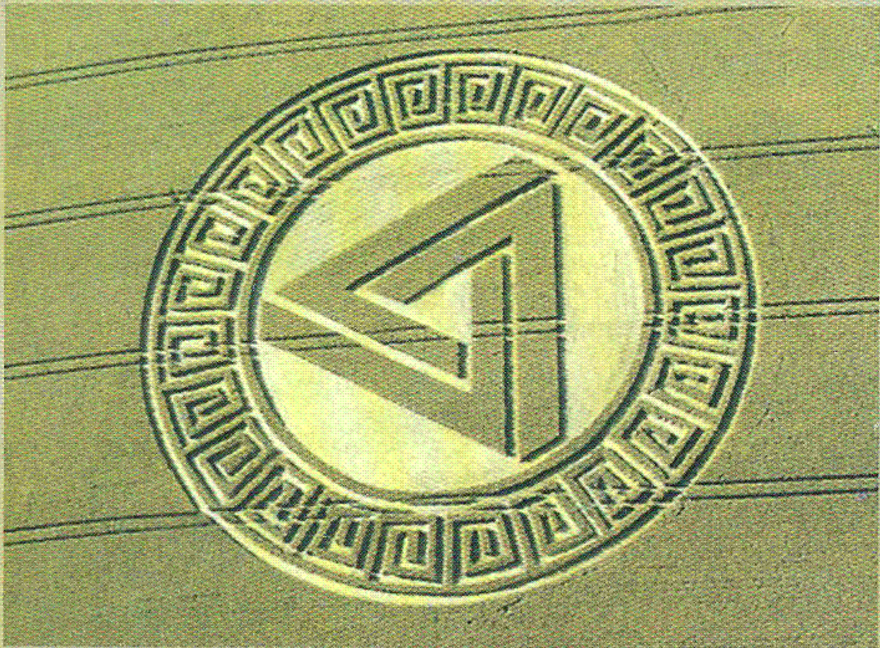

ГАРМОНИЧНОЕ РАЗВИТИЕ СИСТЕМ – ТРЕТИЙ ПУТЬ ЧЕЛОВЕЧЕСТВА

STRUCTURAL AND TEMPORAL ORGANISATION OF SYSTEMS

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Abstract:

In solving problems on analysis and synthesis of complex systems, in particular decision making in these systems regarding structural and temporal solutions, it becomes often necessary to consider the integrative (wholeness) criterion, thereby yielding the emergent effect.

Here the integrative (wholeness) criterion is a defined ratio of components or processes of investigated system, the relationships between which are characterised as a canonical integrative (wholeness) measure or harmony measure, measure related to some structural proportions of a system. It is also shown that the mentioned criterion can adequately describe the temporal organisation of dynamic systems, for instance, during a man's activity in time. Designing such activity into discrete actions (operating period and activity slack) reaches a decision that objectively obeys the Fibonacci series and the Golden ratios. Such a conclusion, grounded theoretically and proved experimentally, gives the possibility to model and optimise strategies of a man's activity in accordance with his psycho physiological characteristics by using the integrative criterion.

Key words: system, space structure, temporal organisation, canonical measure, wholeness criterion, harmony, Fibonacci numbers, Golden ratios.

Реферат:

При решении задач анализа и синтеза сложных систем необходимо принимать во внимание интегративный критерий их структурной и времен***о***й организации, что позволяет получить дополнительный эффект. Интегративный критерий определяется соотношением компонентов исследуемой системы, для которых существует ряд мер целостности, связанных с «золотыми» отношениями (пропорциями). Дано обоснование критерия целостности для описания времен***о***й организации систем. По результатам экспериментов сделан вывод о том, что решения, принимаемые человеком при выполнении некоторой деятельности, формируются в виде периодов работы и периодов отдыха, соотношение которых подчиняется ряду Фибоначчи и «золотому» отношению (пропорции). Такой вывод, обоснованный теоретически и экспериментально, дает возможность оптимизировать стратегию деятельности человека в соответствии с его психофизиологическими характеристиками (с помощью интегративного критерия).

Ключевые слова: структурая и времен***а***я организация, интегративный критерий (критерий целостности), числа Фибоначчи, «золотые» отношения (пропорции).

The mind should not multiply entities beyond necessity.
What can be done with fewer ... is done in vain with more
(William of Ockham)

1. THE WHOLENESS CRITERION FOR ANALYSIS AND DESIGN

1.1. Introduction

Competitiveness, changing demand and new scientific paradigms for different spheres of life are just some characteristics that challenge contemporary researchers and specialists. To be able to follow rapid changes every research team should reorganize their thinking strategies according to modern trends.

There is a great need in understanding systemic, integrative (holistic) approaches which could allow us to overcome paradigms discrepancies and limitations. The traditional optimization criteria for decision making does not reflect a diversity and gives a way to the integrative (holistic) point of view. Only these approaches can provide a needed framework for research paradigms.

The proposed paper is devoted to systemic thinking approach regarding appropriate framework and formal criterion for designing, forecasting and decision making which could consider an object under study as a whole object [1–5].

The paper aims to investigate new systemic method and appropriate tools for researchers (first of all, in organizational behavior area). The traditional optimization criteria for decision making do not reflect a diversity and gives a way to a holistic point of view.

The problem consists in finding such a kind of object structure as a whole (in accordance with the wholeness criterion) which provides more advantages.

Research tasks. The problem of systemic, integrative or holistic thinking consists, in particular in finding such a kind of object structure (for instance, branch network of a company) as a whole (in accordance with the wholeness criterion) which provides more advantages for managers, clients, partners to provide specialists with more adequate information for decision making.

There are following research tasks: a) to analyze the existing approaches involved in systemic thinking problems; b) to develop the wholeness criterion for organizational behavior with regard to incomplete data about system components to assure their requested efficiency; c) to create some models and tools for system designing or decision making on the basis of a holistic approach; d) to adjust some strategies and rules for organizational behavior.

Approach outline. The concept of the wholeness (integrative) criterion could rely on the definition of a whole. Any whole may be understood as, described in terms of, and considered equal to a structure or an organization of component parts (see holism, system). Without recognition of its parts a whole is an essentially structureless and unanalyzable unity. If its parts are independent or randomly sampled by an observer, a whole has no outstanding quality other than that of being an observer's aggregate. If a whole is qualitatively different from a mere aggregate of its parts, the difference lies in its structure or organization. In some cases the properties of its parts may be ignored without appreciable loss of understanding a whole, particularly when parts are numerous, simple and the same as in the objects of some areas computer sciences, macro-economics, and quantum physics all of which heavily rely on mathematics for their constructions. When the parts are few, complex, different, and tenuously related, as in a marriage, the properties or the parts figure more prominently in the understanding of a whole and can not be ignored in favor of such wholes' organization (see Web Dictionary of Cybernetics and Systems).

The integrative (or holistic, or harmonization) approach to a structure or an organization analysis is the point of view with focusing attention directly on the whole and its characteristics as a whole, without any recourse to consideration of its parts. It is close to the well known statement from systemic (or synergetic) approach: "a whole is more than the sum of its parts" (see Web Dictionary of Cybernetics and Systems).

Thus, any whole may be understood and considered equal to a structure or an organization of component parts. Holism is an approach focusing attention directly on the whole and its characteristics (including its parts). In this context every apparent whole can be understood only in context of larger whole containing it. To explore this context and increasingly universalistic kinds of the whole understanding it is necessary to use hierarchy. Hierarchy is a form of organization whose components are arranged at levels from a top level to a bottom level.

The wholeness (integrative) criterion is represented as a number of numerical invariants which are adequate to the object states such as wholeness using entropy and probabilistic characteristics for the estimation of the measure of integrity or wholeness.

The essence of the approach is to estimate some significant object components and its quantitative characteristics and to find the best way for design of the structure and decision making processes of a system components by this criterion.

The criterion can be formulated as follows: the best case of structural organization of an object (independent of its origin) is a structure which has maximal wholeness or integrative estimation in accordance with the criterion.

The structural mechanism for efficient organization of a complex object is suggested and can be formulated as follows: local maxima of object efficiency are only provided that the structure of the object corresponds to the nodes or measures of wholeness (integrity).

Applied aspects are connected with usage of the integrity criterion for quantitative estimation of the efficiency level of the object or project structure and the quality level of project decisions or products:

- analysis of a system strategies for making decision concerning its efficiency,
- finding structural regularities for organization of different nature systems,
- finding numerical invariants of the organizational level with usage of structural wholeness of a system (independent of its origin), description of some coherent properties of the system structure that can be interpreted as a measure of the wholeness of the structure; this approach was used in synthesis of the system structure in which people and technology interact, etc.

The holistic approach to organizational behavior allows us to develop: formal criterion for viewing and estimating of an object as a whole and a quantitative method and appropriate techniques for organizational analysis of systems and projects.

1.2. Formal Criterion of a Structure Analysis

One of the unique and promising criteria for optimisation of systems of different nature presented in this paper is based on the principle of integrity (wholeness) or universally recognized term such as harmony. This canonical principle characterizes a rigorous relationship between interacting elements or functions in a system as a whole and correlates with additive and multiplicative characteristics in math context.

Consider an elementary structural invariant (elementary space volume) of a system that penetrated by some flow (energy or other parameters). In an elementary volume dV for a time dt it is possible determine a density, Z, of some parameter of any system under study.

Assume that $Z(t)$ elements have appeared in an assigned state $S(t)$ at a time moment t in such a volume for this time. In addition, at the previous time moment $t–1$ a system has been affected by $Z(t–1)$ elements being in a state $S(t–1)$. At the next moment $t+1$, a total number of elements

$$Z(t+1) = Z(t–1) + Z(t) \quad (1)$$

will leave this elementary volume. This characterizes the additivity of the observed properties of the system under the study.

The dynamic model, i. e. the expression for the density gradient of interacting elements looks like the ratio

$$Z(t) / Z(t–1) \text{ or } Z(t+1) / Z(t), \quad (2)$$

which characterizes the multiplicativity of interacting elements in the system.

Under steady-state conditions the multiplicativity of interacting elements reduces to the form

$$Z^2(t) = Z(t+1) \cdot Z(t–1). \quad (3)$$

By analyzing simultaneously squations (1), (2) and (3), it can be consulted that the considered space invariant can be described by the following equation

$$Z^2(t) + Z(t) = 1, \quad (4)$$

whose solution is represented by the numbers correlate with the Golden ratios such as – 0.618… and +1.618… at a time moment t.

It should be noted that no limitations on the system, except for the factor of an open system, were allowed for in deriving the last equation (4).

Thus, the structural organisation of an open system (more precisely an elementary space volume) can be «governed» by the unique and promising criterion (with simultaneously manifesting ***additive*** and ***multiplicative*** properties) that correlates with the numbers of the Golden ratios.

1.3. The Criterion of a Wholeness Structure of a System

The wholeness as a generalized characteristic of complex systems' organisation (irrespective of their nature) has a methodological sense, originates from the nature of systems, bears evidence of the fundamental properties of ordering, connectivity, consistency, co-subordination, organisation, etc.

The wholeness is characterized by a variety of manifestations, each of which can serve as methodological support for solving the problems on analyzing and synthesizing complex systems, by preserving some level of their quality under different conditions and objectives of study [1–2].

The criterion of wholeness structure of a system starts with the concept of sufficient variety and uses such an information characteristic as entropy to evaluate the amount of information possessed by a structure of the system. Specialists concerned with systems analysis, for instance, for biological systems make wide use of the notions «entropy» and «negentropy» as function, which take into account the variety of the systems, i.e. their organisation structure.

Here the wholeness criterion is a defined ratio of components or processes of decision making in a system, the relationship between which are characterized as organisation, harmonicity, subordination to some proportions.

Each value of the invariant measure characterizes the objective common qualities of a system (independent its nature) is characterized the certain coherent properties of a system structure and can be interpreted as a wholeness measure of a structure organisation corresponding the concept of organized chaos.

Proceeding from the fundamental conclusions about structural regularities in the formation of complex systems it is worth to use the equation to determine the structural wholeness of a system $M^S + M = 1$, $s = 1, 2, 3, \ldots$, where s is the number of structural components, M is the measure of structural wholeness of a system. The roots of the equation are the quality units or invariants of the measure of the wholeness of a system. Each numerical value of the unit corresponds to the significant variant of the structural organisation of a system taking a set of its structural components as the wholeness. The measures of the wholeness of a system are the following: 0.5000…, 0.6180…, 0.6823…, 0.7245…, 0.7549…, etc.

It is quite natural to expect the existence of invariants with contrary properties. They can be correlated with regimes of the maximum production of entropy and, consequently, the minimum production of organisation of the system. These invariants of the disintegrity of the system should be looked for in the maximum distance from the nodes (invariants) of the wholeness measure. The roots of the equation $N^{S+1/2} + N = 1$, with the half-integer values of the parameter s, i.e. $s + 1/2$ are the quality units or invariants of the diswholeness of a system. The measures of the diswholeness of a system are the following: 0.5698…, 0.6540…, 0.7053…, 0.7408…, 0.7672…, etc.

On solving the problems of analysis and synthesis of systems numerical solutions of the entropy equation tend to numerical values of structural invariants of such system wholeness thus allowing these problems to be solved on a unified mathematical basis.

1.4. Mechanism of a system analysis and synthesis

To adapt the criterion for solving some tasks for analysis and synthesis of a system, it is necessary:

1) to calculate actual or planned estimates of considering parameters of the wholeness of the system under consideration;

2) to obtain the wholeness' estimates for different structural levels of a system (lay-out diagrams of workers' positions, resources, managerial bodies, number of branches, etc.);

3) to match the actual parameters and measures of the wholeness of the system;

4) to formulate informative recommendations on design, decision making and management which could provide the consistency or equivalency of actual or planned parameters with the nearest structural invariants of the system's wholeness.

These recommendations should highlight how the structure of a system could be adapted to the changing circumstances (external and internal) to provide maximum efficiency of a system's organization.

It is pertinent to note that using the wholeness criterion the accuracy of calculations and adequacy of conclusions increase in direct proportion to the number of components of the system under study.

1.5. Some Regularities of a Structure Organisation

The mechanism of efficient organisation of a system (as a universal quality characteristic of a system) consists in the following: local maxima of the efficiency of a system are attained, only provided that the strict correspondence of its structural components (parts and units) is satisfied using the wholeness principle.

Mathematically, a strict determination of structure organisation of a system can be represented by equation, whose real roots are a number of numerical values, i.e. invariants of the wholeness of a system and are its informative entropy parameters independent of the nature of a system structure (i.e. independent of a modality of the quality index of a system).

The system mechanism of efficient organisation of a system (which is represented in terms of its interacting structure and functioning components) as a universal characteristic of quality of a system functioning and development consists in satisfying the wholeness criterion of structure and functioning invariants of system's organisation according to the real roots of the above equation to determine the structural wholeness of a system. These roots form a harmonic series of the numerical values of 'attractors' or nodes of the system's organisation for any modality (content scale of quality) of the quality scale.

The wholeness (integrative) criterion is considered as the main tool of holistic approach for investigation of complex objects. This is possible by means of the criterion that is based on concept of information entropy and some probabilistic parameters.

It is showed that the structure of a system can be described by strong formal quantitative characteristics or measures of the wholeness. Such estimation of the structure (and also functions, actions, etc.) is subordinated to a row of canonical measures of wholeness that are common natural regularities.

In general, the approach allows to find the best way in decision making for planning, organisational design, forecast, management, etc. of complex objects by usage of systemic holistic approach and formal criterion of the wholeness.

Applied aspects are connected with the usage of the wholeness criterion for quantitative estimate of efficiency level of the object's and project's structures and the quality level of project products for complex systems of different origin.

Proposed approach has been tested in practice. Applicability of the criterion has been proved in organisational design and in handling the branch banking systems. Research results obtained are implemented in re-design and development for the number of research projects. As an example, one of the banking company refocused attention on retail banking to reverse the decreasing market share trend in the area of consumer deposits. It was decided that the key to profitable growth would be an increase in personal deposit base. The result conclusion was about necessity redesign and reconstructing branch network of the bank, meaning to find more appropriate variant of the bank's structure. This process of rationalization was based on the usage of holistic approach and the criterion. It was resulted in closing some bank's branches; at the same time several branches were transformed to nearby branches and, in the end, in considerable savings administrative expenses and capital costs, etc.

2. TEMPORAL ORGANISATION OF SYSTEMS

2.1. Preliminaries

Decision making under conditions of uncertainly is a rather common kind of the information management man's activity in complex systems, viz., in man-machine systems, human-centred systems, etc.

For example, it is known that at a visual perception of an object the perception strategies are oriented to the vision psycho physiology regularities that allow for the Fibonacci numbers and the Golden ratios.

This part of the paper is devoted to investigation of such kind of activity concerned with processing of discrete signals by a man-operator and analysis of the management activity quality in the course of control and maintenance of a complex system [6–8].

The input data for a man-operator under such conditions of the information management activity contain different uncertainties pertaining, for instance, to problems, methods or data. Such lack of information is either objective or due to economic restrictions.

On making the decisions under the conditions of information uncertainty (or lack) it is, as a rule, presumed that a man fills a gap in the data with his personal experience, qualification, current situation, etc. in mind and with use of the integrative (or wholeness) principle.

The strategies of decision making by a man and temporal parameters of his activity are the goal of the present research paper.

2.2. Strategies of Temporal Organisation of Systems

We will consider the strategies of man-operator's activity with regard to [6–8].

(a) external limitations on the time of signal processing;

(b) duration of signal processing;

(c) individual psychophysiological data and motivations of a man, i. e. the signal repetition period T, the processing time x of such signals. Now we pass to the dependence $T = f(T)$.

A decision is made by a man-operator within the limits $t_{min} \leq T \leq t_{max}$, where t_{min} (t_{max}) is the minimum (maximum) time interval for a man to perform any kind of activity.

The time required for a man to tike a decision during processing of the *i-th* discrete signal is $T_i = \boldsymbol{\tau_i} + R_i$, where T_i is the *i-th* signal repetition period; τ is the time of the *i-th* signal processing; R_i is the activity slack after termination of processing of the *i-th* signal before starting to process the next *(i + l)-th* signal.

Analysis of the relations $a_i = T_i/R_i$ and $b_i = R_i/T_i$ reveals that $a = f(T, R)$ is a monotones-increasing function, while $b = f(R, \tau)$ is a monotones-decreasing one. Then for an arbitrary fixed T_i there exists the unique value of $\boldsymbol{\tau^*_i}$ at which $a_i = b_i$. In this case the following equality

$$T_i/R_i = R_i/ \boldsymbol{\tau_i} \tag{5}$$

is valid, whence it follows that at $\boldsymbol{\tau_i} = \boldsymbol{\tau^*_i}$ the activity slack R^*_i is

$$R_i = [(1 + \sqrt{5}) /2]\, \boldsymbol{\tau^*_i} = (1.618...)\, \boldsymbol{\tau_i} = \sigma \cdot \boldsymbol{\tau^*_i} .$$

In view of the fact that for numbers of the type σ the relation $1 + \sigma = \sigma^2$ is fulfilled, then

$$\boldsymbol{\tau_i} = \sigma^{-2}\, T \text{ at } \sigma^2 \boldsymbol{\tau_{min}} \leq T \leq = \sigma^2 \boldsymbol{\tau_{max}} . \tag{6}$$

Thus, the locus $\boldsymbol{\tau^*}$ of Eq. (5) may be described by Eq. (6).

2.3. Experimental Results

Experimental studies of the man-operator activities in a man-machine system concerned with processing of numerical data arrays are made in the assumption that some arithmetic operations with integers are to be performed.

In the experiment, the signal repetition period T changed linearity. To evaluate the quality of the man-operator's activity, we used the dispersion $D(\boldsymbol{\tau})$ of duration of signal processing in each array of numerical data.

Such a quality criterion allowed unique interpretation of the obtained result in the experiment within the limits of the temporal range of τ. To calculate Eq. (5), we used the expressions

$$a = 1/N[\sum(T_i/R_i;\ i=1...N)];\quad b = 1/N[\sum(T_i/\tau_i;\ i=1...N)]. \qquad (7)$$

The dispersion $D(\tau) = f(b)$ was at its minimum at b = 1.618... for the all tested man-operators. In this case, the minimum number of various errors (corrections, omission of a signal, calculation errors, etc.) in the man-operator's activity was observed. Also, the dispersion $D(\tau) = D_{min}$ determined the induced deviations of τ from its optimal value. The dynamic range from τ_{min} to τ^*_{min} for a concrete tested man-operator was defined as a regular proportion

$$\tau_{max} / \tau_{opt} \approx \tau_{opt} / \tau_{min} = 1.618... .$$

Thus, it is established that the time intervals of signal processing at the limiting τ_{min}, optimal τ_{opt} and natural τ_{max} rates are interrelated by the geometric proportion with the base b = 1.618... (see Eq. (7)).

In the general case, the temporal characteristics of the activity in the form of values of the function $\tau = t(T)$ at some singular points T_{n-1}, T_n and T_{n+1} specified the character of their interdependence in the form of the recurrent equation $\tau_{n+1} = \tau_{n-1} + \tau_n$ known as the Fibonacci series.

To sum up, the experiments conducted have revealed that optimisation of the temporal parameters of man's activity is accomplished in the same proportions independently of a man or a kind of his activity. The observed strategies of man's activity rest upon the unified behavioural patterns which may be considered as the natural man's functional-structural strategy instinctively employed in processing of digital information and in the general case for decision making with regard for an influence of temporal parameters on the quality of man's activity.

Based on the result of these studies, first published in 1986 by one of the authors [6–7], the following objective regularity of the information management man's activity is formulated: duration of processing of discrete specified values at limited, optimal, and natural rates is described by the Fibonacci series.

CONCLUSIONS

The wholeness (integrative) criterion is represented as a number of numerical invariants which are adequate to the object states such as wholeness using entropy and probabilistic characteristics for the estimation of the measure of the wholeness [1–2].

The structural mechanism for rational and efficient organization of a complex object is suggested and can be formulated as follows: local maxima of an object efficiency are only provided that the structure of the object corresponds to the nodes or measures of the wholeness.

Applied aspects are connected with usage of the wholeness criterion for quantitative estimation of the efficiency level of the subject of study (a system structure) and of the decisions regarding the organization (structure) design. The results obtained are implemented in re-design and development for the number of research projects.

The paper considers some findings of temporal organization, i. e. the strategy of the integral behaviour of man making discrete activity in time. Designing the behaviour consists in subdividing a time interval of a discrete action (i. e., quantum) into sub-intervals (operating period and activity slack). In this case, subdividing the time interval objectively obeys the Fibonacci series. Such a conclusion, grounded theoretically and proved experimentally, gives the possibility to model and optimise strategies of the man's activity in accordance with his psycho physiological characteristics by using the wholeness (integrative) criterion.

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