Methodological Framework for the Information Systems Design Based on the Knowledge Forms Origin Means

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***Abstract*—The paper presents the idea of considering the problem of stakeholders harmonization through the prism of the processes (means) of knowledge forms origin (concepts or system components), while existing approaches consider the issues of harmonization of empirically obtained knowledge forms. As a basic element of systems, it is proposed to use the structure of forms origin means of concepts (the process structure of the forms organization). To use the base element, it is proposed to use a methodological framework. All this gives an advantage in such aspects as the variability of new solutions, adaptability and extensibility of existing systems. Thus, the paper offers a fundamentally different view on the synthesis of complex technical systems and the methods of their design.**

I. INTRODUCTION

Despite the development of technologies and methodological support in the field of information technologies (IT), one of the key problems remains to be solved – the problem of mutual understanding of various forms of knowledge created by customers and developers (stakeholders). The essence of the problem lies in the complexity of the design process, which is characterized by conflicts between the design results of development teams working together to design one system [1], deliberate distortion or limited information exchange between developers [2], semantic barriers between development teams [3], protection by experts of delicate design data [4]. By itself, the process of complex technical systems development requires interaction between several technical disciplines, the authority over which is distributed among a multitude of experts. In this case, experts can be distributed within the organization and carry out activities at various stages of the product life cycle and at various stages of its production chain. The complex nature of such projects requires the interaction of many disciplines in the context of decentralized design authority and imperfect knowledge of development teams about the system.

The problem of agreeing points of view on the target system being developed, often inseparable from the problem of mutual understanding of stakeholders in the process of information systems development, as a special case of complex technical systems, is one of the fundamental for today. The quality of its solution in each case is directly related to the compliance with the terms, the budget of the project, and also the meeting the customer's requirements. According to various studies, less than half of the projects of complex technical systems development are successful and do not exceed the budget. The agency The Standish Group International in its study shows that the cost of the IT project is 189% of the originally planned, and over 30% of the projects do not reach completion [5]. This is observed against the background of the availability of advanced tools for documenting, modeling, design, frameworks for program code development, as well as in conditions of market saturation by good specialists.

II. RELATED WORK

Researchers around the world link the reasons for the emergence of stakeholders mutual understanding problem with the lack of knowledge about the specifics of different subject areas related to different system design stages. The reason for this situation is the inconsistency of the image of the target system, which arises from a misunderstanding between the customer and the developer. The overwhelming majority of modern research and practical developments are aimed at solving the problem of mutual understanding between two participants in the information systems life cycle, located at its neighboring stages.

For this reason, methods, approaches and tools are created to extract and transmit meaning between subjects from two different subject areas:

- extracting requirements techniques [6] (for the customer-analyst / project manager connection)
- model-oriented approaches [7] (for the analyst / project manager - the designer connection)
- interpreted models and code generators (for designer – programmer connection).

Also in a separate class can be selected domain-specific languages (DSL), ideally aimed at a direct transition between the customer and the system. However, such languages require preliminary work of analysts, designers and programmers with a deep immersion into the subject area, and at the output of the development process they give a highly specialized tool that is not suitable for mass use.

The most relevant in time are applied scientific research aimed at solving current problems in the development of complex technical solutions - parallel design [8], consisting in the decentralization of the process of complex technical systems design and based on joint working groups that include specialists from different fields the purpose of which is to harmonize different concepts during the system creating process.

Applied methods of game theory [9], solving problems of interaction between experts in decision-making tasks. Directly these methods in complex technical systems design are not used, but they have a developed formal apparatus and can be applied to achieve consistency between participants of the life cycle stages.

System architecture [10] and the Solution space research method, aimed at studying key decisions made in the early stages of system design and having a big impact on the total cost and success of the project. The method of investigating the solution space in this context allows us to evaluate possible design solutions in order to determine the most effective variant.

The work of the international community on system engineering INCOSE, namely the development of methods, tools and technologies within the framework of the model-oriented approach MBSE [11], the main essence of which is the transition from documentary presentation at the development stages to model presentation. In this case, all the models are consistent with each other and thus form a general model of the system. The feature of this approach is the formation of a unified model of the system in the late stages of development (when all types of models are ready), as well as the consideration of the system from the point of its components and functions.

Requirements extraction techniques. This includes methods for analyzing and tracing requirements, various customer-oriented language and CASE tools, techniques involving the customer or its representatives in the development process [12]. The disadvantages of this scientific direction are limited use (only at the customer-analyst level) and high labor input.

Approaches based on scenario descriptions [13]. The idea of these approaches is a unified view of the system as a certain scenario of its use, which is consistent in the early stages of development, and used as a reference (and sometimes original for the generation of system components) model. Despite the similarity of similar approaches to the subject of the project, a number of fundamental shortcomings can be identified in them: a low average expressiveness of the scenario for all participants in the life cycle (scenarios are more understandable for analysts), and the development of a target system in isolation from the scenario where compliance is tested empirically.

However, this does not solve the problem globally, as above statistics showed. The analyst, using the most advanced methods and techniques, can get a 100% reliable description of the customer's requirements, but he is still neither a domain specialist nor a designer (programmer). In this connection, not having at the moment tools for documenting the meaning of the system with a view to its further transfer to the next stages of the life cycle, it translates the knowledge received from the customer about the subject area together with a set of requirements through a new set of tools to ensure its mutual understanding with the designer. With this approach, the loss of important aspects of the subject area and the target system is important for the successful implementation of the project. Thus, the problem of agreeing the stakeholders' points of view, eliminating contradictions and misunderstandings between participants in the life cycle stages of the information system is relevant and leads to a significant increase in project risks.

Despite some successful attempts to solve the problem of mutual understanding between two neighboring participants of the software life cycle, all the above approaches have one essential drawback: the tools created do not agree with each other and, most importantly, they do not allow one time to fix the meaning (semantics) of the system and transmit it through all stages of the life cycle. This causes the urgency of developing new approaches to the formulation, documentation and use of a single evolutionary semantic model of the target system at all stages of the life cycle.

III. MAIN PART

A fundamentally different view is needed on the synthesis of complex technical systems. The essence of the proposed idea is as follows. It can be assumed that the empirical stage of obtaining the original form, which can then be developed by transformation, is preceded by the stage of origin of the source forms. At the stage of origin of forms, it is necessary to create structures of meanings of knowledge for the organization of forms, in [13] such a structure is called a form for forms. At the stage of forms creation, the problem is solved as one form for forms passes into another form for forms, for example, as the forms of forms origin created by the customer should pass into the forms of origin of the designer forms. The point is that it is necessary to harmonize the ready-made forms that are not empirically obtained, for example, by the customer and the designer, but the forms in which the process of origin takes place, the organization of forms of knowledge. It is proposed to coordinate the forms of the processes of origin of knowledge (forms for forms), and not ready yet, empirically obtained forms of knowledge.

As a basic element of systems, it is suggested to consider the structure of the process of knowledge forms origin (forms for forms) (Fig. 1).

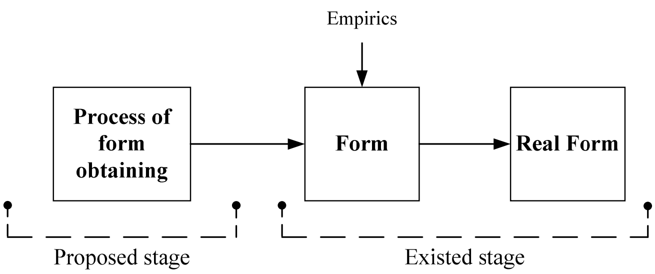

Fig. 1. The process of knowledge forms obtaining

Thus, the form of knowledge acquires two aspects – a structural (in the form of an insubstantial structure of organizing tools of knowledge forms origin process) and meaningful. The structural is expressed by the structure of the tools of the knowledge forms origin (tool is understood as the structure of the process that describes the origin of the knowledge forms), consisting of characteristics: elements, functions, tools, result. The meaningful aspect determines the embodiment of the concept in a specific environment (data model, user interface organization, method of performing computational operations) and is expressed in specific values of the tool characteristics. Organic unity, the number of structures of the processes of knowledge forms origin build the system structure of its form origin (the means of organizing the concept unity). This means that in the target system, as well as in the original semantic model, the matching of components should be achieved. The coordination of components means the absence of connections in the form of interfaces (converters), and the establishment of interpenetration of means for creating concept forms. The only form of interpenetration of creating concepts tools is the intersection of characteristics of various means of knowledge forms origin. To simulate such an organic unity, a new graph model is proposed, where the vertices correspond to the tools concepts forms organization from which the target information system consists, the ribs in their classical representation correspond to the uncertainty (variability) of the possible interpenetration of the processes of origin of concept forms that may be represented as partial or complete overlapping vertices on top of each other.

The hypothesis is that the basis for a uniform representation and understanding of the target system meaning is a certain generality of not concepts and relations between them, but the totality of the structures of the means by origin of the forms of concepts of different levels of design and the rules for organizing their interpenetration. This commonality of tools and rules is a space of possibilities for creating object design processes. Using this generality, it is possible to construct the structure of the means (sense) of the target information system being created in the form of a certain sequence of interpenetrating means for creating forms of individual concepts (the meaning of the system is to create from the meanings of concepts). At the early stages of the life cycle, this community, through its structure of interpenetrating facilities, provides an idea of the process of origin of the target properties of systems of this type. At the next stages of the life cycle, responsible specialists (experts of their domain) fill the generated structure with content (specific means, entities, attributes, functions, etc.), and expand the structure with new means if technology requires it.

For this, it is necessary to develop a semantic model [14] of the target system on the basis of a basic abstraction of the structure of the tools (meaning) of the origin of concept forms. Using the basic abstraction of the structure of the means of origin of concept forms, it is proposed to develop the structure of the process of creating a system in the form of a structure of organized interpenetration of means of origin of forms of individual concepts of different stages of the life cycle.

Organized interpenetration of forms origin tools creates an organic unity of means of origin of forms of separate concepts of various stages of the life cycle that will ensure their mutual coherence. Such coherent unity of interpenetrating structures of means of origin of forms of concepts from different stages of the life cycle is the structure of the process of designing systems of a given kind, which can be considered a methodological framework.

The methodological framework is due to the fact that methodological tools can also be used as tools. The concept of a methodological framework is to divide the process of creating an information system into three phases:

1). Creation of a space of opportunities to create a specific information system. The space of possibilities is a graph in which the vertices correspond to the means of origin of the forms of concepts (system components) expressed, for example, by the structure of the function, and the edges - possible connections between the means. Thus, the admissible framework for the composition and structure of information systems of this type is marked.

2). Development of the structure of the process of creating the origin of the forms of the system in the form of a structure of organized interpenetration of the means of origin of the forms of individual concepts from different stages of the life cycle. At this stage, experts from different technical disciplines and stages of the life cycle form an agreed view of the future system. The coordinated representation is a graph of a special form in which the edges are degenerate, and the presence of a connection between the two vertices, which are the means of origin of the forms of individual concepts, is represented by the intersection of vertices by individual characteristics of the function (interpenetration). It is important to note that the structure does not have content (specifics), it indicates only the typification of the means of origin of the forms of characteristics of the function for creating forms of concepts.

3). The coordinated filling of the structure of the process of the system forms origin. At this stage, experts from different technical disciplines and stages of the life cycle fill the structure of the process of creating the origin of the forms of the system with specific values of the characteristics of the function, thereby developing a specific information system.

Thus, the methodological framework, which represents the structure of means of information system forms origin of this type as a coherent structure of interpenetrating means of origin of the forms of individual concepts, and the process of their creation as filling the structure of the origin of forms with content, will solve the problem of conflict between the results of designing the development teams and agreeing points of view parties. And in the methodological framework itself, a whole set of new approaches and methods to software development will be concentrated.

The main differences of the proposed idea from the known approaches are:

1) Representation of a single process of origin of the forms of systems of this type as an organic unity of the structures of interpenetrating facilities (representing the meaning) of creating the origin of the forms of individual concepts of

different design stages, and the subsequent use of the structure of the origin of the system forms by all participants of all stages of the life cycle to create specific systems of this type;

2) Consideration of the meaning of the target system as a structure of the process of origin of forms, and not a description of the empirically obtained ready-made forms created or, more often, necessary to create parts of the system and their interrelations, as is done today. Such an evolving semantic structure of the system in the form of the structures of the processes of origin of forms can be represented by a graph of a special kind, in which the vertices correspond to the means of origin of the forms of individual concepts, from which the process of creating the forms of the target information system can consist, the edges in their classical representation correspond to uncertainties, the establishment of interpenetration between the means of origin of forms, and the established interpenetration of the means (vertices). The forms of individual concepts will be reflected in the partial or complete interpenetration of vertices (means) into each other. Documentation of such models can be provided with the use of modern graph database management systems, such as Neo4J.

IV. Conclusion

The ideas proposed in the work are of great importance both for the private field of science, which considers the issues of automatic and automated creation of applied information systems, and in general for areas of knowledge related to the design of complex technical systems. This is due to the similar nature of problems arising in the design.

The paper presents the idea of considering the problem of stakeholders harmonization through the prism of processes (tools) of knowledge forms origin (concepts or system components), while the existing approaches consider the issues of harmonization of empirically obtained knowledge forms. This gives an advantage in such aspects as the variability of new solutions, the adaptability and extensibility of existing systems.

Limitations on the wide application of the proposed methodological framework are contained in the graph model of the space of possibilities for creating a specific information system that forms the basis of the framework and reflects the specific features of the processes of creating information systems. The basic principles embedded in the methodological framework are of an interdisciplinary nature.

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