# Validation of architectural solutions during permanent design of sociotechnical systems

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**Abstract.** Authors consider the most significant approaches to creation of architectural concepts for hardware-software systems and the problems arising at their application nowadays. Solutions to the problems of this area are identified through consideration of permanent design process of sociotechnical systems and supplementary technologies capable to help the designer of the designated systems.

## 1 Introduction

Nowadays, systems engineering presents a large number of approaches, regulatory support methods and best practices for the design, development and management of artificial systems lifecycle [1, 2, 3]. Not only technical, but also sociotechnical systems are able to act as artificial systems. The social part of the latter has a great impact on the system lifecycle management processes as a whole.

Back in his time, Blanchard described adequate methods and approaches for the creation of technical systems and management of their life cycle, taking into account this social part [2].

On the other hand, various methods of managing social (soft) systems – Checkland's Soft Systems Methodology including Rich Pictures technique [4], Ackoff idealized design approach [5] Jackson system approach methods [6] – have been widely developed. Among them are the approaches and tools of the Moscow Methodological Circle, in particular, the Collective Mental Activity and organizational and activity games [7]. Members of this Circle also proposed a technique for permanent design,

according to which the design of the system is inseparably associated with the implementation of this project. According to Kosyakov's method of system engineering [3] and to the ISO / IEC15288 standard, the formation, selection and validation of architectural solutions play an important role at the stage of defining the concept of the system, and serve as the basis for the further process of system development. There are several known approaches to the construction of technical systems architectures to which, in particular, relates ATAM [8].This method represents a series of successive steps from the description of the stakeholder needs to the presentation of the resulting architectural solution to the customer.

Verification of solutions is carried out on the basis of traceability matrix, and validation is conducted by communication with customers through reports and presentations.

In the second case there are a number of issues:

- reports are often formal and do not reflect the actual state of the sys-tem;
- while listening to the presentation, not all customers are able to adequately picture the system and ask grand questions;
- the customer can be difficult to get to seminars and meetings on the validation requirements.

As a result, even at the formal flow of the validation process, the actual system may not completely satisfy the customer.

In order to avoid these shortcomings, it is suggested to apply the permanent design approach to include those stakeholders on the part of the customer who will later participate in the implementation of the decisions taken.

These individuals are identified during the special workshops during which the tools such as self-determination, positioning, reflection, schematization are used.

The result of this work should be not only the architectural solution of the future system and the system design scheme based on it, but also the further implementation scheme of the technical system in a social environment.

## 2 The process of permanent design for the sociotechnical systems

Any modern technical system cannot exist by itself, so it is necessary to consider it in the early stages of development in conjunction with the surrounding social context. At the same time, in order to take this factor into account adequately, it may not be enough just to gather the information on the stakeholders needs which is mandatory in most development methodology for technical systems. Therefore, for the successful implementation of the technical system, it is proposed to consider it as a sociotechnical one, applying the principles of permanent design in the process of its development.

One of the main principles of permanent design suggests that systematically organized design does not have a final ideal conception, that it is inextricably related to the implementation of the project. In other words, there will be two parallel but relat-

ed processes – design and implementation of the project. As applied to the sociotechnical system, this principle may be implemented the following way. In this case, the social part (subsystem) of the project of the sociotechnical system is the activity featuring the developed technical system, which also needs to be designed in the aggregate. Thus, the designer must organize (design) a successful "embedding" of the technical system in the social context of the customer's enterprise. According to the principle of permanent design, the designer's activity becomes a subject of project reflection on a regular basis. Reflection of any activity assumes that any of its elements can be subjected to critical analysis and transformation. The figure below presents this statement (Fig. 1). Project 1 – the first version of the sociotechnical system project is implemented by reconstruction of activity involving a technical system in a test mode (process 3), moreover, in the context of implementation, there is a reflection of values and attitudes, goals and objectives of the methods used, etc. As a result of reflection, the subsequent transformation of the social part of the system may contribute to the transformation of its technical part (as a rule) and vice versa. As a result of the Project 1 modification (process 5), we come to Project 2, the second version of the sociotechnical system project, which will be implemented afterwards.

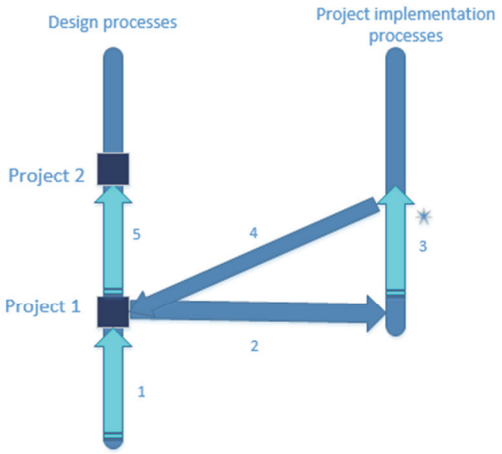


**Fig. 1.** The process of permanent design

The given figure corresponds to the first iteration of permanent design. As a result of multiple iterations similar to the given above, the project will be implemented as an introduction of the sociotechnical system to the customer's enterprise. After the introduction of the system, the process of permanent design does not end, because any modern enterprise is constantly in the condition of transformation and therefore the introduced sociotechnical system will be subject to constant analysis and consequently to the development and regular synchronization of the activities being built up and the supporting technical system.

While performing the above steps it is important to understand that the introduction of the developed sociotechnical system at the enterprise proceeds more successfully when those who are directly affected by it are involved in its design: the customer, users of the technical system. Thus, there is a collaboration of the designer (project team) and elements of the designed socio-technical system. The involvement of a design object representative in management or in fact, the project activity assumes that he is able to form and occupy a certain place in this activity, assuming responsibility for its result, or, from our point of view, determine himself as a subject of project activities. [9]. The process of this kind of collaboration is described in more detail in the next section.

## 3 Method validation/development of architectural solutions during permanent design of the sociotechnical system

Validation and architectural design of the future technical system are important to development process of the sociotechnical system. Validation of the architecture is recommended at the early stages of the development technical system. Architecture Tradeoff Analysis Method (ATAM), one of the methods of building and validating architecture, is oriented on it. The aim of ATAM is to understand the consequences of architectural solutions in accordance with the requirements for the quality of the technical system.

In this article, we will deal with features of realization of the given method at application of principles of permanent design to development of the sociotechnical system. This process of architecture validation will be carried out within the framework of the formation Project 1 (Figure 1) as the final stage in the architecture design of the future system. ATAM consists of the following steps:

1. Presentation of ATAM to a project team.
2. Presentation of business drivers.
3. Presentation of the draft preliminary architecture of the technical system.
4. Identification of architectural approaches.
5. Developing the quality attribute utility tree.
6. Describing and analyzing architectural approaches.
7. Forming and prioritizing of scenarios for the use case.
8. Comparing scenarios of the highest rank use with the identified architectural approaches. If it is necessary, return to the step 4.
9. Presentation of validation results to persons concerned [8].

Verification of solutions in this method is carried out on the basis of traceability matrix. Validation results of the architecture are presented to persons concerned at the last step of the process in the form of a presentation and a report containing the documented steps of validation process. At this stage, the important thing is the customer's «immersion» into the specifics of the system and understanding the consequences of the made solutions, which is often difficult to implement due to the following:

- while listening to the presentation, not all customers are able to adequately picture the system and ask important questions;
- reports are often formal and do not reflect the actual state of the system.

As a result, even when the architecture validation was made with the customer, the implemented system can significantly differ from its representations.

According to the principle of permanent design indicated in the previous section for solving these problems, it is necessary to involve key players – customers and users – into the development process of designing the architecture with the use of a projected technical system which is the element of sociotechnical system. Such cooperative architecture design of the technical system should begin at the stage of the project activity formation with the participation of the system, where scenarios of its use case are identified, on which the further design of the architecture is based. It's supposed that as a result of such collaboration – collaboration of participants in the sociotechnical system and the project team in the form of workshops – the participants' interests would be taken into account as well as most of inconsistencies between them, which are unavoidable in case of serious project innovation, can be smoothed. The mechanism of this kind of interaction can be described as following. During the collaboration, it is important to organize communications and build common information space for formulation and solution of problems. Moreover, this approach allows coexistence of contradictory statements, because the difference can be caused by the divergence of positions, each of which has the right to exist. The process of mutual understanding in such communication assumes an understanding (not necessarily a mutual agreement) of the position of the other and the possible convergence of the participants' positions in any area of cooperative activity.[9]

The result of this work should be not only the architectural solution of the future system and the system design scheme based on it, but also the further implementation scheme of the technical system in a social environment, as well as a project of introducing a sociotechnical system in an enterprise, the implementation of which may also have an iterative nature.

There are situations when it is hard to invite the customer or other persons concerned on workshops and meetings on validating requirements. Various decision support systems can be used to solve such problems. Researches in this area are actively continuing and attempts are being made to create more intelligent decision support systems on the basis of persons concerned analysis and balancing. Similar systems can also be called a "virtual customer". Also, the conception of a virtual customer can be considered as a recommendatory system based on preference prediction systems – one of the most popular applications of data mining and machine learning.[10] A possible strategy for creating such recommendatory system is the "Content Filtering" strategy, which involves the collection of a detailed characteristic description of the customer and the objects of recommendations, in our case, some solutions for the design and development of systems.

## 4 Conclusions

There were some approaches to creation of architectural concepts for artificial system project discussed in this article. The authors in detail described a permanent design approach, that was developed in Moscow Methodological Circle in 1980s and the forms of architecture validation that takes place during permanent design of sociotechnical systems. Also the ATAM was described as often used approach for architecture evaluation of technical systems. It was pointed that methods and approaches, used in the technology of permanent design, may, in fact, be used in ATAM approach to make a validation process more resultative. Described approaches can be used by system engineers at the concept development stage of sociotechnical systems engineering during system architecture trade-off analysis.

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