atanassova, Shahpazov, & Capkovic, 2015). Comparison is possible by indicators in groups, groups among indicators, definition of consonance degree, indistinguishability in coupled indicators and models with similar behavior of criteria in groups of intercriterial pairs.

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The application of IKA to the creation of innovative clusters shows great potential. Moreover, it is demonstrated in (Atanasov K., 2015) that it can be a invaluable instrument in the area of Data Mining.

Software realization contributes to its practical application. Additionally, it relieves the not-so-small computational complexity, entrance to large arrays of data and results visualization, which helps interpret and analyze researched objects.

This software product is realized in the C++ programming language. The original environment for its development is Microsoft Windows. Its compiler is the „CL.EXE“ from the Visual C++ 2012 packet. The multiplatform library Qt was chosen for the development of its user interface. It provides classes with which graphical objects (visible on screen) are created, as well as the classes for non graphic function e.g. strings, connections to databases, etc. (Mavrov, 2015).

The applications was also realized for Linux through the distribution OpenSUSE and the compiler „g++“ from the GNU Compiler Collection.

The application can receive input data in two ways - in the form of a file supported by Microsoft Excel or in the form of a text file, in which the elements of each row are separated by tabulations.

The result of the intercriteria analysis method is a matrix intuitionistic fuzzy pairs. It is presented as two tables, one under the other. The first table deals with degrees of membership (μ) and the second - degrees of nonmembership (ν) between criteria pairs.

The application has additional functionality. It has a module for prediction of pre-selected criterion values. It provides two possibilities for work - Prediction of evaluation on D-criterion for a new object, and trial prediction of all available objects for both methods.

The application gives the option for graphical visualization of the result in the intuitionistic fuzzy triangle. The assessments of all criteria pairs are expressed as points in a triangle, placed in a resizable window.

If it is necessary to check to which pairs of criteria certain points refer to, a rectangle can be drawn around the points, which opens a window with the names of the pairs of criteria found in that area and their corresponding values for □ and □.

To classify the criteria, the intuitionist fuzzy triangle is divided by means of a rectangular grid positioned relative to the endpoints in the graph. In the appendix, a diagonal strategy method is used and the results are displayed if the form of a list. It is possible for some pairs of criteria to take the same position.

The intercriteria analysis algorithm was also developed in the MATLAB environment in order to facilitate the calculations of some applications (e.g. meta-heuristic algorithms).

2.4. Sociocractic approach to decision-making.

Some of the models in Sociocracy (now known as S3) are presented in the exposition below. The selection was made with a view to brief introduction and direction of attention to the advantages of using or fully implementing models in the creation, development and management of economic clusters.

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S3 is an innovative platform for management of self-organizing structures with both economic and non-profit aims. It is entirely or partially applicable to various organization or hierarchic levels. Economic clusters, as a concept, structure and goal, have the necessary potential for the realization of S3 in full detail and diversity.

A decision of individual heads of enterprises, teams or projects is to what extent are the offered transformations a prerequisite for the introduction of a new way of thinking, practicing and managing relations when creating innovative clusters. These transformations are compatible not only with the values of equality, concordance, agreements, and collective responsibility, but also with pure economic indicators of effectiveness (efficiency), competitiveness, flexibility and sustainability.

Sociocracy is a management framework for development of effective, sustainable and flexible organizations. It functions as modular models and practices for all aspects of management and development. It is designed to support organizations in the improvement of their services and products by introducing a painless and iterative approach, which promotes the use of already existing facilities to their fullest and allows for the creation of structures for efficient cooperation (Reinventing Organizations: An Illustrated Invitation to Join the Conversation on Next-Stage Organizations).

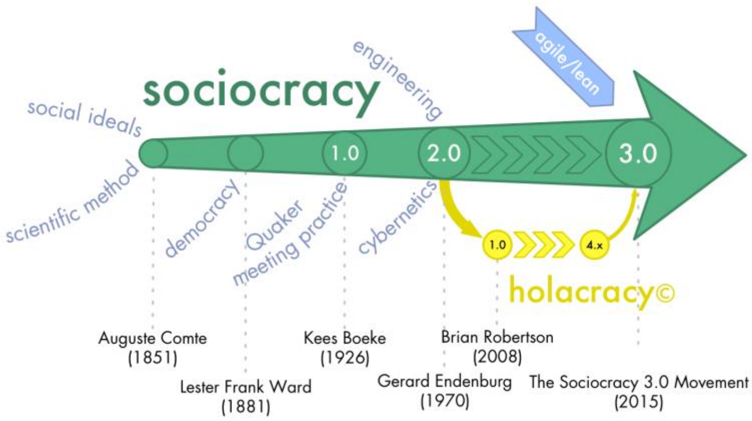

Fig. 2 Short history of Sociocracy from 1851 until today[2]

Sociocracy as a form of management has been mentioned since 1851. It was later adapted from various scientists and organizations such as Gerard Edinburgh, The Sociocracy Group (TSG) and Brian Robertson (HolacracyOne) In 2014 The Sociocratic movement establishes as their mission the spread and accessibility to the highest number of organizations possible through the creation of Sociocracy 3.0 (S3) which is completely free and open-source (www.sociocracy30.org) Fig. 2 shows a diagram for the historic development of S3 as a combination between social modeling and the application of scientific methods for management of social and business structures.

[2] This figure and all other figures used in this chapter are from the following source: (Bockelbrink & Priest, 2016).

Introduction and common terms

S3 is a framework of module principles and practices for cooperation in organizations which are looking for higher effectiveness, flexibility and stability (Bockelbrink & Priest, 2016) It's applicable for organizations on every scale, from small businesses to large multi-national business networks in the framework of national or international partnership.

The principles in S3 format the language of the template e.g. every principle can be applied individually, while the templates reinforce each other. In this way, the reorganization process is made easier through positive transformation of the activity and relationships between the different individuals, teams and organizations by:

- engaging with agreement between participants;
- education;
- improvement of products, processes and skills;
- development of flexible organization structures in support of the effective flow of information;
- attracting the collective intelligence and experience of the teams;
- development of strategies which are "good enough for now" and "safe enough to try"

The Sociocratic approach for management is based on **basic concepts:** for a model, principles, drivers (leading motives), domains, agency, responsibility, self-organization and semiautonomy.

In the sense of S3, **the principle is a pattern for navigation in a specific context, which can be developed and adapted to different contents and grouped in nine categories** (fig. 3): making and evolving agreements; governance; effective meetings; coordinating work; building organizations; people and roles; organization structures; alignment; bringing in S3 patterns.

Fig. 3 Categories of patterns in S3

S3 principles are based on seven principles of organization culture and are of utmost importance in their integration (Laloux & Welber, Reinventing Organizations, 2015).

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1. **Principles of effectiveness:** Time is alloted only for those activities that help achieve aims. Wasting resources, time and effort is avoided. Obstacles are removed and decisions which are “good enough for now” and “safe enough to try” are sought after.
2. **Principle of consent**: Actions are undertaken only when there are no causes which prevent achieving aims more effectively. In complicated situations, the collective experience ranks above the individual experience. Consciously harvesting objections stimulates the teams to strive for consent and helps the early identification of disagreements.
3. **Principle of empiricism:** Testing all proposals for a given organization and their interactions through experiments and constant re-examination. In every complex, adaptive system (for example a group or organization) the knowledge of the system and the relationships of its elements are preliminarily stated and dependent on the content. Experience, gathered through examination and observation creates a learning practice which is effective and sustainable to changes.
4. **Principle of continuous improvement:** the reaction to changes is realized in small steps by developing and transforming what is already available, so that the risk and resistance is reduced and an adaptation to constant empirical learning is achieved. Evolution is more effective and more sustainable than revolution in the majority of cases. The constant improvement is related to all aspects of activities and relationships, for example strategies, guidelines, products, skills, processes, values and instruments.
5. **Principle of equivalence:** The teams affected by certain types of decisions can change them based on a set of reasons. Post, rank, function and role have no significant influence on decision making.
6. **Principal of transparency:** The complete set of information is available to everyone in the organization. Confidentiality requires consent. The necessary information is maintained, actual and historical information is archived for reference.
7. **Principle of accountability:** A response is required when necessary and responsibility is taken for things that have already been agreed upon. It is applied to groups, organizations and individuals, and encourages the change of state from “holding people accountable” to “taking personal responsibility”.

The main term in S3 is **agreement: a** *contractual framework for a process or protocol with the aim of directing the flow of values.*

The life cycle of an agreement (fig. 4) has the following stages: presence of tension, identification of a driver (a driving motive), collaborative development of proposal for support of the driver, consent with the proposal and periodic revisions and improvement of the agreement.

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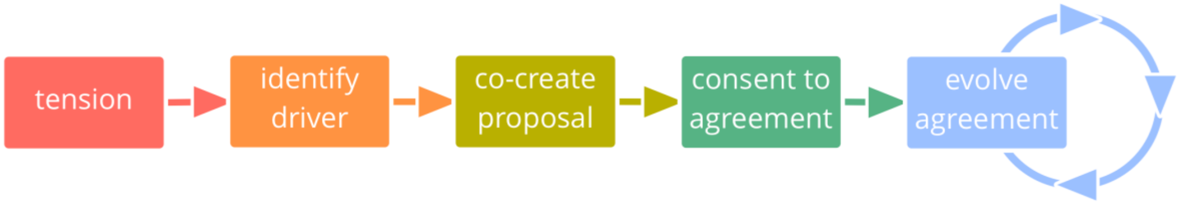

Fig. 4 Life cycle of the agreement

Tension is personal experience: symptom of disagreement between perceiving a given situation from a different person's perspective and their expectations (or their preferences) The challenges and opportunities for an organization are revealed in situations in which teams realize and own up to their tension which they feel in regards to them.

Identifying organizational drivers can be allocated to a suitable domain for examination.

Driver *is a driving motive of a person or group (team) for reacting to a certain situation (aim, task, issue).* It is used to extract aims, missions, visions and purposes. Drivers are dynamic and can change with time. The main drivers in S3 are "value" and "waste". *Value* is importance, worth or usefulness of something related to the driver. *Waste* is something which is not needed or is getting in the way of the effective function of the driver.

Domain *is a separate sphere of influence, activity and decision making in an organization.* All domains are contained in the common domain of a given organization, but can also overlap and/or be contained entirely in other domains.

The joint creation of a *proposal* is the basis on which agreements are made. Agreements are made on the basis of reaching assent and develop through periodic revision, specification or editing.

Below are some brief explanations of the principles, included in the nine thematic categories of S3. The principles do not follow a specific order of realization, but rather detail activities and describe procedures for attaining a certain result. A given organization, team or individual can prefer the use of separate principles in regards to the their needs, aims or as an experiment.

Creation and development of agreements

The category "Creation and development of agreements" includes 15 principles (fig. 5), some of which will be described briefly.

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Fig. 5 Principles in the category of "Making and evolving agreements"

The "*Driver*" principle is aimed towards clarification of the resulting situation and the needs of the team or organization in regards to defining the necessary actions and decisions (incl. creating a role, agreement, alignment, helping a team or creating a domain.

The Drivers are directly or indirectly connected to the main driver of the organization [organizational drivers], others can be outside the domain of the organization.

The driver is defined as a task, problem or opportunity, dependent on the point of view of members of the team, the whole team, or the organization. The description includes a short synopsis of what's available and the definitions in a given situation.

*The Principle "*Circle*"*. The Circle is an equal, semi-autonomous and self-governing group ofpeople, which cooperate for the rendition of an account of a domain *(fig. 6). The circle is an integral part for cooperation in which there are no hierarchies. The Circles are:*

- *semi-autonomous:* Each circle has a unique driver and can create value independently;
- *self-organized:* independent when organizing daily tasks;
- *self-governing:* independent in the creation of strategy and agreement.

In relation to the principle "Circle" the term role *is formulated.* ***Role*** is a field of responsibility defined by a given domain and assigned to a given individual. Principles connected to roles, their description, advancement, selection, overview of effectiveness and plans for development are included in the category of "People and roles" and will be touched upon briefly, aside form the instances for clarification of other principles.

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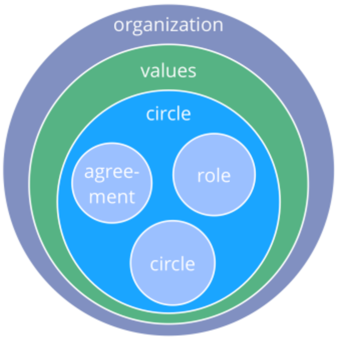

Fig. 6 Connectivity and dependency of positions and elements

The principle "*Objection*" is used when *something which is in the way of the effective response of the driver* is identified. The Objection consists of information for a different or plausible consequence of harm, ways for improving proposals, decisions, existing agreements or measures.

Voicing objections is the responsibility of separate individuals. They take steps or formulate proposals for the consideration of arguments and working out objections. Objections can be made at any time and stop current and planned activities, the execution of decisions, and increases the operation time of existing agreements.

S3 offers a separate principle for overcoming objection which will not be reviewed here.

The principle "Consent decision making" is one of the most important ones in S3. *The minimal definition of consent is the lack of well-grounded, first-rate complaints on the part of the affected entities by the given decision.* The aim is to quickly reach a decision that is good enough for now, without it necessarily being completed.

Consent is not consensus. It serves as a basis for cooperation in achieving a shared aim and is used as a main principle for all interactions within the organization and can be applied to every decision or agreement.

Consent is used for formulating and developing all agreements in a given circle.

The principle "*Formulating a proposal"* is a format for jointly creating a response to an answer of drivers, which includes people in joint creation of agreements, encourages responsibility and the feeling of ownership. It is realized in the following steps:

1. *Definition:* of the driver;
2. *Consideration:* Collecting reasons as questions which showcase the scope of the issue;
3. *Creation:* Collecting the parts / ideas for decisions;
4. *Specification:* Comprising a proposal from some or all parts;
5. *Review:* process of making decisions based on consent.

The principle "*Strategy*" is an approach aimed at creating values in the framework of the domain. It is maintained by an organization, team or role. It includes a description of the planned result. If there is a complicated issue or driver, it is usually not known what the best response is. To increase security, the approach - strategy which sounds the most convincing is chosen. The strategy is realized by breaking it down into separate decisions. In this context, all decisions are experiments and decisions are made on how they will be segmented and in what order they will be realized.

If there are indicators that the strategy is not effective or successful, “navigation” is necessary, e.g. using the experience of the experiment to attune the strategy or create a new one.

The principle “*Evaluation of agreements*” includes suggestions and procedures for reevaluation of agreements, removing “*waste*” and adapting to the changing context. In short, this is a process of evaluating whether a given agreement can be made better and if there are reasons against its continued existence.

Waste is tension. Tension exists in various forms and levels of abstraction, for example in tasks, agreements, working processes, organizational structures or mental principles. The process of acquiring experience when identifying waste is long but also helps in understanding drivers.

Establishing a process for constant removal of waste allows for the natural evolution of an organization in the direction of higher effectiveness and optimized flow. As a side effect, the organization will naturally adapt to changes in the environment.

The principle “*Result*” includes a short description of expectations from agreements, actions, project or strategy, as well as specific criteria for evaluation and indicators which can be useful when reviewing the results

The result **is something that is acquired following an agreement, usually in the shape of a product or service.** Results can be set for organizational strategy, circle strategy, development plans, descriptions of roles or other agreements.

The specific definition of results is important for the improvement of:

- organizational strategy;
- strategy for forming and functions of circles;
- development plans;
- description of domains;
- every other agreement (for example for business purposes, rules for processes, communication with clients).

The principle *“Evaluation criteria”* allows us to see the extent to which a given agreement has the desired effect. The evaluation criteria need to be unambiguous. Using metric values makes it easier to locate diversions from the expected result and to make the necessary adjustments.

The principle *“The committed decide*” helps to include all participants which have been affected or are otherwise involved in the decision making process. It is necessary to maintain equivalence, accountability and to increase the quantity of available information on every topic requiring a solution.

For larger groups, the process is split into several stages and smaller groups are created, which choose delegates.

The principle “*Agreement*" is a guideline, framework, process or protocol, designed to direct the flow of values. Agreement is created to reflect the leading drivers, to coordinate the accountability of the circle which has made the agreement, to define the evaluation criteria. Agreement is subject to regular review.

S3 suggests the following example of agreement (fig. 7):

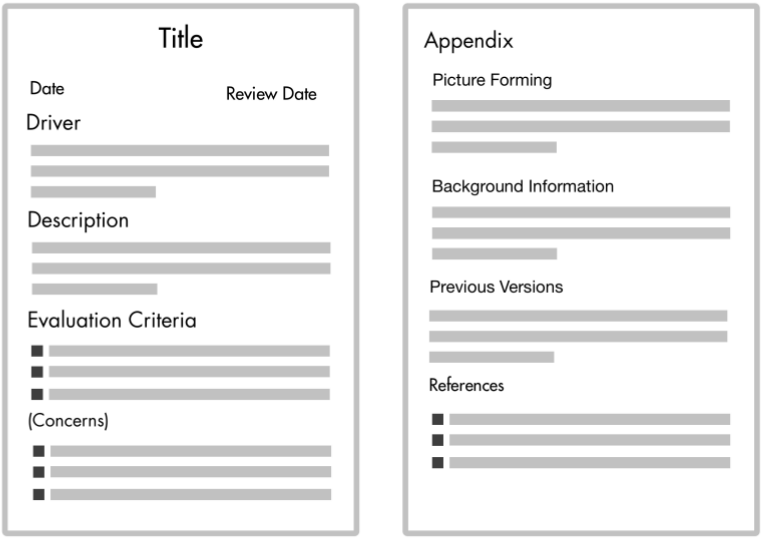

Fig. 7 Agreement form example

All elements of the agreement are descriptive. The driver of the agreement is described in detail, e.g. the primary motive for its conception. The description is made in as much detail as possible, because the information in it explicates the evaluation criteria, as well as any concerns that have arisen in the course of the discussion on forming and accepting the proposal.

The appendix to the agreement includes a summary of the overall picture of the situation, the object of the agreement, the background information, previous versions if the agreement is reviewed and the new aspects in its current version.

Governance

In the category of “Governance” (fig. 8) the principle “Navigation via tension” deserves the most attention. The idea here is that people behave like sensors for the organization. Tension emerges when our conception of what is happening is in conflict with our expectations or values (and principles) Examining tension reveals leading motives behind tension. The principle’s procedure prescribes a description of the situation and identification of the needs associated with it. After developing a certain level of understanding, two possibilities emerge.

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The first one is to decline or postpone undertaking new activities. This option terminates the procedure.

The second one is a response to tension via:

- updating the agreement (if there is one), terminating the agreement (again, if there is one) or creating a new agreement and
- updating a driver or splitting the driver, when a new circle or new role is created for his response.

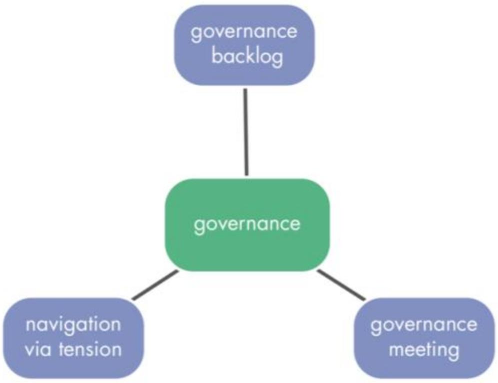

Fig. 8 Governance

The final two principles prescribe procedures for governance of incomplete activities and activities in the process of realization. The other model prescribes procedures for governance of assemblies and meetings, their initiation, documentation and coordination which is partially covered in the next category, "Effective assemblies".

Effective Meetings

This group of models covers a constant scope of activities related to the regular meetings of the teams, the format, frequency, agenda, documentation and the governance of these meetings (fig. 9):

The same applies to the principles recommended for realization of meetings of separate circles: technique for simplification of the maintenance of equal treatment group; selection of assistants; preparation of agenda and topics; evaluation of the meetings; through the required time for consideration of the experience of the meetings or seminars, reflection on the interactions, marking the success and the proposals for improvement, etc.; problems of governance, set as drivers related to responses of a certain domain and requiring attention, forthcoming reports, decisions, proposals for the creation and discussion of overview agreements and selection of people for roles.

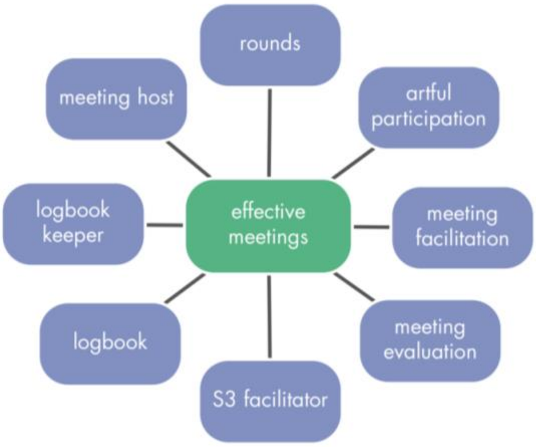

Fig. 9 Effective meetings

If necessary the complete description can be found in the respective guidances in S3 (Priest, Bockelbrink, & David, 2017).

Work Coordination

Work coordination includes principles for backlog and a to-do-list of the incomplete activities (drivers) which are often prioritized and are under kept under review. These include: Incomplete missions, emergency operations and detained products. Principle of "Visualization" of work which ensures transparency of the condition of all work positions in progress or completed ones. Principle for organization of startup and stimulation of work, restriction of the current tasks (fig. 10):

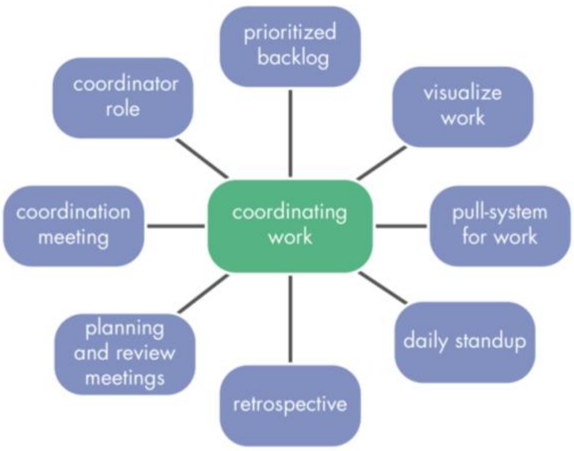

Fig. 10 Coordinating work

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Building organizaitions

The category "Building organizations" (fig. 11) includes principles of linking and creating open systems and aligning the values in flows. This category is related to the three main categories - "People and roles", "Organizational structure" and "Alignment". This link enables and promotes the application of the principles which are part of linked categories and standardization of the procedures in the creation and startup of S3.

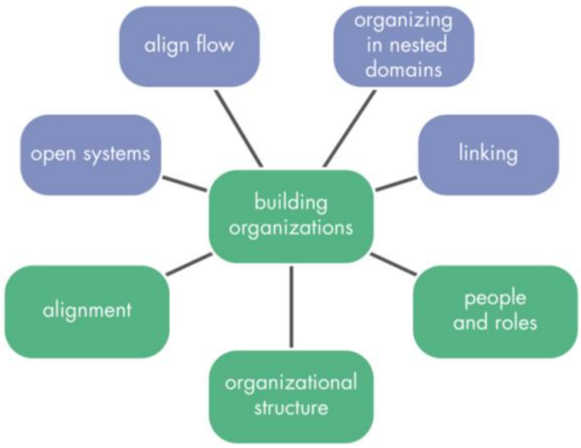

Fig. 11 Building organizations

The "Aligning the flow" Principle (fig. 12) deserves attention because it is designed to keep the constant flow of value through the constant perfection of agreements between the work circles in the organization.

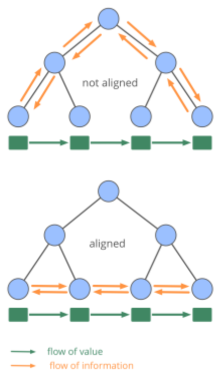

Fig. 12 "Aligning the flow"

The flow is directed and coordinated by (obvious and implicit) agreements and proposals. The current work is regarded as "waste" because it requires and ties up resources. The continuous flow of resources reduces the potential of accumulation of waste and makes for shorter feedback loops and amplifies learning.

The "Linking" principle simplifies the information flow and the influence between two circles (groups). The group selects a delegate from their members to stand for their interests in the decision making of another circle (fig. 13).

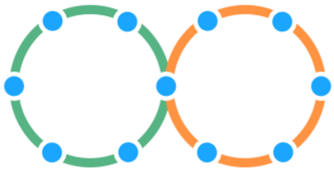

Fig. 13 Linking principle

In the principle of "Open systems" the organization can benefit from its relationships and training with other parties.

Through the recognition of its dependency an organization can consciously invite external information, influence or skills in order to support the decision making process and to support the collective training. The external experts can offer an external perspective and contribute to knowledge, understanding and skills.

People and roles

This group of principles describe the recommendations for building, maintenance and regulation of relationships in the organization, for example Searching for co-operation, feedback, partnership overview and plans for their development (fig. 14).

Fig. 14 People and roles

Organizational Structure

The main function of the principles in the "Organizational structure" category is effective co-operation, through aligning the flow of information to support the flow of values (fig. 15). The organizational structure has to constantly develop in order to adapt to the changing environment.

Sociocracy 3.0 describes a variety of principles for the growth of the organizational structure. The principles are applied to different layers of abstraction (main, micro, macro and meta). They use different drivers and can be combined according to the needs.

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Fig. 15 Organizational Structure

The principle ’’Double Linking” is designed to simplify the two-way flow of information and influence. Two mutually dependent circles select their delegates who will participate as full members in the meetings for governance of the two circles. The organizational structure can be used for prevention of tension in the hierarchical structures (fig. 16).

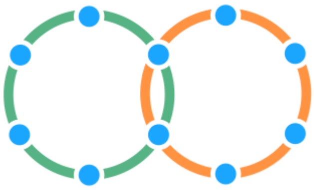

Fig. 16 Double - linked circles

The Principle “Delegate Circle” is for coordination between several teams or circles (fig. 17). Motivation for the use of this principle is the availability of a shared domain and the impossibility for autonomous decision making. The principle provides for a selection of a delegate from each circle. The delegates form a functional team which coordinates the exchange of flow of information and decisions for the shared domain. The role of the delegates is to inform their colleagues about the anticipated decisions and the result of the activities of the delegate circle as well as to provide feedback in the delegate circle.

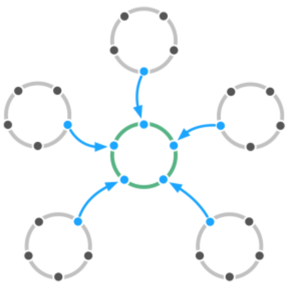

Fig. 17 The delegate circle consists of delegates and other circles.

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The ’’Service circle” principle is used for outsourcing of shared services. When several teams identify a service they can share, each team selects a delegate to a service circle. (fig. 18). The service circle can then increase its capacity by bringing in more people.

Fig. 18 Service Circle

The “Peach” pattern is applied when there is a periphery and a center where the periphery drives the organization and the center provides services (fig. 19). All teams in the periphery of the organization are in exchange with the outside world, e.g. with customers, users, partner organizations or affiliates. Services required for the periphery are grown in the center, e.g. administration, coordination, finance, HR, IT services.

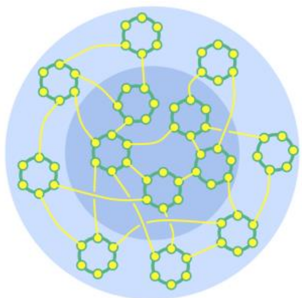

Fig. 19 Peach Organization

The “Double-linked hierarchy” pattern is used for the early phase of a transaction (fig. 20). In a double-linked hierarchy, the flow of information and influence between adjacent levels of the hierarchy is balanced through sending delegates upwards and downwards.

Each level of the hierarchy is made up of a team (instead of individuals).

Each team on a lower level selects one delegate to represent them in the team on the next higher level. Each team on a higher level sends one delegate to each team on the lower levels. This way, there are always two people familiar with the perspective of each team present in decision making on the next higher level. Also, when making decisions on the lower levels, there’s always two people present who can bring in the perspective of the next higher level.

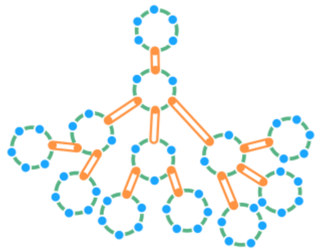

Fig. 20 Double - linked Hierarchy

The “Fractal organization” is used for earning, coordination and alignment across organizational boundaries (fig. 21).

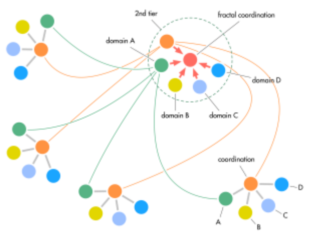

Fig. 21 Fractal Organization

Alignment

The patterns in this section help an organization align through the adoption of formal and informal regulations, cultural and ethic values in the base ideological framework of the personnel, teams, leadership and contractors (fig. 22).

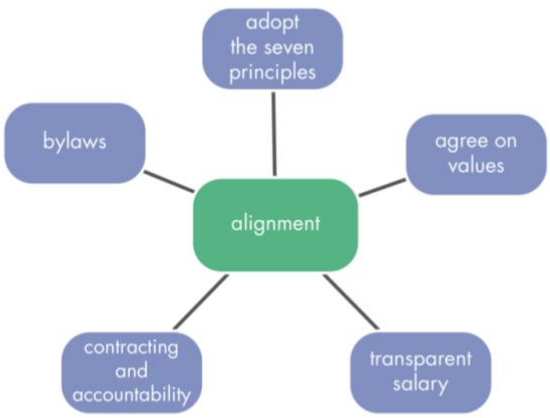

Fig. 22 Alignment (grouping, aligning, ordering)

The "Adoption of the seven principles” pattern aims to reduce the number of of explicit agreements and to adopt the S3 principles in the context of the organization.

The “Agree on values” pattern is for intentionally shaping a culture in an organization. Values are principles which guide behavior. They define the scope of action and the ethical

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constraints. Each member brings their own values to an organization based on personal experiences and beliefs. The teams and organization may choose to collectively adopt values to guide their collaboration.

Values offer guidance to determine appropriate action, even in the absence of explicit agreements.

Defining values is a strategy that supports effectiveness of an organization. It reduces the potential for misunderstanding, aligns decision making action and the explicit agreements in action.

Values are agreement and thus subject to regular review.

The "Transparent salary" pattern makes the value of remuneration in an organization public. This is one of the most considerate patterns.

The pattern is functional on the condition of fairness in remuneration, although perception of fairness is specific to organizational context.

The formula of forming the salary is a prerequisite for relieving the introduction of the pattern may consist of:

- Fixed: Subsistence guarantee;
- Variable: fair distribution of gains and costs;
- Remuneration for changing roles;
- Transition towards new contracts and compensation agreements.

There are two approaches to the realization of this pattern (fig. 23):

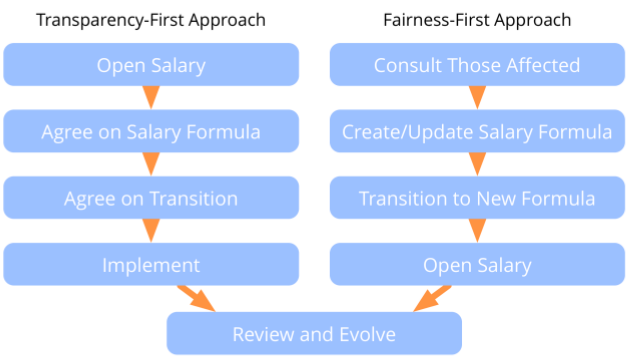

Fig. 23 Two approaches to transparent salaries

The first approach, "open salary", is in the first place, then "agree on salary formula", "agree on transition" and "implement". In the second approach "fairness" is in the first place, then "consult those affected", "create/update salary formula", "transition to new formula" and the result - "open salary".

The "Contracting and Accountability" pattern for formal and informal agreements is to ensure all parties understand what is expected of them and intend to keep to the agreement. To preserve the organizational structure, maintain self-accountability. To provide a smooth start, help new members of an organization or a team and define expectations for them (both cultural and legal).

Contract alignment with the organizational culture and legal requirements. There need to be clear procedures for breaches of contract.

The “Bylaws” pattern secures inclusion of S3 principles and patterns in regulations to protect legal integrity and organizational structure. The formation of regulations provides: consent and equivalence in decision making, selection process for leadership roles, clear organizational structure, formation of values and principles, influence of owners and stakeholders, sharing gains and costs.

S3 Adoption

The "S3 Adoption” category patterns are presented in fig. 24:

Fig. 24 Bringing in S3 Patterns

The “Adapt Patterns to Context” pattern of a given organization it should be accepted that patterns are merely ideas but the context is certainly different, so if it is simply copied and pasted it might not work.

The basic steps of the process of adapting a pattern are very simple, and can be implemented in various levels of detail:

- develop shared understanding of the pattern and context of an organization;
- develop the patterns in the adaptation;
- co-create an adaptation of the pattern;
- consent to adaptation;
- test adaptation;
- evaluate and evolve;

The “Pull-System For Organizational Change” pattern is applicable to e.g. reorganization. Change in organization is commonly designed by a small group of people, often without even consulting many those teams or parties affected by that change. This is not only a sure way of creating resistance to change in people, it also does not take into account the actual

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capacity for change, often overloading the system and therefore reducing the overall capacity of the system - the exact opposite of the intended outcome of the change.

In S3 a pull-system is created by giving the people decision making power over all agreements which affect them and thus they will be able to navigate both scope and speed of organizational changes.

In context to S3, organizational change is creating and evolving agreements on organization and collaboration in the form of agreeing.

Of course, taking responsibility for all decisions that affect them is tough to swallow for any groups, and different members will have a different understanding of what makes a good decision making process. To reduce resistance, the group or groups are invited to carry out a short-term experiment (a month) For creation of proposal and decision making process. In the absence of objections, review sessions are scheduled one month in the future.

The “Continuous improvement of work process in S3” pattern aims to reveal tensions and helps establish a metrics-based pull-system for organizational change.

“Driver mapping” includes procedures for workshop format for identification of effective response to a complex situation, e.g. Organization of start-ups, kick-off projects, tackling major impediments or opportunities, alignment of organizational structure to the flow of value.

Small or large groups identify and prioritize drivers, progressing quickly from concept to action in self-organizing teams.

The result of driver mapping is organizational structure aligned to the pull of external and internal actors, e.g. customers/users, partners, members, communities and municipalities.

Most of the activities described below are suitable for groups of 10-15 people (depending maturity of the group and skill of the facilitator), for larger groups consider having participants self-organize into groups of up to five people, and add activities to consolidate input of the groups and consent to the result.

The implementation of driver mapping explained below is just one way to implement it, it has to be made sure to adapt it to the organization’s specific needs.

Step 1: Identification of the drivers. Identification and description of the driver for organization in terms of needs and conditions to each driver. Output of this phase is one or more posters with details on the driver.

Step 2: Who are the actors (roles). Defining the actors and the relevant parties. Actors can be individuals or groups, also the organization itself, or parts of it, as well as individual members. Output of this step is defining all relevant needed actors who can support or impede.

Step 3: What do they need? Output of this step is a collection of needs of each role and the expectations of them.

Step 4: Identify domains. Output of this step is a set of posters with domains, which will later be implemented as circles, roles, or, in some cases, agreements.

Step 5: Organize. Output of this step is an agreement on how domains will be connected and coordinated (if necessary), as well as the type (circle, role, agreement) for each domain.

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Create a proposal for circle structure (including roles, if any), include delegate circles, coordination circles and service circles to link domains as needed.

Step 6: Populate circles. Find members for each circle. Output - a list of members for each circle.

Step 7: What do we need to run safely? Collect missing resources, skills or capacity, unclear boundaries or scope of the circle, open questions, required handovers or tasks for transitioning from the previous structure (if any), risks, challenges, impediments and opportunities. Output - a collection of proposals for amending circle structures and circle membership, as well as open questions, work items and governance items for each circle.

Conclusion

In conclusion to what has been presented above remain the motives concerning the recommendation for S3 adoption in the cluster formation in economics.

The main difficulty in the clusters is not in their formation as an initiative and selection of participating profit and non-profit organizations, it is in their management. The cluster functions as an equal and self-organizing structure whose hierarchy is studied on the level of elements (a separate firm). On a higher level of organization hierarchy can lead to temporary and unstable characteristics. In the standard case hierarchy regulates and distributes responsibility, it also maintains functions and the flow of resources and information. Hierarchy on the highest level is a blurred concept due to the fact that the different firms keep their autonomy but their relations are regulated by agreements and mutual consent to sharing of financial and non-financial resources aiming to increase the stability, competitive power, effectiveness, innovation and the common economic condition of the elements in particular the cluster as a whole.

Examining the human resources as a material or non-material asset, we see that it has used up its capabilities and requires redefinition of the aspects of management and regard, because the results are based on internal and external motivation while the material asset doesn't form motivation for improving or increasing its current condition.

The cluster is a voluntary unification of enterprises in which people work, is an organization managed by people, and as a structure is maintained by people. They create, convert and disband groups, teams and circles, which in the context of S3 can mobilize their collective experiences, potential and ability to learn through personal motivation, shared value system and framework for ethical behavior in which the causes and consequences from decisions are a result from dialog, collective effort, purpose, discipline, commitment and shared responsibility.

The creation of such a configuration of relationships combined with the full variety of economic aims has the potential to create a favorable environment, which can serve as the foundation of a new cluster management and is of interest to apply on a larger scale even as an experiment, training alternative or a prospect for integration.

3. Overview of main conceptual methods for clustering.

Experience shows that high competitiveness is maintained by combining technologically linked and businesses ready to interact on a cluster basis.

The main characteristics of a cluster are:

- A cluster includes manufacturers, clients, suppliers and agents from other industrial sectors which have supporting functions, training, qualification, and services related to innovation in industry, advertising, research, administration or other activity.
- Relationships in the cluster are based on mutual partnership, cooperation and mutual interdependence in the conditions of the market economy. The cluster is a unique, self-regulating production system in which firms can cooperate in vertical and/or horizontal chains to receive added value and to increase competitiveness. Clustering is a practical step towards business cooperation, it stimulates asset growth, technology, infrastructure and joint investments (effects which are harder to achieve working alone) (CSD, 2007) (GCIS, 2008).

The advantage of the cluster organization lays within its direct stimulation of development of competitiveness on the national economy, where the emphasis is on regional development. The disadvantage is the high dependency between the effectiveness of the cluster organization and a stable national policy regarding the public-private partnership and the established rules, regulating relationships between it and government institutions.

Identification is the first stage in the development of the cluster design. It defines the elements and their structuring in a network on which existing interdisciplinary nodes and missing units are designed. In this way, the structured network can develop into a cluster.

The classification of concepts for economic clusters is:

1. According to the theoretical principles of localization and specialization of proceedings where their main reason for industrial specialization is the existence of basic resources, markets or historical preconditions.
2. According to the balance of the interdisciplinary nodes (Input-Output (I-O) tables).
3. Porter's theoretical approach to competitive advantages and concentration on effective, interconnected economic activities of individual enterprises linked through the "diamond of competitive advantage" or the "golden Ratio" of national or regional economics, providing competitive positions for the specialized, national or global markets.
4. *"Top-down"* clustering: national economics is decomposed on regional clusters, determining a national framework for cluster development by defining missing elements; and *"bottom-up"* clustering: determines a significant industry for the region and the elements related with it. This concept is suggested when designing emerging clusters.
5. Cluster integration: geographical - development of economic activity on the local level; horizontal - integration of various industries; vertical - linking on the chain "sellers - buyers"; lateral - integrating different sectors for realization of the "scaling effect"; technological - integrating analogous industries; focusing - integration of a single center.

The concepts are directed towards analysis of already established clusters and are harder to apply when forming new ones. Newly created clusters require forecast scenarios and elements to be developed, and existing or estimated monetary relations between elements to be identified.

The choice of the type of method of identification is determined by the chosen concept. The nodes between elements in existing or emerging clusters determine the selection of concepts. The purpose of the methods of identification is in the successful and reliable identification and argumentation of these nodes. These methods can potentially be split into three groups: **qualitative, quantitative and hybrid.**

3.1. Quantitative, qualitative and hybrid methods of identification

A basic step and method for identification of economic clusters diagram is shown in Figure 25.

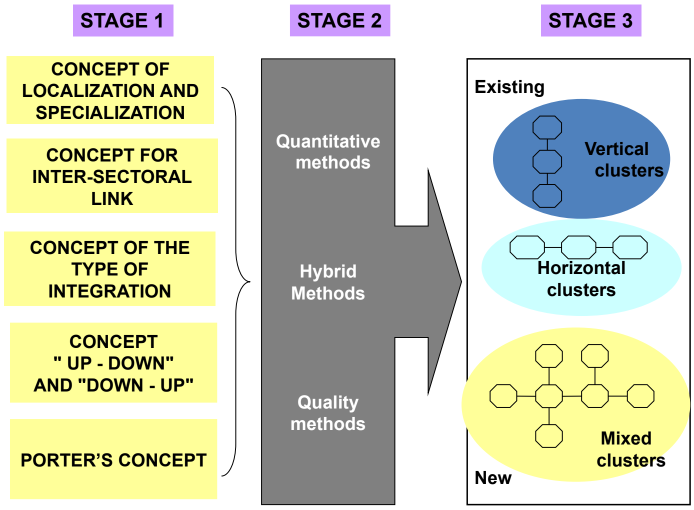

Fig. 25 Basic methods for identification of economic clusters

Qualitative methods are expert scores and research. For the first ones, information is gathered from interviews, polls, brainstorming, etc. Preferred methods for processing are the Delphi method, SWOT analysis, GEM+, MSQA (Multi-Sectoral Qualitative Analysis). The method research is realized by examining formal and informal horizontal and vertical nodes, incl. ones in an economic environment.

Qualitative methods are: I-O (Input - Output) table analysis and analyzing the level of specialization or regional importance through coefficients of localization. The following refer to the first ones: multivariate statistics; methods based on graph theory; analysis of main

components and factors. Based on the I-O table data, clusters are identified by determining the potency of the nodes between the various industries from the supply chain. The various methods differ in the technology they use to process and analyze information by evaluating

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the potency of nodes related to the “sales and purchases” of products/services or the intensity of exchange of innovations.

The different industries are grouped by sets of criteria when using multivariate statistical analysis as the industries are separated in *c* by number of clusters (expertly set c) based on their similarity. Hierarchical methods use binary comparison of industries.

In the methods based on graph theory, the cluster is defined as a collection of technologically linked industries, interacting in the same production cycle, controlled by market factors. Clusters have a hierarchical structure, on the top of which lays the production of the final product. The structure is described using a graph, on the vertices of which the technologically linked industries are placed. The connections describe the economic links the respective streams flowing on them, while the edges describe the manufacturers of the cluster-defined final products. According to the theory, each graph can be represented as a symmetrical matrix which reflects only internal commodity-monetary relations in the cluster.

Analysis of main components and factors processes I-O tables by defining a number of industrial cores (basic or main components and factors) between which the primary streams of “sales and purchases” flow. The intensity of trade nodes is determined by doing a correlation analysis. Research shows that if the correlation is between 0.35 and 0.6, the industries belong to a cluster.

Methods of analysis on the level of specialized or regional importance through coefficients of localizations. They are appropriate to identify vertical clusters or ones having elements pertaining to a sector. They define industries with the highest level of concentration or development, export-oriented, leaders of a given region. Various coefficients of localization are used under the assumption that leading industries with a higher than average development form different industrial clusters. The calculated coefficientd $К_л$ represent the ratio between work of employees in the given industry from the total employees in the region and the work of the employees in this industry in the country as a whole form the total employees in the country. This is how the level of concentration of the working force in the respective industries is determined and the level of specialization in the region is characterized. When $К_л > 1$, the concentration is above average for the country (high level of specialization in the region and export-oriented industry). When $К_л < 1$, the concentration of this industry is lower than the country’s average and when $К_л = 1$ it’s on an average level for the country. After ranking the industries using this indicator, the existence of the cluster is defined for all industries for which $К_л > 1.25$ (Велев, 2007).

The advantages and disadvantages of the quantitative and qualitative methods are summarized in Table 1.

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Table 1 Advantages and disadvantages of quantitative and qualitative methods

	NAME		ADVANTAGES	DISADVANTAGES
Qualitative methods	Expert score		Processing a large volume of inaccessible information. High reliability	Insufficient representativity of the samples. Subjectivity.
	Research		Full characteristics of industries. Developing new EC	High price. Duration in time. Applicable for different sectors or small regions
Qualitative methods	I-O table analysis	Multivariate statistical analysis	Choice of criteria	Large volume of information. Forming mutually exclusive clusters.
		Graphs and technological sets	Visualization capability	Only the internal commodity-monetary relations are represented, under the condition that the industry is only used in EC
		Analysis of basic components and factors	Statistical evaluation potency of trade nodes. Identifies closely related industries	Forms analogous behavioral alignment in "sales and purchases". Does not report vertical nodes. Can not be applied to new EC. Can not be applied to Horizontal EC
	Coefficients of localization		Clearly sets parameters	Does not report inter-firm nodes. Is not used for vertical EC. Allows for uniformity of conditions on regional and national levels.

Searching for the best method for identification of clusters leads to the creation of hybrid methods. They are a combination of qualitative and quantitative methods, and the type of combination is determined by the specific research. The goal is to expand the conceptual framework of the identification method. Research shows that there is still no hybrid method which is satisfactory to analysts. Realistically, the identified clusters deviate sharply on completeness and precision of the used information. An even bigger issue is identifying emerging clusters.

Using combinations of different methods with the purpose of partially dampening the identified disadvantages is one of the main trends in solving specific tasks. The most used combinations are the methods of I-O tables and expert scores, coefficients of localization and expert methods (IPM method) Verification of expert information is a risk factor when it comes to application, even though hybrid methods in practical research allow for achieving significantly better results (V elev, 2007).

As a selection toolset of the identification method, in regard with the chosen concept, the use of the “Concept x Methods” matrix is applied.

3.2. "Concepts x Methods" matrix

The “Concepts x Methods” matrix shows how the selected identification methods relate to concepts of cluster design and to what degree do they manage to successfully identify the industry nodes. The matrix can be used as a tool for selecting a method or a combination of methods if preselected concept is chosen (Radeva, I., T. Naneva, 2007).

”Concepts x Methods” matrix

Concepts \ Methods	Qualitative methods					Qualitative methods		Hybrid methods
	I - O tables	Coefficients of localization	Factor analysis	Graphs	Multivariate analysis	Expert score	Research	
Marshal	X	X	X	X	X	X	X	X
Between industry nodes	X	X			X			X
Porter			X		X	X	X	X
"top-down” and "bottom	X	X				X	X	X
Type of integration		X		X				X

Analysis shows that **quantitative methods** are effective when there’s enough statistical data if the adopted concept relates to the identification of a geographical location or interdisciplinary nodes. A disadvantage when using these methods is that they can’t satisfactorily identify emerging formations, competitive motives and specific forms of integration.

The concept of competitive advantages enables the tendencies of localization and competitiveness to become the main motive in the economic clustering and to have a great potential in the description of “informal” relationships.

The hybrid methods have the potential to involve the structure, links and relationships in the cluster regardless of the concept adopted by the analysts. They are practically unlimited combinations between quantitative or qualitative methods and especially effective with the identification of newly-formed clusters.

Research shows that the main problem with the identification of economic clusters remains the defining of the basic cluster concept and the selection of an effective identification method. The proposed matrix supports selection. It is observed that the hybrid methods have a greater potential in solving particular problems. The techniques of fuzzy information and the based on them systems for decision making based on a multi-criteria analysis are a possible solution. The correct selection of identification method is the first step in the constructing of such systems and enables the effective reflection of the analyzed economic environment and cluster strategic positioning control.

3.3. Network models

The compiling of different organizational tools for cluster initializing leads to the formation of new synergy effects which reveal additional opportunities for improving competitiveness and innovation (CSD, 2007).

In a modern environment a structural integration model can be applied in several directions. Key aspects are the vertical branch integration, regional integration and network integration.

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The first two forms are used on the macro level with the aim of increasing national competitiveness. On a microlevel to which MSP relate, network integration is most commonly used (Paunov, 1997) - horizontal integration of agents for manufacturing a specific product/service (groups of products/services) or a collection of manufacturers of a product/service (groups of products/services) for the purpose of operating on a common infrastructure (information systems, educational systems, technologies, marketing and others).

The network model has developed the most in recent years. This model forms the network organizational structure which is characterized with a freely linked flexible vertically organized network of equal different in role and functions independent partners with specific limited resources. This organization enables the achievement of a synergistic effect through voluntary and collective self-limitation and specific contribution to achievement of results which meet the interests of all partners and preservation of their individuality (Kaplan R., D. Norton, 2006).

When the networks are formed, the group participants are: scientific organizations, enterprises, financial and management institutions.

The main advantage of the network model is its flexibility and adaptivity. Mobility and ease with which this structure changes its form and lines are the key factor for the speed with which it would respond to the requirements set for it. The price of these advantages is too blurry and it is impossible for it to be precisely defined. The structure organized in this way is significantly effective with the agents functioning in a dynamically changing aggressive environment and for strategies in which the innovation component vividly dominates.

The networks compile both effectiveness from the “scale economy” and dynamics and effectiveness characteristic for the agents. In the European practice business networks have proved their effectiveness.

The result from the activity of similar business networks is the achievement of sustainable competitiveness not through price but through quality, topicality, security and speed of deliveries and the unification is done not with new technology but with successful market result and innovations.

Advantages of the network model can be the following:

- The programmed (balanced) participation of agents in the process of manufacturing and realization of goods/services.
- Emergence of additional an additional organizational resource, allowing for the effective use and reproduction of social capital;
- Forming an effective and sustainable instrument for communication and balancing mutual interest and activity.

A disadvantage of the network model is that as opposed to the classic market approach (Tunzelman, 2002) market-based networks do not guarantee an automated sustainable growth, especially in transitioning countries. It is a fact, that in the practice of networking, the existing networks follow their own strategic aims which are incompatible with other networks with which they interact in the industrial environment.

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During the integration of economic agents[3] as a main development potential of national economics, the development and perfection of approaches for designing clusters on a regional, branch or product principle become topical.

Evaluating the effectiveness of income for economic clustering is based on the supposition that it is not only the result of an effective activity of each agent but a consequence of a synergistic effect in their interaction. The main effect is sought in group interaction with the internal and external environment ensuring sustainable competitiveness which is a function of the knowledge, capital and qualification of the working force and the integration of innovations.

[3] From this point on, instead of “economic agents” we will use “agents”, for short.

4. Developing an approach to cluster design.

Cluster design is the result from analysis of a set of enterprises - potential elements and their distribution on the DM - defined technological network. The network has to meet the the strategic aim of the cluster in full. Generally, it is possible to formulate several alternatives for realization of the cluster design. To support the decision making process, two models are applied:

- *for the selection of agents - participants in the cluster and*
- *for the selection of a cluster structure, formed by the chosen agents.*

The models include two steps, procedures and stages which describe the general scheme of the approach, integrated as a concept in the cluster development.

4.1. Descrption the basic non-formalized formulation of clustering approach.

Basic non-formalized formulation of the cluster approach is shown on fig. 26, 27 and 28.

The process for agent selection and forming lists of cluster candidates is shown on fig. 26 and includes a definition of input information regarding the cluster technological network, the system of agents - candidates' evaluation criteria and the basic branch indicators for the nodes of the technological network. After a calculation of the indicators by chosen models, regulations of agents by network nodes are acquired, as well as for the entire network by complex scores, alongside lists for the following analysis.

The process of selecting cluster design is shown on fig. 27. Here we include an analysis of the acquired regulations by agents, formulating a strategic aim and strategic topics of the newly-forming cluster, determining the forecast time horizon, compiling lists of activities, scoring foretasted income and expenses and distributing them by activity on the strategic topics and forming strategic budgets.

The process of final selection of cluster design is shown on fig. 28. It includes the formation of a system of balanced score card as an evaluation system of alternatives for forming foretasted budgets, verification of budget acceptability, prognosis of agent parameters for the preliminary time horizon in their work in the conditions of the structure of cluster and a final selection of cluster design in case that the potential participants reach an agreement. The final selection process provides a module for risk evaluation which is not discussed here.

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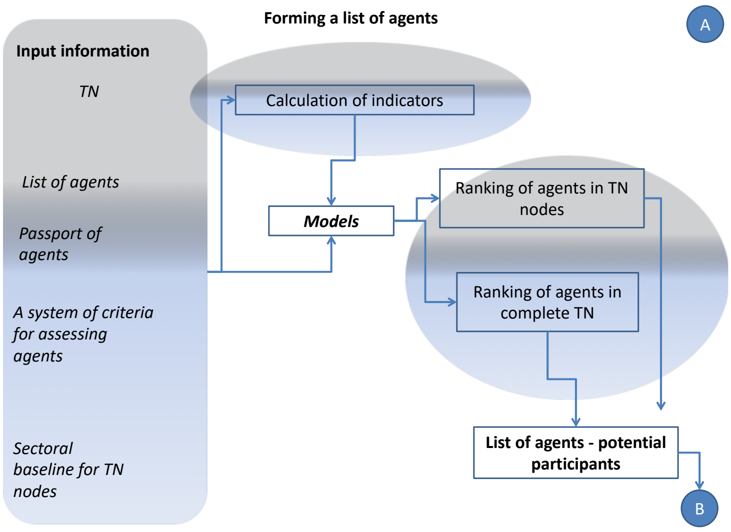

Fig. 26 Diagram of agent selection

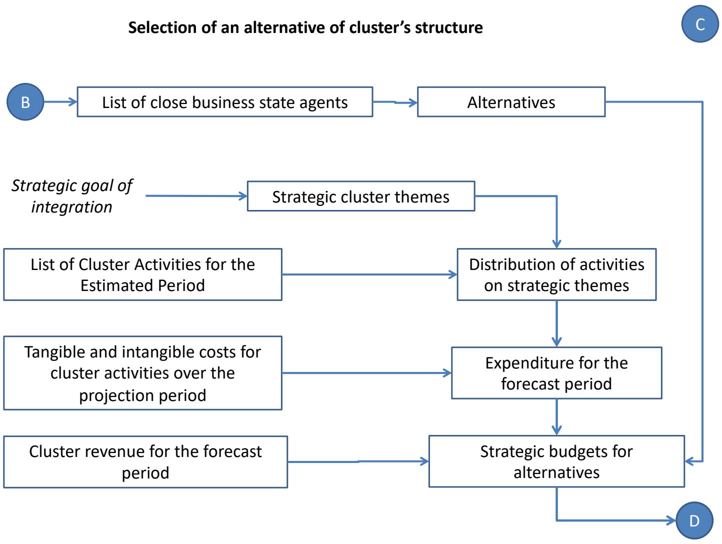

Fig. 27 Selection of alternative of cluster design

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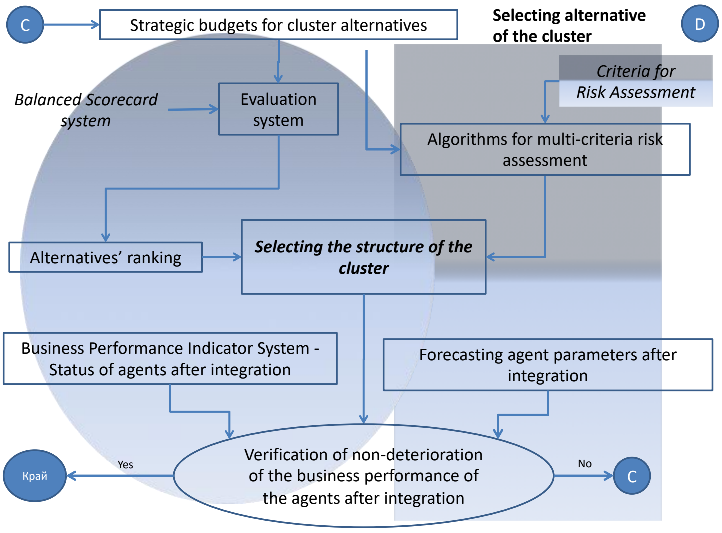

Fig. 28 Selection of the final cluster design

Below are presented detailed descriptions of the agent selection models, cluster design, formulated problems, steps, stages, procedures and the needed information.

Selection of participants in the cluster design

The selection of participants in the cluster design aims to - from a set number of enterprises (agents) distributed in the links of the technological network (specialized belonging, main activity) on the basis of the assessment of the state of development (DS), select similar to this evaluation agents. It is realized in three steps:

- Regulation in descending order by evaluation of the state of development of the agents by network nodes;
- Regulation of agents in descending order for evaluation of the condition of development for the whole network;
- Selection of agents - participants. Selection criteria: Similar values of the evaluation of sustainable development (SD).

The criteria included in the complex development state assessment and sustainable development assessment are presented below.

In order for the three steps above to be implemented the solution of three tasks is proposed.

Task 1: Calculation of DS of the agents which belong to one and the same network link (horizontal integration), and ordering of the network links in descending order. Output - lists of agents for each link of evaluation in descending order.

Task 2: Calculation of DS of the agents and regulation for the entire space of the technological network in descending order. Output - list of agents for the entire network in a degree of lowering the evaluation.

Through application of the outputs of the first two steps a list of agents is expertly formed - potential participants.

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Task 3: In the system of criteria defined as “sustainable development”(SD), the agents from the list (step 2) are positioned on the polygon of sustainable development. Output - distribution of the agents on the polygon of sustainable development which enables the description of groups with similar in value evaluation.

DS is introduced as complex evaluation of the sustainable competitiveness defined through the position of the agent in the economic space. Evaluation is implemented in the context of two integral parameters - economic creativity (EC) and competitiveness growth through competition (GC), which define the position of the agent over the polygon of sustainable development.

According to the main definition for the synergy effect, a number of agents is needed - potential participants in the cluster, to define a subset of similar in sustainable development agents.

For this purpose a system of multi-criteria evaluation of DS of agents (depending on the solution to the particular applicable task, in this evaluation system particular indicators are included) and a system of multi-criteria evaluation of SD are developed.

For the calculation of DS evaluation of agents “passports" are used, which include the values of main structure defining characteristics.

Each agent fills in a “passport”. The passport is generally presented in Section 4.4 Table 2. The criteria for calculation of DS value are presented in Section 4.4., Table 3. For evaluation of SD, criteria presented in Section 4.4., Table 4 are applied.

Through an expert procedure, if needed, local criteria weights which form the integral evaluations are assigned.

The solution to Task 1 includes the following steps:

Step 1: Description of the network and the number of nodes $\boldsymbol{m}$ is defined, industry, relations and connections in the products/services production and marketing process, etc.

Step 2: Compilation of the lists of agents for each nodes A_{mn} where $\boldsymbol{n}$ is the number of potential participants. Compilation of the lists of agents is done for each node $\boldsymbol{m}$**.**

Step 3: Compilation of “passport” for each A_{mn} with database for the given evaluation criteria system of DS (application of different methods for multi criteria decision making is possible).

Step 4: Ordering of A_{mn} (in this case in the role of alternatives) in each node of the network.

The solution to Task 2 includes analogical steps from Step 1.

Step 1: Compilation of “passport” for each A_{mn}, consisting of deviations of individual current values of parameters from the assigned basic values. The basic values are assigned for each node $\boldsymbol{m}$ from the network. The regulation of A_{mn} refers to the whole network.

Step 2: On the basis of relations from Step 1, complete ordering of the number of alternatives is implemented and a list of the ordered A_{mn} for the whole network is compiled.

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The solution to Task 3 includes the following steps:

Step 1: Analysis of the lists from Step 4 of Task 1 and Step 2 of Task 2. In accordance with the specific task from the list of each node a threshold value is inserted and a list of A_{mn} - potential participants in the cluster.

Step 2: Through the given criteria system the evaluation of SD for each A_{mn} is calculated. It is recommended that the applied criteria enable growth evaluation through competition (GC) and the economic creativity (EC) of A_{mn}.

Step 3: A polygon of sustainable development is assigned - two-dimensional space which enables the defined group A_{mn} with similar values of SD.

Step 4: Through the calculated in Step 2 values each Amn is positioned on the polygon of sustainable development.

Step 5: On the basis of the acquired positioning of Amn on the polygon groups with similar SD are formed. The solution of this step can have the following variants:

- No alignment *of* A_{mn}. This means that there are no agents with similar SD which increases the possibility of occurrence of negative synergy as a result of integrating various elements;
- **A high number of sparsely populated groups,** which makes the formation of a cluster design more difficult;
- **A low number of groups** among which there is a group with a majority of A_{mn}. *This is a prerequisite for the formation of a cluster.* If the requirement that every link in the network should contain at least one *Amn* is not met, further analysis is required and a decision to either attract elements from other groups or build up *Amn* for activities in the empty link, or to organize activities in the link as an external service;
- *A group, the network links of which are filled in.* In this case, there is a decision for the cluster design which fulfills the requirements.

Solving the three aforementioned tasks allows for the creation of lists with similarly matched agents in terms of sustainable development who participate in the cluster. The close proximity of the agents is reason enough to assume that during the integration process the effect of negative synergy will be avoided.

Selection of cluster design

The selection of cluster design is the result of analysis of the technological process of the manufacturing/realization process of a given product/service, the conditions of the business environment and the state of development of the many agents. The results of the analysis allow a product-oriented network to be implemented. The main condition for the implementation of the network is: maximum accomplishment of the set strategic aim. In the common case for realizing this structure, many alternatives can be formed.

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To evaluate the effectiveness of integration we use a criterion called *Investment Preference* (Radeva, 2008), (Popchev, I. Radeva I, 2004) (IP_{KC})
Investment preference is an integral evaluation of the cluster design, which characterizes the perspectives of its development, profitability of its assets, cost-effectiveness of its assets, and its interaction with the external environment (markets, suppliers, clients).

To sum up, from a profitability and risk standpoint, the evaluation of IP_{KC} means that there is a presence of an economic effect from using materials, financial and non-financial resources with minimal risk[4].

The evaluation of IP_{KC} is achieved by solving a multi criteria decision task. The procedure for evaluating IP_{KC} is achieved with the help of a developed system called Balanced Score Card (BS_C).

4.2. Describing the structural pattern of clustering.

As the primary indicator for investment preference, an estimated consolidated budget is chosen. It is developed on the basis of the respective activities plan, results from the analysis of the business environment of the establishments and the work environment in which the design will function. A feature of the consolidated budget is the combination of financial and non-financial resources required for the realization of activities, allowing the completion of the strategic aim. for this purpose it is suggested that:

To define a system of indicators for the evaluation of the investment preference of the cluster alternatives;

Calculation of the estimated consolidated budget of the cluster.

Balanced score card system

For the evaluation of the investment preference of the cluster a system of balanced score card (BS_C) is developed. The development of the system is based on the methodology (Kaplan, R.S., D.P. Norton, 1996), (Kaplan P., 2006) called "system of balanced score card" BSC is one of the instruments for the realization of the cluster strategy.

According to (Kaplan, R.S., D.P. Norton, 1996), (Niven, 2008), (Niven, 2010) BS_C is a system for strategic governance. The measurement and evaluation of the effectiveness of optimally chosen indicators which describe financial and non-financial aspects of the cluster activity allows the use of BS_C as an instrument of governance. BS_C has to be implemented in such a way as to bring balance between short term and long term aims, financial and non-financial indicators, internal and external factors of activity. The integrated indicators measure the degree to which the set goals are realized and serve as evaluators of the effectiveness of the structure activity. In this case the BS_C system is the result of a multi criteria decision process of the indicators.

Clusters can be designed on the basis of the following suggestions:

- Integration of the business processes;

[4] The most widespread definition of risk is: probability of the occurrence of an event followed by loss. This probability is objective and equal for all objects in a given situation. A condition for the existence of risk is for it to be a future event and its occurrence to be possible, a number of possible results to exist and the probability some of the specific results to be defined. In essence, $Risk = Probability \times Impact$.

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- Interaction with clients and suppliers;
- Segmentation of customers;
- Globalizing scale;
- Innovation
- Intellectualization of the business processes.

These suggestions form the work environment in which the cluster has to function. The aims and indicators of the system form on the basis of the defined strategy for development and include the following guidelines for development: finances, markets (clients/suppliers), internal business processes, knowledge and development.

This is how BS$_C$ formalizes the incorporation of strategies, critical success factors for success and key indicators with the goal of measuring and evaluating the activities which realize strategic topics.

Consolidated budget

The consolidated budget is a collection of separate strategic budgets developed in accordance with strategic topics. A diagram for the development of the consolidated budget and its connection with strategic budgets by topic is shown on Fig. 29.

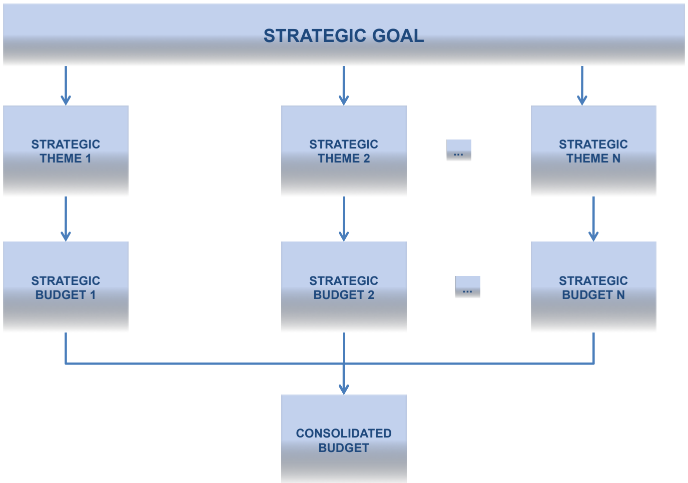

Fig. 29 Relation between strategic budgets and the consolidated budget

The development of a budget is a multistep, interactive procedure which allows the effect of cluster activity to be compared with the financial and non-financial resources required for its realization.

Organizing the budget starts by structuring a plan for activity. The plan relates predefined strategic topics with tasks (activities) which ensure their realization. Every task and activity is

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characterized by the duration of a preset period of time and the required resources (material, financial and human).

Organizational management distinguishes two types of budgeting: long-term (Capital Budgeting) and short-term (Continuous Budgeting) The estimated budget falls under long-term capital budgeting and has the following characteristics:

- Planning period of 3-5 years;
- Integral forecast of cluster activity;
- Main goal - evaluating the effectiveness of cluster activity.

Developing the plan which relates the strategic aim with the strategic topics and the realizable activities within the framework of these topics (fig. 30) realizes with these operations:

1. After strategic analysis of the information related to the governing environment (internal and external) a *governing strategy and strategic aim* are formulated.
2. Using the results from the model for selection of agents - participants *alternative cluster variants* are built.
3. *Strategic topics* for the accomplishment of the strategic aim assigned in 1 are defined.
4. By distributing the formulated strategies by topics for each of the cluster alternatives in 2 a *set of activities* required for the realization of the assigned strategy is described.
5. Based on the strategic topics, activities, resources and their distribution in time the *cluster activity plan* is formulated. The plan is a foundation for developing an estimated budget for a set estimated period for each of the alternatives of the cluster.

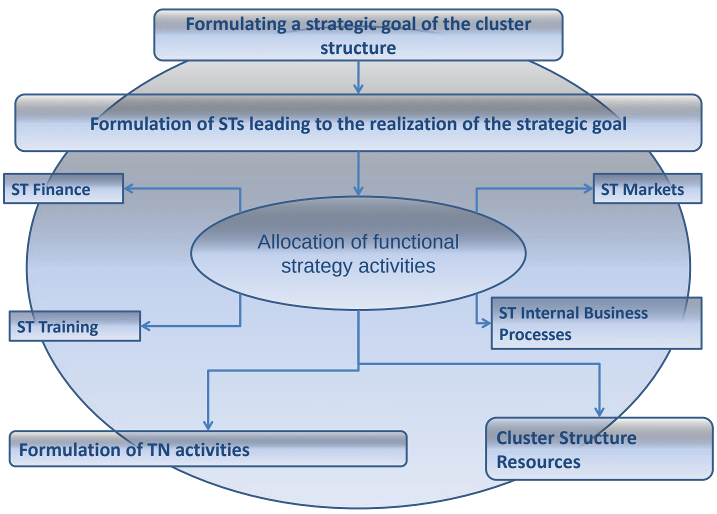

Fig. 30 Steps for strategic planning

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6. Budgets are calculated by strategic topics, which combine to form a common consolidated budget for each option (alternative) of a cluster. Verifying the acceptability of the alternative is done by comparing the discounted net cash flows (NCF) of the consolidated budget with the estimated expenses for activities which provide the estimated results. For the alternative to be acceptable the difference has to be a positive value. If the difference is negative a correction to the foretasted activities is made by lowering expenses or even excluding some of them. This procedure is called balancing the budget. Only balanced budgets are acceptable. To achieve a balanced budget the critical point of investment preference (CPIP) of the cluster design is calculated. This is an indicator which describes the point of intersection of the dimensions of the common expenses for the implementation of the activity and the changes in income from the activity generated from these expenses.

$$CPIP = \frac{DPC}{\left(\frac{(1 - CSDC)}{RR}\right)}$$

where:

DPC - direct production costs

CSDC - cluster design development costs

RR - revenue from realization

Quality evaluation criteria for the budget are:

– Variance from CPIP (ΔCPIP), Δ*CPIP* = *RR* - CPIP - (ΔCPIP/ Revenue from realization) (%)

Realizing this procedure requires these steps:

Step 1: Expert group formulates the strategic aim of the cluster design.

Step 2: Expert group describes the set technological network. The budget is developed for the defined network. The technological units (links) of this network and the links between them are defined in detail.

Step 3: Cluster alternatives are formed. The cluster alternatives are based on the A_{mn} lists distributed along the links of the network. The alternatives can be:

- *ALTERNATIVE 1* the network is incomplete and **the empty units will be serviced from external** for the network agents;
- ALETERNATIVE 2 the network is incomplete and the **empty units will be filled with newly established agents for the cluster (personal investments)**

  During the development period of the agent/s, the activities will be carried out by an agent who's external for the network;
- ALETERNATIVE 3 **the network is completely filled** will close agents from the **polygon**

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of sustainable development;

- ALETERNATIVE 4 the network is incomplete and the **empty units will be filled by attracting agents from those agents who aren't grouped.**

Step 4: For the defined in 1 strategic aim a planning period is chosen for the development of the budget. As a rule, it is within 3-5 years.

Step 5: A BSC structure is developed. (The model for BS_C development is described in Chapter 4.3., and an example in Table 17 in Chapter 4.4.)

Step 6: Activities are defined, which realize the specific alternative and the financial and non-financial resource needs. The resource needs are determined by statistical data or by experts.

Step 7: The information on the basis of which the budgets are calculated is verified (Table 6, Chapter 4.4.).

On the basis of the verified estimated consolidated budgets a program for “action - time” is developed. This program includes all types of activities, required for the realization of the various strategic topics. As a result of integration, a “actions - time” is developed for the realization of the strategic aim of the cluster (Table 7, Chapter 4.4.).

Depending on the conditions of the specific task, this example list of activities can be altered.

In relation to the developed program “actions - time” the financial and non-financial resource needs (work, assets, raw materials both physical and otherwise) are calculated. A forecast is made for the resource needs of every strategic topic and is generalized for the cluster. The used information is quantitative and expert. The calculated expenses are consolidated in the tables in Chapter 4.4.:

- Table 8 - work expenses for the planning period on separate qualification groups (in kind and value);
- Table 9 - expenses for material and non-material assets for the planning period (in kind and value);
- Table10 - expenses for raw materials by type (in kind and value);
- Table11 - “other expenses” (in kind and value);
- Table12 - total expenses by activities for the planning period.

In table 13 on the bases of tables 8-12, the expenses of the cluster by activities and periods are calculated.

The revenue side (Table 14) of the estimated consolidated budget can be formed by the following sources:

– Voluntary contributions by agents of a preset % of their net earnings and the value of FA, forecasts for which are made as a result of their structural integration.
– Proceeds from national and European projects and programs.
– Income from personal economic activity, including a prearranged part of the effect of scaling.

The resulting structure of the estimated consolidated budget is shown in table 15.
The common procedural pattern for building up the estimated consolidated budget is shown in Figure 31.

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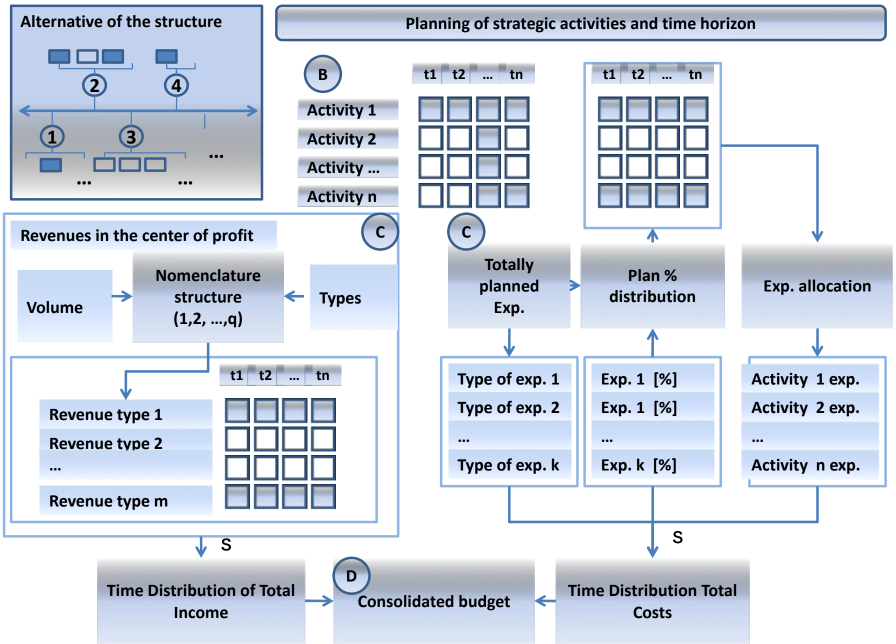

Fig. 31 Estimating a consolidated budget

The resulting consolidated budget is evaluated for acceptability. During analysis, the following alternatives are studied:

- The discounted NCF for the analyzed period is positive. The budget is seen as acceptable and participates in the decision process for a cluster alternative.
- The discounted NCF for the analyzed period is negative. The procedure for calculating the budget goes back to the beginning and a reduction of activities or a reduction of expenses for resources is made, i.e. the budget is being balanced. The iterations repeat until the discounted NCF becomes positive. If the balancing process cannot be achieved within 3-4 iterations the cluster alternative is excluded from the decision process.

The BSC indicator values are calculated by the developed alternative budgets and the forecast of the OSR evaluation of agents after integration.

For the sake of convenience, the primary data for indicator calculation of BSC can be systematized in Table 16, Chapter 4.4. An example of a finalized BSC structure is showcased in Table 16, Chapter 4.4.

The evaluation of the cluster investment preference as an integral grade for the given set of alternatives can be realized by standard algorithms for multi criteria decision making. In the case that the results of the multi criteria evaluation do not meet the requirements of the DM, an iterative cycle is provided, which runs the calculations of the corrected budgets again, after the corrections of the primary data for the development of the budget are introduced. As a general rule, the results of the first iteration direct the analyzers towards making the necessary corrections.

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In the case that the resulting decision doesn't meet the restrictive conditions of the task again, the iterative procedure returns and the budget calculation process is repeated for a new set of cluster alternatives.

The connection between the analyzed cluster alternatives, the provided planning time horizons, the distribution of activities, the revenue and expenses forecasting, the place of BS_C, the evaluation and resulting regulation of the cluster structure alternatives is displayed in Fig. 32.

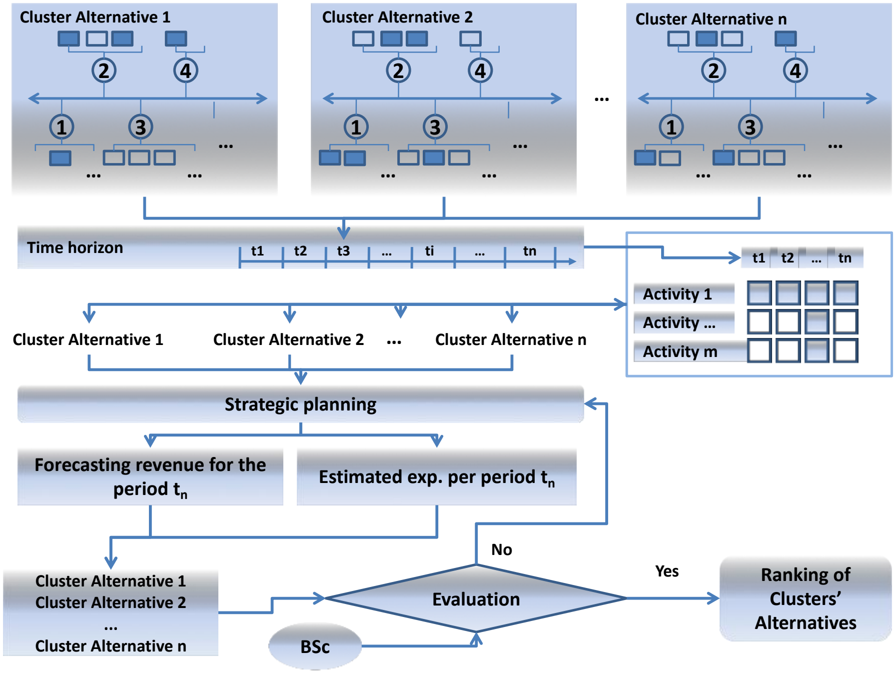

Fig. 32 Functional diagram of cluster structure selection

4.3. Formulating a strategy, critical success factors and key indicators for activities.

The formalized union of strategies, critical success factors and key indicators on a pattern principle is shown on Fig. 33.

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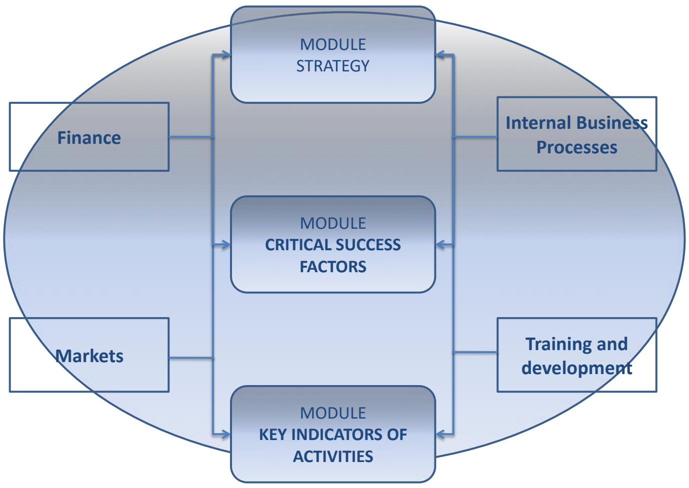

Fig. 33 Formalized union of strategies, critical success factors and key indicators

Pattern "*Strategies'*" unites the common aim and strategic topics (fig. 34).

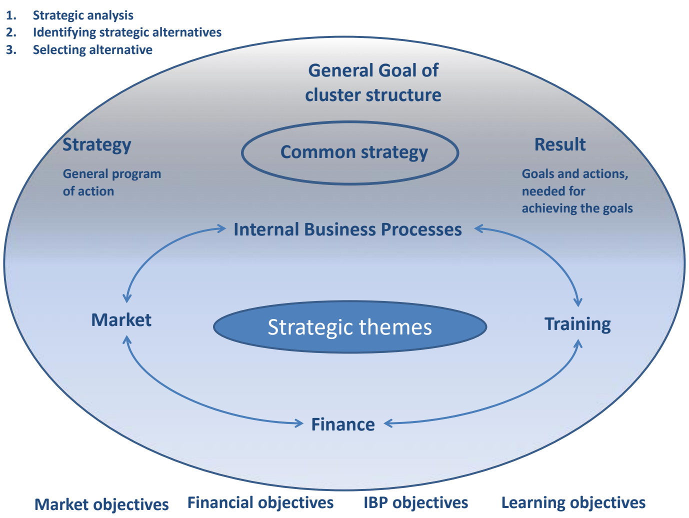

Figure 34 Pattern "Strategy"

By strategy we mean the complex governance of a given business structure, defining the main directions for actions, the mechanisms for decision making, the approaches and guidelines for development and structuring your work.

Strategic topics are guidelines for cluster activity, ensuring the realization of its strategic aim. Aligning activities by topics is:

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- “Internal business processes” - continuous chain of activities, aimed at satisfying the values of clients and combining three main processes: innovations, operations and after sale service.
- “Finances” - return on investment and economic added value.
- "Markets” (clients/suppliers) - market and customer share, required for the realization of internal business processes.
- “Knowledge and development” (education/development) - dynamic, systemic approach to defining a mechanism for effectiveness, including measurers of change, the factors which devise it and constant education.

The pattern *“Critical factors for success*” is a structure which reflects the internal links between factors which ensure the realization of activities and reaching the shared goal.

Critical factors for success are a collection of a small number of indicators which, if attained, guarantee the success of the entire structure. Formulating critical factors for success is a basis for development of a set of actions which ensure the realization of strategic goals.

The following **factors** can be applied:

- Increase in the effectiveness of using investment resources (effect of scaling);
- Common marketing research;
- Building a common information system;
- Common service;
- Unified system for standardization and certification;
- Common system for qualification and education.

The pattern *“Key indicators of activities*’" is a system of indicators which measure the condition of the critical factors of success.

When choosing key indicators of activities, you must consider the following requirements:

– Correspondence of the chosen indicators of the strategic goal of the cluster
– Measuring the chosen indicators - the indicator must be qualitatively defined to allow measurement;
– The number of chosen indicators is limited;
– A relation of chosen indicators should be defined.

The following indicators are suggested:

Financial indicators

	Profitability of income
	Profitability of expenses

Internal processes

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	Improving productivity (increase in the productivity of an individual) Improving the effectiveness of using assets (Increasing earnings per asset unit) Share of collective deliveries in groups of the total volume of deliveries Investing in new technologies; Developing a common information system Indexing the loyalty of the different agents in relation the activity of the cluster
Markets:	
	Number of clients Market share Share of loyal clients Average volume of sales to a single client.
Knowledge and development	
	Expenses for training Cost of shares for education in the total volume of expenses Number of the individuals engaged in qualification groups Share of highly qualified specialists in the overall number of employees.

Developing BS_C

For the development of BS_C, the following must be chosen beforehand:

Selection of elastic aims. The chosen aims must lead to qualitative changes in the activity of the cluster overall and to be variable and realistic for each element in the structure. *They must be formulated as strategic aims of the cluster.* In the process of formulating the strategic aims, it is useful to attract consultant groups which use modern methods for strategic planning and have access to current information. Aims are developed for a specific technological network for the realization of a product /service with the complete information for agent-elements of the network. The technological units (links) of this network and the links between them are defined in detail. Those links are horizontal (connections between agents in the link), as well as vertical (connections between links).

Selection of strategic topics. Guidelines for activities and strategic initiatives which ensure the realization of strategic aims are defined here.

Selection of a planning period, which ensures that aims are achieved.

Defining strategic initiatives and collective activities of the cluster.

Defining resource needs of the cluster for the realization of strategic initiatives and collective activities.

Structuring information for the cluster - design, elements, governance.

Structuring information for the external business environment - analyzing competitors, analyzing technological developments, analysis of specialized developments, market analysis.

For the development of BS*c* we offer the following PROCEDURE:

Stage 1. Defining the strategic topics for cluster development. Strategic topics are defined on this stage, which ensure the success of the set strategic topics. Activities are defined, which are completed during the cluster's work process and are assigned to strategic topics.

It is important to consider the following restrictions:

– The number of strategic topics shouldn't exceed 3-5;
– To be achievable;
– To be connected to the strategic aims;
– To be meaningful;
– To be distinguishable and to influence the financial outcome of the cluster.

Stage 2. Defining critical success factors. On this stage we formulate the indicators which could give the most precise account for the realization of the strategic topics in detail. Formulating critical factors for success is expertly carried out.

Stage 3. Selection of indicators. This is an interactive expert procedure which is based on the chosen strategic aims, the branch indicators, the tendencies in development of the separate internal business processes, and basic evaluation of business processes up to the moment of BS_C structuring. *For the selection to be made, a collection of indicators is formed, which are evaluated, based on* 5 criteria as follows:

– *Linking with strategic topics* (K_1). This is the most significant criterion which allows only indicators which control the organization and make it possible for effective decisions to be made for emerging issues to be included into the system.
– *Quantitative value* (K_2). This criterion gives preference to quantitative indicators and reduces the subjective evaluation of the project by using qualimetric procedures which make it possible for qualitative evaluation to be transformed into quantitative.
– *Accessibility* (K_3). This criterion makes it possible for indicators which exist in the traditional infrastructure of the information system to be chosen and used without necessarily increasing financial expenses.
– *Explicitness* (K_4). This criterion assumes the value of the indicator and forms only when there is accessible information on the same algorithm.
– *Balance* (K_5). This criterion makes a selection of related indicators which do not perceive the improvement of one indicator as a significant and permanent worsening of the others.

Additional conditions: Only the maximum of each criterion is accepted.

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Expert evaluation. A 10-point grading scale is used to evaluate the indicators on every criterion.

The “weights” are expertly set and the value of all weights is 1.

This is an interactive expert procedure which is based on the chosen strategic aims, the branch indicators, the tendencies in development of the separate internal business processes, and basic evaluation of business processes up to the moment of BS_C structuring.

The most commonly used main indicators by strategic topics are (Гершун, А.М., Ю.С. Нефедьева, 2007), (Friedag, H.R., W. Schmidt, 2007), (Симеонов, 2005), (Бъфет. М., Д. Кларк, 2011):

Financial indicators	
	Value of assets (th. lev.)
	Value of assets/number of employed (%)
	Revenue/Value of assets (%)
	Revenue/Number of employed (%)
	Profit/ Value of assets (%)
	Profit/ Number of employed (%)
Markets (clients/suppliers)	
	Number of regular clients (no.)
	Number of regular suppliers (no.)
	Market share (%)
	Client loyalty index (%)
	Supplier loyalty index (%)
	Reputation
Internal business processes	
	Direct contact with clients (share from direct/indirect sales)
	Growth of productivity
	Expanding the list of items
	Growth of sales
Knowledge and development	
	Expenses for qualification / Total Expenses
	Expenses for Highly qualified specialists / Total number of employed
	Expenses for scientific research / Total expenses

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Administration / Total number of employed

In BS_C we must distinguish (Nils-Goran Olive, Jan Roy, Magnus Wetter, 1999):

– The indicators for measuring results: directly connected with activities after the realization of which a specific product is created. They are evaluated in physical units or in currency. These types of indicators are especially important on the project level because they define in a measurable way, what will be achieved after the realization of the project;

– Indicators for measuring activities, planning for the achievement of a specific result.

Along with the advantages of BS_C, it also has one potential flaw. It's related to the absence of a basic indicator which allows for the measurement of the quality of realization of the system integrated strategic topics and the effectiveness of the structure functioning. There are at least two options available for overcoming this flaw:

– Based on strategic and expert information basic indicators are expertly set.

– Including Economic Value Added (EVA) - economic value added (an indicator which measures the difference between net profit and the value of using its own structure capital for its realization) in the BSC system. In the EVA strategic governance, alongside the criterion "Market Value Added, it's successfully used in combination with various other instruments for strategic analysis (Boston Consulting Group Matrix, matrix GE/Mckinsey - market (industry) attractiveness and competitive positions) (Stern, C., G. Stalk, 1998). The combination of these instruments allows for the development of Value-Based-Management (VBM). The main function of this management is maximizing the integrated group (Касърова, 2010).

Building a strategy map

A "Strategy map" (Parmenter, 2010), (Rampersad, 2005) for all indicators is built. It contains the following:

– a number of indicators for each strategic topic, their scores following the five criteria and

– a complex evaluation of each indicator.

The complex evaluation can be a linear combination of the weighted scores following the five criteria to determine "weights", traditional expert methods can be used.

The strategy map determines the accepted strategy by the cluster by aligning the aims/goals by the topics set on the previous stage. A strategy map is shown in Chapter 4.4., Table 5.

Given the fact that BS_C is a system for measuring the effectiveness of cluster activities and is an instrument for acquiring information which improves the quality of the decision making process of this structure, *one of the main issues is developing an approach to describing the activity of the cluster which can be evaluated with BS_C.*

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4.4. Determining a conceptual vision of the necessary information.

In this chapter the suggested criteria, indicators and basic information used for the realization of the design and selection approach are showcased in tables.

Basic information for establishments

Table 2. Passports of the agents

№	Indicators	Currency unit /CU/
1.	Fixed assets (FA)	**CU**
2.	Capital	**CU**
3.	Short-term claims	**CU**
4.	Short-term liabilities	**CU**
5.	Long-term liabilities	**CU**
6.	Realization revenue	**CU**
7.	Realization expenses	**CU**
8.	Number of employees	no.
9.	Average salary	**CU**
10.	Investment expenses	**CU**
11.	Expenses for training	**CU**
12.	Profit	**CU**
13.	Market segment	coef.
14.	Share of “loyal clients”	coef.
15.	Interest in structural integration	coef.

Table 3 Evaluation criteria of the developmental state (DS)

CRITERIA	
Profitability	Realization revenue/Realization expenses
Total liquidity	Short-term assets/Short-term liabilities
Reversibility[5]	Realization revenue/ Short-term assets

[5] Reversibility of working capital

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CRITERIA	
Leverage	Long-term liabilities/Capital
Effectiveness	Net profit/ number of employees
Investment activity	Investment expenses/ Realization expenses
Investments in human resources	Qualification expenses/ Realization expenses
Market share	coef.
Share of loyal clients	coef.
Interest in integration = Yes/No	coef.
Productivity	Average salary / Realization revenue
Effectiveness of FA	Net profit / FA

Table 4 Evaluation criteria for Sustainable development

1.	**Economic creativity**	
1.1	Investment activity	Investment activity = Investment expenses/ Total Expenses
1.2	Cooperation with research institutes	Quality evaluation on a 10-point grading scale
1.3	Level of technological development	Quality evaluation on a 10-point grading scale
1.4	Information provision	Quality evaluation on a 10-point grading scale
1.5	Staff level of qualification	Quality evaluation on a 10-point grading scale
2.	**Growth through competition**	
2.1	Product quality	Quality evaluation on a 10-point grading scale
2.2	Market share in relation to base value	Passports
2.3	Level of professionalism of the management team	Quality evaluation on a 10-point grading scale
2.4	Level of success of the business	Profit/FA+Profit/ number of employed
2.5	Level of clarity of development perspectives	Quality evaluation on a 10-point grading scale

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Table 5 Strategy map

K_n / Indicator	K_1	K_1 "weight"	K_2	K_2 "weight"	K_3	K_3 "weight"	K_4	K_4 "weight"	K_5	K_5 "weight"	Complex evaluation
Finances											
Indicator 1											
Indicator 2											
Indicator 3											
Clients/suppliers (markets)											
Indicator 1											
Indicator 2											
Indicator 3											
Internal business processes											
Indicator 1											
Indicator 2											
Indicator 3											
Knowledge and development											
Indicator 1											
Indicator 2											
Indicator 3											
Total score of indicators by set criteria											

Table 6 Relative conditions of the task/completeness of information

Principle	**Basic information**	**Completeness of the conditions for defining the task***	
		Yes	**No**
Strategic aim formulation	Formulating strategic aim		
Defining the technological network of the cluster structure	Description of the network		
Filling the network with agents with similar OSR.	Basic information for agents		
Developing a strategy map	Strategy map		

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Principle	Basic information	Completeness of the conditions for defining the task*	
		Yes	No
Developing BSC	BSC system		
Estimated planning time	Number of periods		
Number of CLUSTER alternatives, minimum 2	List of alternatives		
Defining activities for each CLUSTER alternative	List of activities		
Information of the resource needs by activity	Nomenclature of resources in kind and value		
Budgets for defined activities			
Consolidated budgets of CLUSTER alternatives			
Integral decision score	Definition of score		
Methods of decision making	Describing methods		
Verification of the acceptability of the consolidated budgets**			

* Completeness is evaluated in binary (yes/no)

** The score of the cluster investment preference by evaluating the consolidated budget when using BS_C is done after balancing the consolidated budget for each cluster alternative (the amount of discounted NCF for the planning period shouldn't be lower than the expenses for the same period).

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Information for the estimated consolidated budget

Table 7 Program "Actions - Time"

Types of activities	**Period**			
	1	2	….	n
Managing the CLUSTER	X	X	X	X
Developing missing elements	X	X		
External favor (missing element activity)	X	X		
Collective delivery of raw materials	X	X	X	X
Collective purchase of FA, new technologies, patents, licenses	X	X	X	X
Developing a common information system		X		
Investing in human resources	X	X	X	X
Advertising		X	X	X

Table 8 Expenses for work and forecast period of activity N

Qualification **	Expenses (man-days)					Tariff rate (lv. /day)	Expenses by period						Total expenses
1. Highly-qualified manager													
2. Qualified manager													
3. Beginner manager													
4. Highly-qualified IT specialists													
5. Operators													
6. Administration													
7. Support staff													
TOTAL:													

* It is assumed that the annual expenditure for cluster activity is constant for the entire period while its share distribution varies by activity. In the column "total expenses" the value for the entire 5-year period is forecasted.

** The proposed qualification categories are examples.

Table 9 Expenses for assets and activity of N

Type of asset	**Depreciation rate /%/**	**Price of acquisition / CU/**	**Deprecation charge by period / CU/**	**Expenses by period**						**Total expenses**
Material										
1. Asset 1										

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Type of asset	Depreciation rate /%/	Price of acquisition / CU/	Deprecation charge by period / CU/	Expenses by period						Total expenses
2. Asset 2										
3. ...										
Intangible										
1. Asset 1										
2. Asset 2										
3. ...										
TOTAL:										

Table 10 Expenses for raw materials for activity of N

Type	Quantity	Unit price	Expenses by period					Total expenses
1. Type 1								
2. Type 2								
3. Type 3								
4. ...								
TOTAL:								

Table 11 Other expenses for activity of N

Type	Quantity	Unit price	Expenses by period					Total expenses
1. Type 1								
2. Type 2								
3. ...								
TOTAL:								

Table 12 Budget (expenditure side) for activity of N

INDEX	Periods				Total expenses
	1	*2*	...	*n*	
Activity costs 1					
Raw material costs (Table 9)					
2. Depreciation costs (Table 8)					
3. Labor expenses (Table 7)					
4. Other expenses (Table 10)					

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5. Total costs (p.5 = p.2.+ p.3.+ p.4.+ p.5.)					

Table 13 Cost distribution by activities and periods

Types of activities	**Period**				
	1	2	…	n	Total:
Managing the CLUSTER					
Developing missing elements					
External favor (missing element activity)					
Collective delivery of raw materials					
Collective purchase of FA, new technologies, patents, licenses					
Developing a common information system					
Investing in human resources					
Advertising					
Total:					

Table 14 Cost forecast distribution by source and periods

Types of income	**Period**				
	1	2	…	n	Total:
1. Agent contributions	X	X	X	X	
2. National and International projects and programs	X	X	X	X	
3. Other costs	X	X	X	X	
Including: collective deliveries of raw materials, collective deliveries of FA, advertising, information resource, net profit share of the newly established agents, etc.					
Total:					

Table 15 Structure of a consolidated budget

INDEX	**BASE**	**Periods**				**TOTAL**
		1	*2*	...	*n*	
I. Income (Table 13)						
Raw material costs (Table 11, p. 1)						
2. Depreciation costs (Table 11, p. 2)						

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INDEX	BASE	Periods				TOTAL
		1	*2*	...	*n*	
3. Labor costs (Table 11, p. 3)						
4. Other expenses (Table 11, p. 4)						
II. Total costs (r.6 = r.2.+ r.3.+ r.4.+ r.5.)						
7. CLUSTER profit (r.7 = r.1 - r.6						
8. Taxes and charges (10%) (r.8 = r.7.*.0.1)						
9. Net profit (r.9 = r.7. - r.8)						
10. Discount factor (%)						
11. Discounted profit (r.11 = r.9 * r.10)						
12. Discounted cumulative profit						
13. Net cash flow (r.13 = r.9 + r.5)						
14. Discounted NCF (r.14 = r.13 * r.10)						
15. Discounted cumulative NCF						

Table 16 Basic data for the calculation of BS_C indicators.

	INDICATORS	Unit	FORECAST PERIOD				
			1	*2*	....	....	*n*
1	Revenue	**CU**					
2	Contribution from profit	**CU**					
3	Contribution from FA	**CU**					
4	Proceeds from collective delivery of FA	**CU**					
5	Proceeds from collective delivery of raw mat.	**CU**					
6	New agent dividend	**CU**					
7	Other costs	**CU**					
8	DCF	**CU**					
9	Deprecations	**CU**					
10	Expenses	**CU**					
11	Net profit	no.					
14	FA	**CU**					
15	Number of employed	**CU**					

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	INDICATORS	Unit	FORECAST PERIOD				
			1	*2*	....	....	*n*
16	Number of highly qual. spec.	**CU**					
17	Costs for developing a new agent	**CU**					
18	Management costs	**CU**					
19	Development costs	**CU**					
20	Training costs	**CU**					
21	Costs for scientific research	**CU**					
22	Advertising costs	**CU**					
23	Income of PRP [6]	**CU**					
24	Expenses of PRP	**CU**					
25	Growth rate of the market share of PRP	Coef.					
26	Number of employed $Agent_T$	No.					
27	Income from loyal clients of $Agent_T$	**CU**					
22	CPIP	**CU**					
23	Δ CPIP	**CU**					
24	θ CPIP						
25	Average annual number of employees in the activity	number					
26	Average annual number of employees in agents	number					
27	Average annual number of employees	number					
28	Highly-qualified specialists	number					
29	Number of periods	number					
30	Net profit	**CU**					
31	Net present value	**CU**					
32	Discount rate	%					
33	Discount coefficient	Coef.					

[6] Agents which participate in the realization of the final product of the structure.

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Table 17 Example BS_C structure

INDICATOR	Weights	BASE					Total:
		1	*2*	....	....	*n*	
ST Finances							
1. Revenue/Expenditure							
2. Net profit / Expenditure							
3. Net profit / Number of employees							
4. θ CPIP							
ST Markets							
1. Costs per agent total/Income $agent_T$ total							
2. Income from loyal clients of $agent_T$ /Income of $agent_T$ total							
3. Total market share of $agent_T$							
ST INTERNAL BUSINESS PROCESSES							
1. Expenses for the development of a new agent / Expenses total							
2. Expenses for the development of a new information system / Expenses total							
3. Expenses for advertising/ Expenses total							
ST KNOWLEDGE AND DEVELOPMENT							
1. Highly qualified specialists in the agents/ Number of employees in agents							
2. Expenses for scientific research/ Expenses total							
3. Training costs/ Expenses total							

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5. Summary, suggestions for adaptation to specific realizations of clustering and conclusion.

5.1. Summary

The economic cluster can be defined as a collection of economic agents (suppliers, manufacturers, other types of elements such as material, information, political, commercial, non-commercial, social and research infrastructure on a national, supranational or global subject level), related to the calculation of added value which ensures the growth of competitiveness, sustainable productivity development, innovation and public utility of every element and as a whole. In other words, this is a multi-aspect group, united by durable economic, uneconomic or purely social relationships which are not defined by organized membership.

The strategic focus of the economic cluster is to increase the degree to which we use knowledge, accrued and newly-acquired experience for the development of new cooperation networks and structures in the development of products, services and the additional economic and uneconomic benefits related to them in the form of the newly introduced in a narrow sense, and innovations in a broader sense aspect. The Advantage of the economic cluster organization lays within its direct simulation of the development of competitiveness. The Disadvantage is the potent dependency of the clusters on the stable national policy regarding the development of micro, small and medium businesses which are a main initiator, driver of competitive integration and the final beneficiary of results.

The current paper includes four topics, related to the aims of the economic clustering, known mathematical methods and approaches to decision making, applicable to this area of practical experience, overview of conceptual methods of clustering and a description of an approach to designing a structure of economic clusters.

The main emphasis in the report can be systematized in the following summary:

1. Varies tasks for planning, control, analysis and management in economics, transport, manufacturing, education, ecology and other similar fields can be reduced to multi criteria decision making tasks For their solutions, a wide range of methods of analysis, optimization and the most modern intelligent methods and approaches have been applied. A key moment when selecting the right tools is the available information, the specific levels of generalizations and abstractions, type of data, motives and capabilities of the persons, making decisions for the selection, acceptability, competitiveness and tolerances related to the available basic information. The specific decisions are achievable by setting clearly defined goals, competitively formulated tasks, clearly determined input information, readiness of carrying out an objective analysis and accepting the results through the set output parameters and conditions.
2. Decision making can be perceived as a prerogative not only of mathematical methods but of pure socio-organizationally defined problems. In this sense, the generalized sociocratic approach to the socio-organizational aspect of the economic clustering can be applicable. The cluster is a voluntary unification of enterprises in which

people work, is an organization managed by people, and as a structure is maintained by people. They create groups, mobilize their collective experience, potential and ability to learn, their shared value system and an ethical behavioral framework in which causes and consequences of decisions are a result of dialog, common efforts, aim, discipline, commitment and shared responsibility. Developing a similar configuration of relationships, in combination with economic aims has the potential to formulate a new paradigm for cluster governance.

3. The combination of various organizational instruments for initiating clusters is a prerequisite for synergistic effects which provide additional opportunities for increasing competitiveness. In a modern environment, a structural model for formulating clusters can be applied in various directions. Key aspects are the vertical branch integration, regional integration and network integration. The first two forms are used on the microlevel with the aim of increasing national competitiveness. On the microlevel to which the small and medium businesses refer, network integration is most commonly used, or the unification product/service manufacturers (groups of products/services) with the purpose of joint usage of a common infrastructure (material, information systems, training systems, technologies, marketing etc.). The main effect is seen in group interaction with the internal and external environment which ensure sustainable competitiveness which is the function of the knowledge, capital and qualification of the working foce and the capabilities of its training.

4. When developing the structural model for integration a system approach is used, which allows for institutional consolidation of production, financial and management assets of the economic agents through the assured retentions of economic interests of each and every one of them. Basing a structural model for integration on a system approach allows for the use of a well developed toolset for designing economic structures. This toolset includes the use of methods and models of multi criteria analysis, intercriteria analysis, applied statistics and other approaches. They allow for the development or adaptation of models and algorithms for decision making when solving tasks for specific groups of economic subjects.

5. The described approach for solving a problem for preliminary analysis, selecting participants, forming cluster structure alternatives and choosing the ultimate solution uses aggregate criteria - indicator for effectiveness, sustainability and competitiveness called investment preference. This criterion is develop on the basis of a balanced system of indicators which looks at financial and non financial resources, outcomes from forecasting and strategic planning of cluster activities. As a result, the decision maker has the opportunity to make an informed decision among a number of cluster structure alternatives.

6. The information needs for the realization of the suggested approach for structure selection with present clustering in economics are grouped in two main guidelines: the basic information for agents - potential participants in the process of economic clustering and information, required for the needs of planning and the following estimated evaluation of showcasing the potential cluster and its included elements for a predetermined forecast period. This information includes evaluation criteria which are based on standard statistical data for economic agents, for the state of development, economic sustainability, strategy map format, map for the conformity of conditions of the problem and the completeness of available information, format of the plan for action in the planning periods of forecasting, data for forming the income

and expenditure side of the estimated budget, an example structure of a system of balanced score card. It must be mentioned that the proposed approach is information dependent, which is underscored not so much as a detriment of the approach than an accent which is absolutely necessary during preparation, decision making and the following realization of each resulting solution.

5.2. Suggestions for adaptation.

The suggestions for adaptations can be presented in the following guidelines:

– *Defining the task for economic clustering* - identifying strategic aims, strategic topics, motives, restrictive assumptions, evaluation system and criteria, organizational boundaries and interfaces, as well as all interested parties participating in the integration process are aims of a strictly individualized task.
– It depends on the maximum specific unformalized and formalized description of the output starting conditions which describe the essence of the task.
– *Determining the requirements* - verbalized description and formalized definition of requirements is used as conditions which have to be met in every acceptable solution to the problem. Shown mathematically, these requirements are the restrictions in accordance with which the various possible (acceptable) solutions are made.
– *Determining the aims* - aims are common declarations of intent and target values of indicators or others, accepted for appropriate measures. The aims usually exceed the minimal requirements. Mathematically, they are target functions, unlike requirements which are limited. Aims can be contradictory which occurs most often when solving practical tasks. Contradictions stimulate the specification of the set aims and correction of formed tasks and the instruments for their solution and realization. On earlier stages, their identification and ironing out is a contribution to the common system, technology and is a way of acquiring good practices for developing meaningful relationships. On the later stages, contradictions are an obstacle which violates the principles of consent. When forming clusters which are voluntary and self-organizing structures, this could lead to negative outcomes and failure.
– *Generating alternatives* - alternatives offer various approaches for changing the original state of the process into the desired state. Regardless of whether they exist or are imaginary, all alternatives must meet specific requirements. If the number of possible alternatives is finite, they can be verified one by one if they meet the requirements. Unacceptable alternatives must be excluded from following review so that the list contains only acceptable alternatives. If the number of possible alternatives is infinite, the variety of alternatives is regarded as a variety of solutions, which meet requirements and are mathematically presented as restrictions.
– *Determining the criteria* - the criteria which will be used to evaluate the alternatives are objective measures of the aims, so that the level of realization of aims can be measured by each alternative. Having in mind that aims can be presented as criteria, each aim has to generate at least one criteria, while some complex aims can be presented by several criteria.
– *Selecting tools for decision making* - Various instruments exist for decision making (or assisting it). The choice of an appropriate tool is a task which depends on the specifics of the given problem as well as the goals of the people making the decisions. When selecting applied tasks, a limitation of the tools is their basis on comparatively simpler, convenient for calculation methods and easy to interpret

results.

– *Evaluation of alternatives in relation to criteria* - each method for decision making requires input data. Depending on the criteria, the score can be objective (factual), by relating it to some conventional and understandable measurements or subjective, reflecting the subjective judgment of the expert. After evaluating the alternatives, the chosen tool for decision making can be applied to classifying the alternatives or to help the selection of a subset of the most promising alternatives.
– *Verification of the solution* - the alternatives which have been chosen through the use of the accepted means for decision making must always be verified according to the requirements and aims of the task. There can be an incorrect application of the toolset for decision making. For complex tasks, the chosen alternatives can also be an object of attention of the people making decisions and the interested parties in regard to the necessity of setting additional goals or requirements which are added to the already chosen model of decision making.

5.3. Conclusion

In this report an overview of methodologies for economic clustering on the basis of one or more criteria and various procedures and technologies are presented, which are based on theoretical and applied results from the field of theory for assisting decision making which are suitable and promising for using in the task of forming integrated economic structures from specifically selected suppliers, base manufacturers and customers.

Integrated in the core of clustering are information exchange and coordination of interests between the various elements with the purpose of increasing sustainable competitiveness and innovation.

We propose a concept for integrating economic agents in a mixed technological network.

The concept systematizes known theoretical and practical approaches for the development and identification of economic clusters.

We have developed an approach to designing clusters, selecting a cluster structure, formulating strategies, critical success factors and key indicators of activities related to the process of decision making, designing and estimating processes.

It should be emphasized that in application, the main hurdle when working with clusters is not only in their design as a single initiative or in the isolated selection of the participating organization with economic or non-profit purpose, but in the process of their management for longer periods of time.

The cluster as an idea is equal and self-integrating structure. On the highest level, the governance process can be a fuzzy concept because the different businesses maintain their autonomy in full, while the relationships are regulated by agreements and mutual voluntary consent of unification (sharing) material and intangible resources.

On a deeper level, the cluster is a voluntary unification of teams. They create, convert and disband groups which mobilize their collective experience, potential and ability to learn through personal motivation and a behavioral framework in which the causes and consequences from decisions are a result from dialog, effort, discipline and responsibility.

Creating such a configuration of complex relationships, links, information streams and values, combined with the full variety of economic objectives has the potential to create a favorable environment, which can be the foundation for a new approach to cluster governance and is a challenging task even as an experiment, training alternative or a prospect for integration.

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