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Concept Of Component Technology Application In The Lifecycle Management Of The Project For Complex Innovative High Technology Product

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Abstract- The article considers scientific application and capabilities of component technology in the management of projects for creation of complex innovative products using reuse components. The main stages of the components lifecycle and their interrelation within the project are considered and explored. Component technology application in project management enables to significantly reduce the cost, time and risk of the project, as well as to streamline the selection process of project implementers, to choose the best management and technological solutions at all stages of the project lifecycle with a high degree of innovative solutions.
Key words: reuse component, project lifecycle, requirements specification, design stages, parts and assembly units.

Introduction

Modern conditions of social development dependent to a great extent on the pace of scientific and technological development, rapidly changing requirements to the level of produced and consumed products, continuously increasing competition between manufacturers have expressly determined key trends in the development of innovation activity in the sphere of high technology products [1].

A general trend to reduce the lifecycle of industrial products dictates contradictory requirements at the stages of their development, production and operation.

Problem statement

Analysis of the current state of theoretical and practical aspects of product lifecycle management in the context of innovation activities has revealed the following basic problems of innovation activities of industrial enterprises: uncertain risks, terms, cost, selection of project implementers, selection of the most appropriate management and technical solutions at all stages of the product lifecycle with a high degree of innovative solutions [2-4].

In spite of introduction and adoption of new methods of calculation and design, development of new structural materials, production equipment and automation facilities, it is obvious today that the solution of the above problems of innovation activity in the sphere of high technology products is impossible without application of effective, efficient and reliable methods of product lifecycle management at all its stages [5].

Main part

If we assume that the project is a process of obtaining the final product, and the final product is a hierarchy of structural elements of the created complex product, we can distinguish the design solutions related to each element of the created product [6]. The project component is thought of as a set of management, organizational measures and shop-floor applications aimed at the implementation of a specific structural element of the product. Thus, the project component is a process related to a particular object being the part of another object – a container, which is quite natural for the component-object model.

Project component duality lies in the fact that it simultaneously specifies the object as a structural element of the product and a process associated therewith as a component of the project. The component of the project is a complete micro-project with all its stages in the framework of the global project. This information structure clearly and expressly links the product structure with the structure of the project for creation thereof.

Advantages of the component model can be clearly demonstrated by the example of the project lifecycle [7]. Lifecycle of the project built on the basis of component model can be represented as follows.

Upon completion of the external design stage the requirements specification is drawn up which is the basis for all subsequent project stages. It includes necessary documentation for the product, technical requirements thereto, basic conditions of the project execution. At this stage, the customer previously estimates the terms and costs of the project and selects the project team on a competitive basis [8].

The first stage of the project consists in development of the project concept within specified deadlines. At this stage, information contained in the requirements specification is analyzed, and then the product architecture is determined. Structural elements of the product (parts and assembly units) later constitute a basis for identification and creation of the project components in accordance with the previously given definition of the project component. Proper structuring of the product guarantees correct representation of the project in the form of hierarchical tree of the project components.

At this stage, based on the component tree, the project team is formed taking into account their differentiation and experience. Ultimately, upon completion of the concept development stage, the tree of the product structure is transformed into the tree of the project components, and the components in a certain way are distributed among the project implementers. In this case links among the product parts and assembly units being responsibility of different project implementers are not broken, but converted into cross-component links which synchronize the actions related to execution of the project components.

At the planning stage much attention is paid to careful scheduling of work completion by the project team and timely transfer of the results to the main implementer. The basic idea is that the project components may not be executed after the fixed time, as this will lead to significant delay in the project implementation, unforeseen costs and financial risks. On the other hand, early execution of the project component will result in idle hours of a particular implementer, which may also lead to lower economic effectiveness of designers' actions. In addition, early execution of the project component will require storage of the product element until it becomes necessary, i.e. availability of storage facilities and, therefore, additional expenses.

Great importance is attached to the "top-down" planning method, i.e. scheduling by means of the countdown from the project deadline. Peculiarity of the project component model is that it is impossible to determine in advance the transition points between the main stages of the project, except for the first and final stages, as various project components are spread out over a period of time.

The stage of execution of the project component is followed by compulsory testing of parts and assembly units which may reveal inconsistencies with the requirements specification being the main project risks.

Additional risks may be assessed by monitoring inter-component links at the previous stages until execution of the component. The task of minimizing the risks specified by inter-component links is imposed on the main implementer.

The final stage is introduction of the finished product which includes warranty routine maintenance and repair with help of the service centers, as well as the product transportation and storage.

Let us consider lifecycle of a separate component of the project (figure 1).

In pursuance of the foregoing, the first stage of the component lifecycle (concept development) has the same duration as all other project components since its planning and execution cannot begin until the project team has been selected and all major design solutions typical for this stage have been made.

Taking into consideration that the duration of the project depends on execution of a separate component which takes most of the time, the rest of the project implementers will be underloaded. There are two possible mutually unexclusive options:

– additional work load of underloaded project implementers with other tasks not related to the project;

– reduction of implementation period of the most critical component with regard to its implementation period.

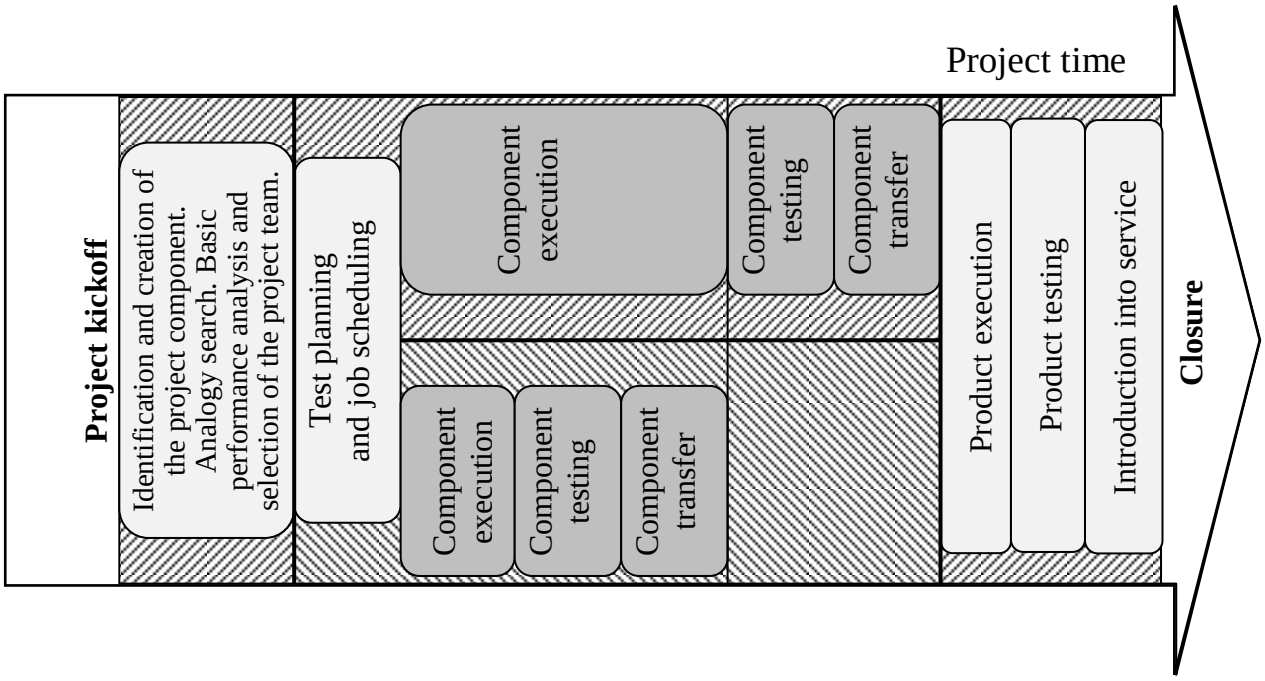

Figure 1 – The lifecycle of a project component

It is obvious that the first option is associated with a number of disadvantages: (a) the project implementation period is longer and (b) lack of flexibility in economic decision-making.

The second option is the most appropriate, especially that there are two ways for its implementation where their combined application is possible. Firstly, it is possible to execute the most critical component with regard to its implementation period by several implementers. Secondly, the most effective way not excluding the first method is the application of reuse components.

The essence of reuse components of the project lies in the fact that they enable to use in the project ready and approved basic solutions (organizational measures) allowing to significantly reduce the execution period and mitigate the risk while executing. The concept of reuse components involves project team differentiation

and implementers' experience that simplifies their selection.

For structural components of the product with a greater degree of innovation the characteristic (a set of characteristic) of which does not conform exactly to existing reuse components, the components are selected on the basis of expanded production and technological classifier. In the future, these components are partially modified, supplemented by missing functionality and can later be used as complete reuse components. Unlike the above case, such indicators as reliability of technological process, prime cost, risks of any nature and other indicators for this component in the case of its first application will be known only partially. Accordingly, the structural units of the product associated with such components will carry a great deal of uncertainty and risks than in the case of complete reuse components.

Parts and assembly units the design or technology of which is absolutely unique, initially cannot be linked to reuse components or ready reuse components subject to modification, as in the first two cases. For these structural units, which are completely innovative, the components are created for the first time, and consequently, major project risks, possible economic costs, structural and manufacturing errors will be concentrated in these components. But in the case of reuse of these components all their performance will be given a quantitative evaluation enabling to control and predict all possible risks and costs.

Certainly, reuse components are not static. Introduction of any new technology may and should be reflected in both existing and newly created component as one of the alternative solutions. Design, technological or managerial solutions which turn to be outdated may be removed from the component. Thus, relevance of the reuse component is continuously maintained.

The component structure includes functionality that controls the component at each stage of its lifecycle. Fleshing out a component is done only in sequence, from one level of detalization to another, based on the logic-mathematical apparatus that operates at this stage of the lifecycle, allowing you to move to a new stage as detailed information related to the component becomes available on the basis of design specificity and operations planning.

In order to ensure full operation under such conditions, the component is represented by dual structure.

On the one hand, the sequence of lifecycle stages, taking into account inter-component interactions is described by formalism of Petri nets and graph theory [9]. Figure 2 shows the dynamics of evolving process constituting the lifecycle of Kn component and two other components (Kn1, Kni) embedded therein. Each event of Petri net is a set of properties characterizing the state of the object αi and procedures Zi performed in this state. Each performed procedure Zi complies with transition condition Xi, that equally applies to transitions within the component and to inter-component links Wi. The advantage of such a description is invariable structure of the basic element with a regular description of the state.

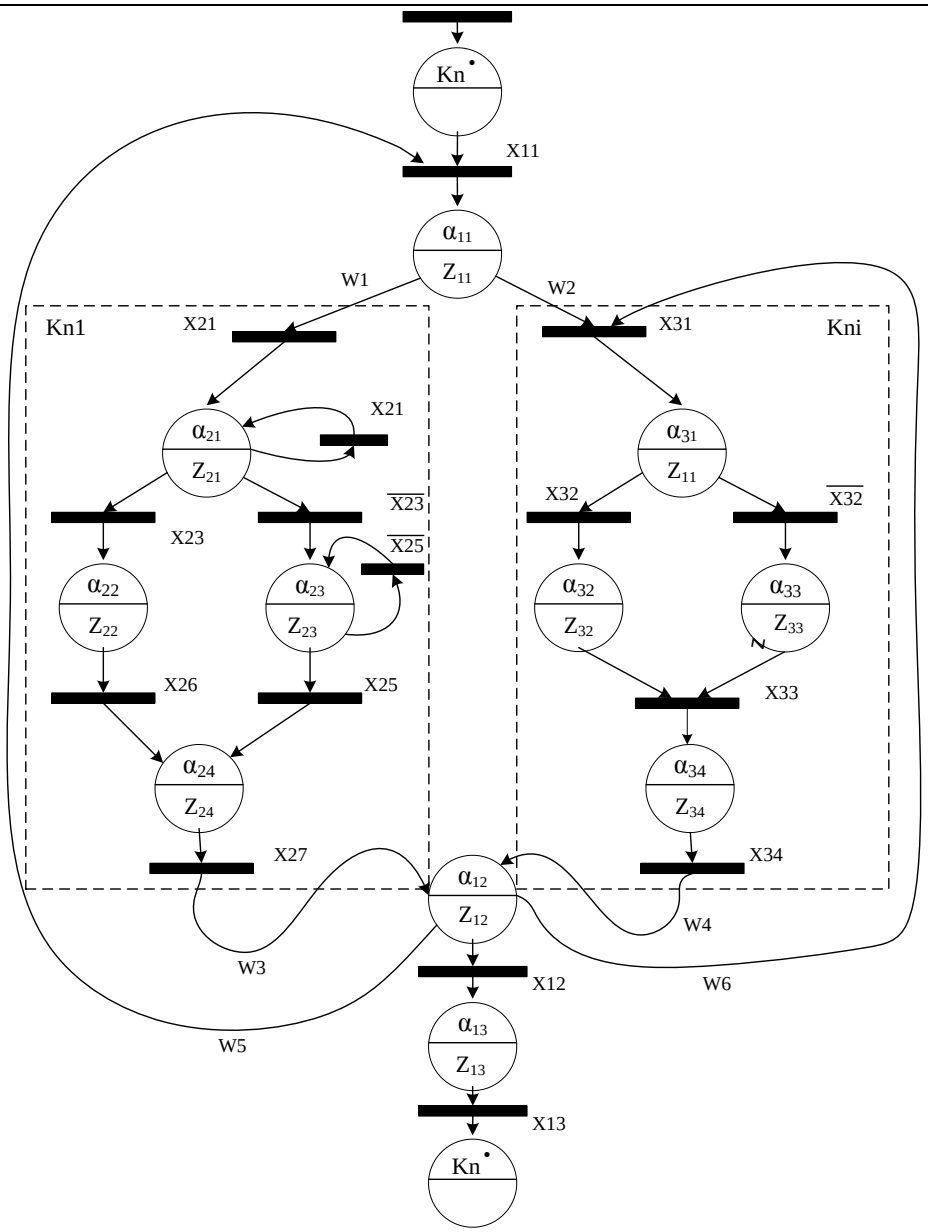

Figure 2 – Lifecycle of the component and inter-component links with the aid of Petri nets formalism

The mathematical representation of graphs of this type forms the basis of internal structure of reuse components and the project as a whole. Petri nets naturally allow to combine individual components in the full-scale project by introducing inter-component links, as well as to stipulate additional conditions of locking and synchronization on parallel processes in various reuse components. Development of processes of almost unlimited complexity may be described in a similar way.

On the other hand, at every stage of the lifecycle functionality of the component is based on the object-oriented approach [10]. This enables to extensively use such advantages of the object-oriented approach as inheritance, encapsulation and polymorphism, making reuse components extremely flexible in use. At the same time the concept of transitions in oriented graphs is closely associated with the concept of events, properties and methods in terms of object-oriented approach, and object-oriented approach event-related apparatus provides for ample opportunities for organization and implementation of inter-component links in graphs.

Thus, the project reuse components are in full conformity with the classical concepts adopted for component-object models.

Conclusion

Relevance of the component model of the project and the use in the project of reuse components has the following advantages: reduction of project implementation period, cost and risk management, reasonable selection of the project team, natural adaptation of the component for corporate projects. The unique link of the project component with a specific structural element of the product reduces the likelihood of errors in the planning stages of the project. In addition, the project can be more easily expanded in the process of implementation by changing the structure of the product and related events that are also represented in the form of a component, or other activities, such as staff training or advertising campaigns related to the project, which is provided due to flexibility of the component model of the project.

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