29th INTERNATIONAL SCIENTIFIC SYMPOSIUM

METROLOGY AND METROLOGY ASSURANCE 2019

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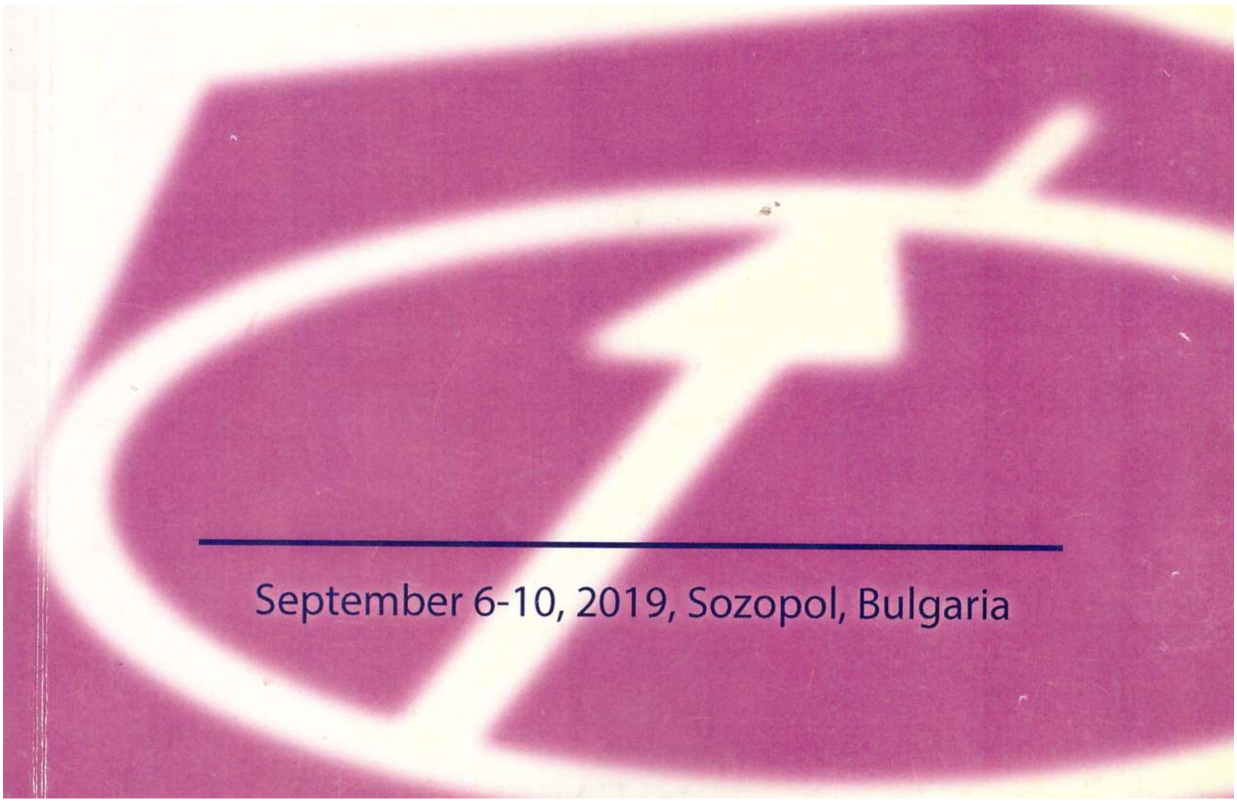

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Analysis of the state diagram correctness of automatic logic control systems on FPGA Paper

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***Abstract*— The work is dedicated to verification of automatic logic control systems by analyzing the correctness of state diagrams of control finite state machines which are represented in the form of the code in the hardware description language. As a method for state diagram analysis the, it is proposed to use the concept of orthogonality, as a system of incompatible events. Analysis of the correctness is carried out by analysis the results of behavioral modeling and logical synthesis using CAD tools.**

***Keywords*— *finite state machine, state diagram, HDL-model, synthesis,* orthogonal Boolean function.**

I. Introduction (*Heading 1*)

One of the metrological tasks is the quality control of the software. If for traditional programming languages these issues are worked out in sufficient detail, then there are no established approaches for hardware description languages.

Hardware Description Languages (HDL) are characterized by dualism. From one side, this is a code in a formal language with all its characteristics and properties, and from another side, this is a description for digital circuit with all restrictions imposed by the corresponding technological base. In addition, a computer-aided design tool (CAD) has a component called synthesizer which is located between the code in the hardware description language (HDL model) and digital circuit. A subset of HDL, which is correctly converted by a synthesizer into digital circuits, which is called, synthesized HDL subset. In addition to the fact that HDL operators, which correctly describe the circuit, must be included in the synthesized subset, the structure of HDL model must fits to certain rules of optimal synthesis. In case of finite state machine (FSM) model, so-called two-processor FSM's pattern, in which the transition and output functions are calculated in one process, and the assignment of new state is performed in another process associated with synchronization.

During verification of logical control system (LCS) it is advisable to apply the functional approach – check not the software HDL-code and the circuit, which was synthesized on its basis, but the functional model of the state machine – the state diagram. It should be noted that from the point of view of synthesis the FSM's pattern uniquely and correctly reflects the functional model of the finite state machine in the form of the state diagram [1].

The rules for checking the state diagram for correctness are developed in sufficient detail and practically standardized. This is check for completeness, consistency, feasibility and the presence of generating circuits [2]. Proceeding from this, an actual task is to develop verification procedures for HDL models of finite state machines taking into account of the correctness under condition of state diagram from one side, and, rules of synthesizers' operation on technology platform of the CAD FPGA from another hand.

II. Correctness verification of HDL-model, which is represented as state diagram

The syntactical correctness of the state diagram is determined by the fulfillment of the conditions for transition functions: consistency (orthogonality) and completeness. Consistency in the state diagram is provided in the case, if transitions are simultaneously forbidden to any of two or more arcs, which come out from one vertex. The completeness of the state diagram (marks' disjunction of all arcs, which is outgoing from a vertex, is equal to one) is checked after ensuring consistency.

A fragment of the state diagram for vertex a_i with K outgoing arcs is shown in fig. 1.

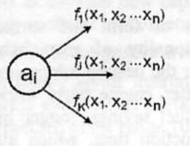

Fig. 1. Mapping of transition function conditions on the graph model

Each arc is associated with logical expression of the transition function conditions $f(x_1,x_2,...x_n)$ in the disjunctive normal form (DNF) also known as sum of products (SOP) form:

$$f(x_1,x_2,...x_n) = f_1(x_1,x_2,...x_n) \vee ...$$
$$\vee f_j(x_1,x_2,...x_n) \vee ... \vee f_K(x_1,x_2,...x_n).$$

Completeness is checked for each vertex of state diagram by analyzing of transitions' conditions of all arcs, which is outgoing from this vertex, i.e. $\bigvee_{j=1}^{K} f_j(x_1,x_2,\ldots x_n)=1$. The completeness of conditions is defined as cover of all 2^n products (terms) of Boolean transitions functions set, where n – quantity of transitions' conditions (input variables which initiate transitions from this vertex), i.e. $f(x_1,x_2,\ldots x_n)=1$.

While ensuring the consistency, for each vertex of the state diagram, the orthogonalization of Boolean expressions of transitions' conditions is checked (the absence of common terms in Boolean expressions of conditions for different arcs) for arcs, which is outgoing from the considered vertex, i.e. $\forall(f_g \cdot f_h = 0),\ g \neq h$ [3].

A normal disjunctive function of the algebra of logic is called orthogonal if all the conjunctive terms are mutually orthogonal. For such function, there is no set of variables' values, which belongs more than to one elementary conjunction, that is, on any set of variables' values, the value of one can be accepted only by one conjunction. If the logical function is presented in the form of a Karnaugh map, the images of conjunctions (products) will not intersect. An example of orthogonal DNF can be its canonical form (CDNF or CSOP), which consists of complete mutually orthogonal conjunctions [4].

Let's consider a method for constructing an orthogonal complete system of transitions functions for the vertex of the state diagram.

Let's use the following definitions: f – complete CDNF from n variables, that is $f(x_1,x_2,\ldots x_n)=1$ – Boolean function that takes the value 1 on all 2^n sets, f^* – complete CDNF from $(n-1)$ variables, f^{**} – complete CDNF from $(n-2)$ variables, f^{***} – complete CDNF from $(n-3)$ variables and so on. Thus, $f=f^*=f^{**}=f^{***}\equiv 1$.

The orthogonality of Boolean function' terms is ensured by decomposing into the corresponding variables, taking into account the completeness of decomposition into all variables [5].

According to the first theorem, the decomposition will be a follows:

$$f=\overline{x_1}\cdot f^* \vee x_1\cdot f^* = \overline{x_1}\cdot 1 \vee x_1 \cdot f^* = \overline{x_1} \vee x_1 \cdot f^* = \overline{x_1} \vee$$
$$\vee x_1(\overline{x_2} \vee x_2 \cdot f^{**}) = \overline{x_1} \vee x_1(\overline{x_2} \vee x_2(\overline{x_3} \vee x \cdot f^{***})) =$$
$$= \overline{x_1} \vee x_1(\overline{x_2} \vee x_2(\overline{x_3} \vee x_3 \cdot (\ldots \cdot (\overline{x_n} \vee x_n)))).$$

Thus, the complete Boolean function of n variables decomposes at least to $(n + 1)$ conjunctions while preserving the essence of all n variables.

As an example, let's consider the complete CDNF $f(x_1,x_2,x_3)=1$. By definition, a CDNF is orthogonal. We write the complete CDNF and perform the decomposition by x_1 with the replacement of the left side of the decomposition inside brackets with 1.

$$f(x_1,x_2,x_3)=\overline{x_1}\,\overline{x_2}\,\overline{x_3} \vee \overline{x_1}\,\overline{x_2}x_3 \vee \overline{x_1}x_2\overline{x_3} \vee$$
$$\vee \overline{x_1}x_2x_3 \vee x_1\overline{x_2}\,\overline{x_3} \vee x_1\overline{x_2}x_3 \vee x_1x_2\overline{x_3} \vee x_1x_2x_3 =$$
$$= \overline{x_1}(\overline{x_2}\,\overline{x_3} \vee \overline{x_2}x_3 \vee x_2\overline{x_3} \vee x_2x_3) \vee x_1(\overline{x_2}\,\overline{x_3} \vee$$
$$\vee \overline{x_2}x_3 \vee x_2\overline{x_3} \vee x_2x_3) = \overline{x_1}\cdot 1 \vee x_1 \cdot (\overline{x_2}\,\overline{x_3} \vee \overline{x_2}x_3 \vee$$
$$\vee x_2\overline{x_3} \vee x_2x_3) = \overline{x_1} \vee x_1(\overline{x_2}\,\overline{x_3} \vee \overline{x_2}x_3 \vee x_2\overline{x_3} \vee x_2x_3).$$

Let's perform similar procedure of decomposition by x_2 for the expression in brackets. Open brackets and get the complete orthogonal function of three variables (1).

Based on this, we can conclude that the complete orthogonal function of n variables has at least $(n + 1)$ conjunctions. So, from each state of the finite state machine with the function of transitions' conditions from n variables $f(x_1,x_2,\ldots x_n)$ there must be at least $(n + 1)$ transitions.

$$\begin{aligned} f(x_1,x_2,x_3) &= \overline{x_1} \vee x_1(\overline{x_2}(x_3 \vee \overline{x_3}) \vee x_2(\overline{x_3} \vee x_3)) = \\ &= \overline{x_1} \vee x_1(\overline{x_2}\cdot 1 \vee x_2(\overline{x_3} \vee x_3)) = \\ &= \overline{x_1} \vee x_1(\overline{x_2} \vee x_2\overline{x_3} \vee x_2x_3) = \\ &= \overline{x_1} \vee x_1\overline{x_2} \vee x_1x_2\overline{x_3} \vee x_1x_2x_3 . \end{aligned} \tag{1}$$

One of the ways of visual analysis of the transitions' functions orthogonality is representation of the orthogonal functions using Karnaugh maps. Karnaugh map for the orthogonal function (1) is shown in fig. 2 (a). From this map, it can be seen that for the orthogonal function, groups of ones for the complete CDNF don't intersect, i.e. conjunctions have no common parts.

Karnaugh map for the orthogonal function $f(x_1,x_2,x_3)=\overline{x_1} \vee x_1\overline{x_2} \vee x_1x_2\overline{x_3}$ is shown in fig. 2 (b), but this function is not complete, since there is no group which is corresponds to conjunction $x_1x_2x_3$. This is due to the fact that the construction of this function violated the rule of completeness of the function, i.e. $f^* \neq 1$.

Karnaugh map for the orthogonal function $f(x_1,x_2,x_3)=\overline{x_1} \vee x_1\overline{x_2} \vee x_1x_2$ is shown in fig. 2 (c), but this function is also not complete, since there is no variable x_3. This is due to the fact that construction of this function violated the rule that in complete function supposed to be no less than $(n + 1)$ conjunctions.

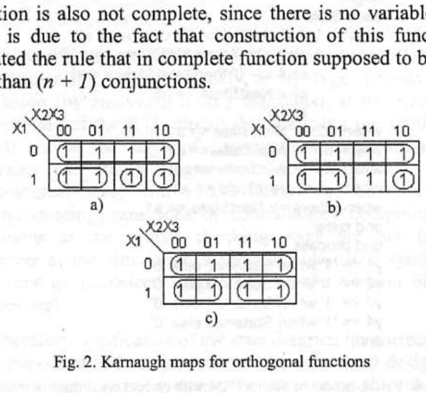

Fig. 2. Karnaugh maps for orthogonal functions

III. Comparison of synthesis results of HDL-codes of correct and incorrect state diagramms

Let's consider an example of the state diagram (fig. 3) with correct conditions for transitions from the a_1 state.

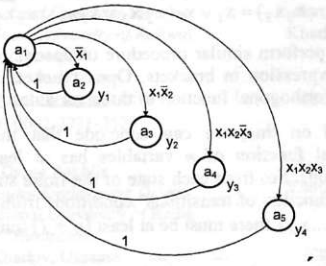

Fig. 3. The state diagram of Moore FSM with the correct conditions of transitions

The transitions' conditions function from the a_1 state is orthogonal, therefore, conditions of transitions are consistent. In addition, the function is complete. VHDL-model of this FSM is shown in fig. 4.

```
library IEEE;
use IEEE.std_logic_1164.all;
entity Fsm_right is
        port (x1, x2, x3, Clk, reset: in STD_LOGIC;
        y1, y2, y3, y4: out STD_LOGIC);
end;
architecture Fsm_right of Fsm_right is
        type State_type is (a1, a2, a3, a4, a5);
        signal State, NextState: State_type;
begin
        Sreg0_CurrentState: process (Clk, reset)
        begin
                if reset='1' then State <= a1;
                elsif Clk'event and Clk = '1'
                then State <= NextState;
                end if;
        end process;
        Sreg0_NextState: process (State, x1, x2, x3)
        begin
        case State is
        when a1=> if x1='0' then NextState <= a2;
                elsif x2='0' then NextState <= a3;
                elsif x3='0' then NextState <= a4;
                else NextState <= a5;
                end if;
        when a2=>  NextState <= a1;
        when a3=>  NextState <= a1;
        when a4=> NextState <= a1;
        when a5=> NextState <= a1;
        when others => NextState <= a1;
        end case;
        end process;
        y1 <= '1' when State=a2 else '0';
        y2 <= '1' when State=a3 else '0';
        y3 <= '1' when State=a4 else '0';
        y4 <= '1' when State=a5 else '0';
        end;
```

Fig. 4. VHDL-model of Moore FSM with correct conditions of transitions

Timing diagram of this FSM are shown in fig. 5.

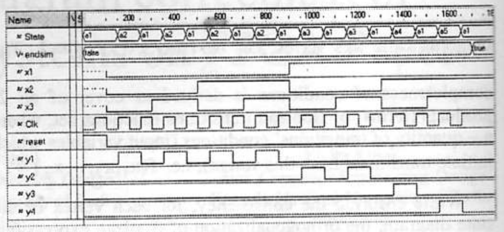

Fig. 5. Timing diagram of Moor FSM with correct conditions of transitions

It reflects the results of simulation in the system ALDEC Active-HDL on all combinations of conditions x_1, x_2, x_3.

The diagram shows that the transitions' conditions function is complete and orthogonal. During the period from 150 ns to 950 ns, the FSM changes to the state a_2 $(y_1 = 1)$ as long as the condition $\bar{x}_1$ is true, i.e. $(x_1 = 0)$, and then returns back to a_1 $(y_1 = 0)$. During the period from 950 ns to 1350 ns, the FSM changes to the state a_3 $(y_2 = 1)$ as long as the condition $x_1\bar{x}_2$ is true, i.e. $(x_1 = 1, x_2 = 0)$, and then returns back to a_1 $(y_2 = 0)$. During the period from 1350 ns to 1550 ns, the FSM changes to the state a_4 $(y_3 = 1)$ as long as the condition $x_1x_2\bar{x}_3$ is true, i.e. $(x_1 = 1, x_2 = 1, x_3 = 0)$, and then returns back to a_1 $(y_3 = 0)$. During the period from 1550 ns to 1750 ns, the FSM changes to the state a_5 $(y_4 = 1)$ as long as the condition $x_1x_2x_3$ is true, i.e. $(x_1 = 1, x_2 = 1, x_3 = 1)$, and then returns back to a_1 $(y_4 = 0)$.

Let's consider the following example of the state diagram (fig. 6). Conditions of transitions from the state a_1 are incorrect from the point of view of transitions' conditions functions orthogonalization; during transition to a_4 and a_5 there is no variable x_1 in the term, but they don't contradict conditions of transitions $x_1x_2\bar{x}_3$ and $x_1x_2x_3$. Transitions' conditions functions are complete.

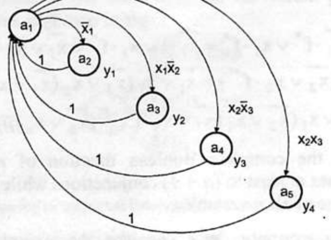

Fig. 6. State diagram of Moore FSM with consistent incomplete conditions of transitions

Transitions from state a_1 can be written in VHDL as follows (fig. 7 (a) or fig. 7 (b)). At the same time, such description is not stylistically correct, but it is not inconsistent and gives the same results during simulation as in fig. 5

```
when  a1=> if x1='0' then NextState <= a2;
        elsif x1='1'and x2='0' then NextState <= a3;
```

```
elsif x2='1'and x3='0' then NextState <= a4;
else NextState <= a5;
end if;
```

a)

```
when a1=> if x1='0' then NextState <= a2;
          elsif x1='1'and x2='0' then NextState <= a3;
          elsif x2='1'and x3='0' then NextState <= a4;
          elsif x2='1'and x3='1' then NextState <= a5;
          end if;
```

б)

Fig. 7. Fragments of the VHDL-model of Moore FSM with consistent incomplete conditions of transitions

In addition, FSM models which are shown in fig. 3 and 6, give exactly the same correct results during synthesis. Synthesis was performed in the system XILINX ISE.

Next, let's consider an example of the state diagram (fig. 8) with a missing transition (by condition $x_1x_2x_3$) and incomplete condition for the transition from state a_1 to state a_4: $\bar{x}_2 x_3$ instead of $x_1x_2\bar{x}_3$. The transitions' conditions function in this case is non-orthogonal and incomplete.

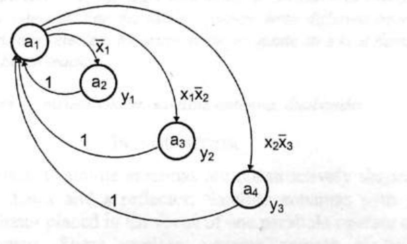

Fig. 8. Moore state diagram with missing transition

A fragment of the VHDL model of this FSM is shown in fig. 9.

```
when a1=> if x1='0' then NextState <= a2;
          elsif x1='1'and x2='0' then NextState <= a3;
          elsif x2='1'and x3='0' then NextState <= a4;
          end if;
```

Fig. 9. Fragment of the VHDL-model of Moore FSM with missing transition

During simulation of the operation of this FSM (fig. 10), at first glance, everything is fine, but in fact, the variable x_3 is insignificant here, on the set x_1, x_2, $x_3 = 111$ the FSM should not go to any state, but the modeling system put him to the state a_4.

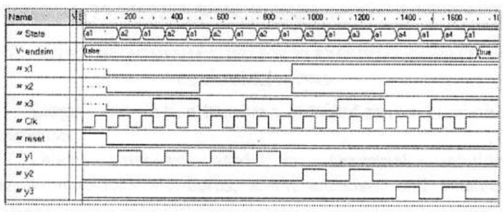

Fig. 10. Timing diagram of Moore FSM with missing transition

Likewise, when conditions x_1, x_2, $x_3 = 010$, the FSM can go into two states a_2 and a_4, which should not be in the case when the FSM works correctly, but the modeling system masks such situation, putting the FSM into the a_2 state. In this example, there is both a lack of completeness and the presence of a contradiction of the transitions' conditions, but this is clearly not manifested at the stages of syntax analysis and simulation.

During synthesis of this FSM can be problems especially in the case of older versions of CAD. For example, when using Xilinx ISE 10.1, a warning appears about four latches in addition to four flip-flops: *Found 4-bit latch for signal <NextState>. Latches may be generated from incomplete case or if statements. We do not recommend the use of latches in FPGA/CPLD designs, as they may lead to timing problems*. That is, instead of two triggers for the four states, 8 triggers of two types are synthesized. This should not be in a correctly synthesized FSM. At the same time, when using the latest version of Xilinx ISE 14.7, this warning will no longer exist.

Thus it is shown that problems associated with incorrect conditions are very difficult to identify during the design process. With equal probability, they can appear both on the timing diagram during behavioral simulation, and in the synthesis process (especially in cases with older versions of CAD). So, the verification of transitions' conditions for consistency and completeness must be carried out at the stage of forming the state diagram of the FSM.

IV. Conclusion

Construction a logical control system based on FPGA is a modern approach to computer-aided design. One of the most common ways to describe logical control systems is the finite state machine model, which description based on the state diagram. The correctness of the future HDL code depends on the correctness of the state diagram.

The concept of orthogonalization, used to decompose logical functions in the synthesis of digital systems [6], can be also used to check the state diagram for correctness [2]. As a result of the research, it was shown that the transitions' conditions function $f(x_1,x_2,...x_n)$ is non contradictory if it is orthogonal. The orthogonal function of transitions' conditions $f(x_1,x_2,...x_n)$, in its turn, is complete if its terms cover all sets $x_1,x_2,...x_n$.

The verification of HDL model is carrying out at all stages of computer-aided design, namely, at the stage of behavioral simulation (by analyzing timing diagrams), at the stage of synthesizing of the RTL circuit (by analyzing the synthesis report) and at the stage of post-synthesis simulation (by analyzing the timing diagrams, taking into account the technological base). Due to the features of the modeling system, missing transitions or contradictory conditions of transitions at the syntax checking stage are not fixed, moreover at the simulation stage and automated synthesis they may go unnoticed (depending on the version of the synthesizer).

Therefore, verification of the state diagram for correctness is an important and integral step in the automated design of automatic logic control systems, the functioning algorithm of which is presented in the hardware description language

References

[1] Shkil A.S., Avtomatizirovannoe proektirovanie sistem logicheskogo upravlenija s ispol'zovaniem shablonov avtomatnogo

programmirovanija / A.S. Shkil', Je.N. Kulak, I.V. Filippenko, D.E. Kucherenko, M.V. Goga. // Radioelektronika ta informatika – 2018. – №3 – S. 75-81.

[2] Shalyto A.A. SWITCH-tehnologija. Algoritmizacija i programmirovanie zadach logicheskogo upravlenija / A.A. Shalyto. – SPb.: Nauka, 1998. – 628 s.

[3] Baranov S. Logic and System Design of Digital Systems / S. Baranov. – Tallinn: TUT Press, 2008. – 267 p.

[4] Zakrevskij A.D., Logicheskie osnovy proektirovanija di ustrojstv / A.D. Zakrevskij, Ju.V. Pottosin, L.D. Cheremisino FIZMATLIT, 2007. - 592 s.

[5] Shalyto A.A. Novyj metod vychislenija bulevyh formul / A.S. A.P.Luk'janova, A.A.Shalyto. [Jelektronnyj resurs] Dvizh otkrytuju proektnuju dokumentaciju – Rezhim dostupa: www http://is.ifmo.ru/download/lbgmx.pdf. – Zagl. s jekrana.

[6] Haskell R. Digital Design Using Digilent FPGA Boards: Active-HDL Edition / Richard E. Haskell, Darrin M. Hanna Books Rochester Hills, MI, 2009. – 381 p.

The manifestation of synergy in management and social sciences, and methods for measuring it

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Abstract— **The article suggests the use of a systematic approach in management by using well-known management schools and areas of achievement at the same time. The article touches on the essence of the concept of synergy, and that synergy exists only in such a system that performs its functions. On its basis, a hypothesis has been proposed for identifying synergy, and in the processes themselves a systematic approach has been proposed to identify phenomena such as synergy. It is proposed that the source of synergy might be "entropy". The author of the article indicates that processes take place in any activity of a human beings and society, such as the humanities, social and economic sciences, which implies the existence of entropy, which is very similar to the theory of transactions and transaction costs. This approach is necessary for the application of budgeting and financial relations for individual entities and as well as the whole state.**

Keywords—schools of management systematic approach, synergy, synergy effect, entropy, process, transactions, transaction costs

I. INTRODUCTION

At the present stage of management development, in most scientific literature on economics and management, it is defined as an effective way to achieve the set goal for the organization through the rational use of all available resources. In purpose of this, various methods have been developed and proposed in order to increase the "efficiency" of the organization in the conditions of a market form of management. So, the founders of the school of scientific management, F. Taylor, spouses F. and L. Gilbert and others believe that the use of such activities as measurements, observation, logic and analysis, using appropriate people appropriate to a particular situation, allows to improve a fairly wide range of operations manual labor, allowing you to use it more efficiently.

The first phase of the scientific management methodology was the analysis of the content of the work and the determination of its basic elements (1), which was based on obtaining more detailed information about the work operation that allows eliminating unproductive movements on standard procedures and equipment that increase the efficiency of work at a particular workplace.

The great achievement of this school was the establishment of real production standards, in which it was possible to assess the intensity of the workload of workers. In this case, the employee overfulfillment of these norms provided for additional payment. Thus, this school made the main emphasis in its research on production management. This allowed F. Taylor to formulate well-known principles of labor organization.

Administrative or classical schools of management were seen as a source of increasing efficiency in managing the whole organization. The founder of this school is A. Fayol, who saw the source of increasing the effectiveness of the organization in determining the characteristics and patterns of development of the organization. Representatives of the classical school of management suggested that the creation of universal management principles could lead to success.

These principles affect two aspects: the development of a rational organization management system, which suggests an optimal way of dividing into work groups, such as: production, marketing, finance, etc .; and the construction of an optimal organizational structure for the organization and management of employees, in which A. Fayol formulated 14 management principles that are relevant at the present stage of the development of management science.

The objective reasons for the emergence of the school of the psychology of human relations and social systems were the inability to fully recognize the human factor as the main element of the organization's effectiveness (2). Thus, this school was based on the achievements of such sciences, the study of which is man and society: psychology and sociology.

All this served the start of the new school of "human relations." The founder of this school is E. Mayo, who discovered that the developed clear operations and high wages do not always lead to higher labor productivity, the employee is not more responsive to pressure from the direct supervisor, but to his colleagues in the group.

The school of human relations emphasized the importance of informal ties between the individual in production. This allowed us to consider such areas as the motives of human activity in the labor process. All this made it possible to develop recommendations for collective decision-making, for the participation of workers in management, and for the ways and methods of continuing education for workers. Also in the field of view of this school were the problems of relations between people in the production process, the delegation of authority of leaders and a number of administrative issues.

The main achievement of this school was the discovery that behind the motives of certain actions of people are not economic incentives, but various needs that cannot be fully or partially satisfied with the help of high wages.

Thus, representatives of the psychological school suggested that if managers show great concern to their employees, this will lead to the fact that the level of employee satisfaction will also begin to increase, which, in turn, will lead to increased productivity. All this served the use of such techniques in the management of human relations as: consulting with employees, providing them with more opportunities at work, etc.

II.

The introduction of computer technologies, communications, etc. in the sphere of management, highlighted quantitative approaches to solving managerial problems. There was an increased need for accurate answers to production and economic questions: how to rationally distribute the enterprise's resources (equipment, raw materials, labor, time, finances) in order to achieve the organization's goals. This situation required accurate estimates, which led to the need for mathematical methods for their calculation.

This situation required the development by scientists from different countries of a new area of applied mathematics, the so-called "Methods of research operations." This contributed to the emergence of such a problem as the quantitative justification of managerial decisions made in various sectors of social activity. Such a problem in relation to economic activity was called as economic-mathematical methods.

Economic and mathematical methods have found their practical application in inventory management; resource allocation; mass service; network planning and the search for optimal solutions using linear, nonlinear and dynamic programming methods.

The management schools proposed above substantiate the importance of applying each aspect of the impact on the employee in management, but, in our opinion, they cannot give an objective assessment or measure how the use of any so-called "tools" proposed by various management schools can lead to any systematic the end result. Since objective reality seems to be the existence of the proposed various management theories in aggregate, all concepts of management schools cannot exist separately. We assume that for the further development of management theory, it is necessary to combine all the achievements of the above schools of management and consider their actions together, since all the management tools of the schools presented cannot exist separately in reality.

The organization of all the proposed methods and tools for influencing an employee of different management schools is used in conjunction; each method of influence cannot exist separately. Thus, we can say that it will be much more convenient to apply a systematic approach to management in determining synergy in it.

The word synergy is Greek (sinergeia - cooperation, commonwealth) and denotes a specific variant of the body's response to the action of two or more medicinal substances, characterized by the fact that such an action exceeds the action exerted by each component individually (3).

The word "synergy" and "synergistic effect" (from the Greek. sinergos - together acting) in scientific works on economics means as a principle provision for increasing the economic effect as a result of the joint use of individual elements of the system, which may imply connections or merging within the system in practice, such a phenomenon in the economic literature is called emergence.

The discoverer of the phenomenon of synergy as a phenomenon manifesting itself in the system itself is generally accepted by I. Ansoff in the 60s. XX c. The above term for explaining "the phenomenon when income from own use of resources exceeds the sum of income from using the same resources separately, is often called the effect of "2 + 2 = 5", taking from the natural sciences as biology called it as "synergism" (4).

Synergy is the effect of the interaction of interconnected elements in the system. Hence, synergy is obtained in the form of a synergistic effect within the system itself. This means that the effect obtained by simply expanding the economies of scale at the concentration of production (due to reductions in fixed costs) is incorrectly attributed to synergy. I. Ansoff, explaining the synergy, divided it into two components: cost optimization and productivity improvement.

By objective necessity, we can talk about synergy only if the system performs its own functions designed for it. In the scientific literature, the concept of a system is classified as: simple, open, closed, conservative, dissipative, linear, non-linear, etc. (5).

As we know, there are dozens of different definitions of the concept of "system" in the world. Thus, L. von Bertalanffy defines system as a complex of interacting components (6).

He also writes that the system is a set of elements that are in certain relations with each other and with the environment (7). A system is a set of interconnected elements, separated from the environment and interacting with it as a whole (8).

Synergy can be represented as a property of a system that arises as a result of the interaction of system elements. This leads to the fact that we can only say that synergy is not characteristic of any system, but takes place in the very processes of interaction of elements within the system. Accordingly, we can say that synergy is due to the existence in the system itself, which arises in the process of interaction of system elements. Therefore, systems do not need to be associated with synergy at all.

The process determines the practical embodiment of the theory into practical applications, which characterizes the phenomenon during the interaction of system elements, without which it seems impossible to quantify the synergy, respectively the synergistic effect.

The process itself can be scientifically explained in detail by the methodology proposed by IDEF0 (Integrated Definition Function Modeling), authored by Douglas Ross, which was developed in 1973. This methodology was designed to cover the emerging needs for the analysis of heterogeneous methods of interactions of individual processes. This technique describes in more detail and explains the essence of the constituent elements of any process that has received public recognition and is accepted in the United States as federal. Such a methodology revealing the essence and content, as well as clearly explaining the process, can be a source of successful application in various humanitarian and social sciences, such as: political science, psychology, sociology, economics, jurisprudence, etc. Currently, the IDEF0 methodology is widely used by researchers not only in the United States, but throughout the world (9).

We will try to demonstrate the very essence of the IDEF0 methodology, in it the process is presented as: the process of transition of the trends of the "Input" to "Output" transition, with the influence of the "Management" tool using the tools that are presented as the "Mechanism". Graphic notation of the process in the modeling (10) system is presented in Fig. 1. (11)

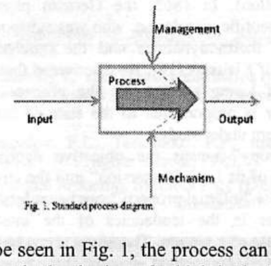


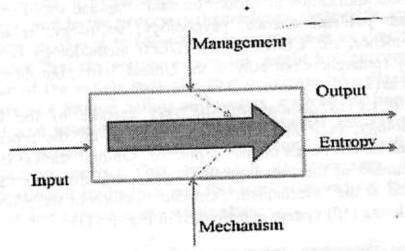
Fig. 1. Standard process diagram

As can be seen in Fig. 1, the process can be represented as a rectangle, the beginning of which is the "Input" arrow from the left, the top is represented by the "Management" arrow, the bottom is represented by the "Mechanism" arrow, the process ends with the "Output" arrow presented to the right. In the presented model, the arrow "Input" means all the initial data in the aggregate included in the process for changing them in it, therefore, "Input" is the initial state of the system itself. Under the arrow called "Output", you can imagine the converted product, through the interaction of a heterogeneous process leaving. "Management" can be presented as a component of the process, representing the human impact on the very interaction of the elements of the system. And finally, under the "Mechanism" arrow, we can mean an instrument of influence by influencing process controls. Mechanisms are those resources that cannot be transferred to the "Output", but create the necessary conditions for the process of transformation (like a catalyst in chemistry). The most important element of the process can be considered the life cycle of the process, which is shown by an arrow in the rectangle. It is in the process of the life cycle that is an algorithm or sequence of effects of process elements with other components and how the transition of the input to the output itself, through the impact of "Management" as a person, and using resources - the "Mechanism".

The transformation of "Input" into the total desired "Output" in society and the economy can be called a process.

Development in the context of the totality of the desired changes in the economy and society, began to be seen as a process (12).

The special model of the process approach given in our article makes it possible to demonstrate the differentiation of the process itself into its components - subprocesses.The whole set of classified systems can be characterized by the description of one or several processes existing in any system. Objectively, it can be argued that when converting "input" to "output" during the course of the processes that transform them, we can say that there are always any losses in the form of energy or matter in the life cycle and the elements themselves involved in the process. Thus, let us dwell on the losses, which we tried to clearly show as "entropy", which is an objective indicator that, in our opinion, will help to measure such losses, which are presented in Fig. 2. (13)



Like "synergy", the term "entropy" has a Greek origin (en, tropē - rotation, transformation). In 1865, the German physicist first introduced it into scientific circulation, who was subsequently one of the founders of thermodynamics and the molecular-kinetic theory of heat, Rudalf Klausius (14). He discovered that all matter has the property of losing energy, i.e. the process of energy absorption by matter is proportional to the state of the "internal property" of the system under study.

Consequently, "entropy" means the objective depreciation of energy as a measure of its loss, "dispersion" into the environment, etc. In our opinion, the "internal property" can be understood as the processes themselves in the tendencies of the interaction of elements in the process of a system. Therefore, it can be stated that "entropy" exists in every component element of the process (input, output, management, mechanism), as well as in the process life cycle itself. For simplicity, we cited it as a parallel exit from the process.

Therefore, it can be asserted with certainty that in objective reality there cannot be processes with a 100% useful action. "Entropy" can be characterized as an additional result of the action of individual elements of the system or a parallel process, which cannot be determined by individual elements of each system.

Thus, "entropy" can exist both on "input", "management", "mechanism" and on the life cycle of the process itself. The appearance of a synergistic effect can be explained by the fact that the "entropy" decreases, i.e. individual elements in the system, in the process of interaction and its life cycle, tend to zero. This, in turn, leads to an increase in an additional useful output - synergy.

So, the objective reality of the law of conservation of energy and mass, says that synergy cannot come from nowhere, which means, in our opinion, it is formed together with "entropy" in the very processes occurring in systems.

Therefore, synergy arises from the utilization of "entropy" by absorbed system elements during their interaction and by the process itself, the elements of which can be "input", "management", "mechanism" and "output". We can conclude that synergy can occur only when utilization of the entropy of jointly acting processes simultaneously and alternately in the system itself. So, we were able to clearly identify the existence of such a phenomenon as synergy. The problems of synergy manifestations also exist in the so-called humanitarian and social sciences. If we assume that all of the above sciences are related to human activity, which means that society as a whole consists of an individual person, then any human activity is accompanied by economic categories, such as the costs of carrying out activities and income, characterizing the receipt of benefits.

O.V. Rybakova uses the following approach to determining costs: Costs are a cost expression of the value of economic resources when a corporation takes any actions (15), which science itself is also pursuing management. She also refers to costs as losses, defining it as the costs of the organization that did not generate income or led to losses (16).

So entropy in the humanities and social sciences, we believe, can be equated with economic categories as costs, presented in the form of cost reduction, while increasing the result, presented in the form of an economic category - income. Since entropy is the absorption of energies by individual elements of the system in the process of their interaction with each other, we can assume this as economic losses in the form of the costs of interaction of the elements of the system, and synergy as the benefits received from such interaction in the form of additional income.

A certain difficulty is presented in the classification of so-called "entropy" costs. For this, we believe that it is necessary to go over to the theory of "transactional" costs proposed by the American economist, Nobel Prize laureate R. Coase, to explain these types of costs. This concept refers to the process of transfer or reproduction of property rights. The term "transaction" is close to this, in which the ownership right is changed or transferred to one or another business entity. In this case, the transaction covers more social and economic phenomena, which should be given using the classification of the transaction proposed by J. Commons, who defined it in three possible forms:

1. bargaining transaction: the transfer of ownership takes place on the basis of a voluntary agreement of the parties, here there is a coincidence of the concepts of "transaction" with a negotiated transaction;
2. managerial transaction: the transfer of ownership occurs in the case of directives of one person and subordination to another, for example, the manager's attitude to the executor;
3. rationing transaction: the transfer of ownership is transferred by a team that is given by a collective body, and submission comes from individuals, a similar relationship is observed between the state and the population;

Transactional costs can be understood, in the aggregate of definitions, as costs in defense of property rights. Also in the scientific literature we can find a definition of transaction costs, as the costs of using the market mechanism or as the costs associated with the conclusion of transactions.

In classical physics, it was believed that when moving objects, the friction force does not significantly affect the result of the movement, but the use of friction force with an increase in the physical effect on the result has not been invented in science. Thus, we can say that "entropy" has the same meaning as the force of friction, which did not come under the scrutiny of economists. The same assumption is made in non-classical theory, where the movement of economic objects, i.e. ownership rights occurs with zero friction, i.e. free of charge. Thus, we can see that the theory of transaction costs, as it tells of the existence of entropy in social, political and economic relations. But due to the fact that it is not possible to measure these costs, it does not find the popularity of their practical application. On the basis of our hypothesis, entropy occurs during the functioning of the system, both during the interaction of the processes of the system and the course of economic activity itself.

...sider system processes in management. Human economic ...vity ensures survival in the natural environment, mainly ...uires an economic nature, which is the basis and creates the ...ditions for political, legal, social and managerial human ...vity.

...sing the process of rationalization of available resources in ...agement, the organization achieves an increase in labor ...uctivity, as a result, the number of manufactured products ...eases at constant production costs. This leads to an increase in ...me, and subsequently, in profit, all other things being equal. ...creating a rational organization management system, the so-...ed "control costs" are reduced, which also reduces economic ...es, which can manifest themselves as production costs, which ...gests increasing the company's profitability in the country's ...cial market. Increasing the atmosphere of an organization's ...iness" in a individual's work can also increase the ...ization's "corporate spirit", leading to an increase in the ...omies of scale from available resources, which also leads to an ...ease in profitability and company's reputation, etc. The use of ...ematical methods in inventory management; resource ...cation; mass service; network planning and the search for ...mal solutions by using linear, non-linear and dynamic ...ramming methods, the organization also eliminates downtime, ...stified losses manifesting in additional unforeseen expenses of ...organization, which also lead to increased profitability of the ...ization.

...e is a cascade of synergy, in the management concepts above. ..., the instruments of the schools of scientific management are ..., then the instruments of the classical school, after applying ...concepts of the school of human relations. And finally, the ...cation of the achievements of the quantitative school increases ...social, political indicators, and the most important they are ...rmed by economic indicators.

...ature, such a combination of processes is practically not ...ble, it is only possible when managing individual processes by ...an based on synergy. For example, managing an orchestra ... the help of a person who is a conductor. Achieving ...stency in the sound of a huge number of instruments in the ... of an orchestra involves reducing the entropy (inaccuracy, ...sistency, errors) of each participant. It can also include ...dination of all functional departments of the corporation, ... will lead to the above described effect. For this, a synergy ...ess is used, the producer of which is the manager, and ...rding to the established system of plans, he addresses each ...ional structure, or even each employee, leading to a decrease ...ropy in production systems and processes, the result of which ... obtain a synergistic effect - synchronous interaction of all ...esses production and system elements at the same time.

..., all the practical activities of a human being, such as social, ...cal, legal and economic, are associated with obtaining and ... synergy, which in any case provides a positive effect and ...ovements in living conditions. Therefore, we can say that the ...ful coordination of all social, political, legal and economic ... of human activity combines, embraces, and can synchronize ...strial management. We believe that the synergistic effect is ...ly manifested in their joint and joint participation of the ...idual elements of the system among themselves, which can be ...ated by economic categories as costs and profitability.

... economic activities of society are associated with the ...ation, production and rational use of available resources. ...omists equate or see resources in terms of commodity-money ...ons as money. The transfer of ownership rights, in these ...tions, is associated with financial flows, i.e. cash payments ...directed to owners of property rights, while owners receive ...cial responsibility to fulfill their obligations. In this case, the ...osure of synergy issues in the field of budget formation and ...tion as separate economic entities and the whole state ...es especially relevant.

Conclusion

Based on the research, the following conclusions were obtained:

1. A hypothesis is proposed, which is based on the concept of a process in management, acting in the system and applying all the concepts of management schools at the same time, because in our opinion, each school is useful and the world is developing not one-sidedly, but comprehensively, and it is necessary to use the achievements of all management schools simultaneously to obtain a synergistic effect.
2. A process approach hypothesis was formed to explain the description as a source of the synergistic effect obtained within the system.
3. All practical human activity is based on certain processes, which means that the process approach introduces a new system of concepts that describes the movement of matter, as well as an explanation of the "postulate" theory of transaction costs based on the latter.
4. Using the developed functional model of processes in nature and the social, political and economic sciences, since processes exist in all of the listed sciences, it allows us to identify synergy and synergistic effect.
5. It is necessary to carry out additional checks of this hypothesis in the budgeting of business entities and a separate state, since the basis of human economic activity at the present stage is commodity-money relations involving financial flows and settlements between them.

[1] Ivanova E.A. Management theory. Tutorial. M 2014 P15

[2] Ivanova E.A. Management theory. Tutorial. M 2014 P18

[3] V.A. Balabaev Synergy: areas of manifestation and sources of receipt // Vestnik TSEU. Number 3. 2006.P. 90.

[4] Ansoff I. Strategic management / I. Ansoff. - M .: Economics, 1989.

[5] The hypothesis of synergy in nature and the economy 05/28/2013

[6] Bertalanffy L. von. History and status of the general theory of systems // System Studies. - M.: Science 1973.

[7] ib.

[8] Peregudov F.I., Tarasenko F.P. Introduction to system analysis. - M.: Higher School, 1989.

[9] Functional Modeling Methodology IDEF0. Guiding document RD IDEF 0 - 2000. - M. - Gosstandart of Russia. - 2000. - 75 p.

[10] Maklakov S. Modeling of business processes with BPwin 4.0. - M :. MEPhI dialogue. 2002 .-- 630 p.

[11] "http://kapital-rus.ru/articles/article/gipoteza_o_sinergii_v_prirode_i_ekonomike/"

[12] Karimsakov M.R. "Scientific aspects of the concept of sustainable economic growth" / Science, new technologies and innovations of Kyrgyzstan. No. 5. 2018. 99 p.

[13] kapital-rus.ru/articles/article/gipoteza_o_sinergii_v_prirode_i_ekonomike/

[14] Popov V., Kraynyuchenko I. The second law of thermodynamics. - An electronic source. Access mode- – "http://holism.narod.ru/Alter/8.htm"

[15] 13. Rybakova O.V. Financial cost management in the system of increasing the efficiency of organizations: dis. ... Dr. Econ. sciences. M., 2010. P. 368.;

[16] 14. A.A. Zemtsov, O.M. Nikulin "The philosophy of cost administration - the meaning of financial management of an enterprise (organization)" / Accounting and Finance Problems No. 2 2015. P. 49.

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