

Method of Project and Operational Processes Integration in the Activities of Project-Oriented Enterprises Based on Functional 4P-Environment

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Abstract. The article is dedicated of description of creating a unified functional environment for managing projects, programs, project and program portfolios and a project-oriented enterprise, which would include tools involved both in the project activity and in the operational activities of the enterprise, is at the forefront and provided a systemic (synergistic) effect from solving a set of tasks of managing portfolios of projects and programs as a single system of functions. Unlike enterprise resource planning systems, where enterprise resource management capabilities are supplemented by project management modules, the creation of a functional projects, programs, project and program portfolios and a project-oriented enterprise environment consists of complementing the software tools for project management by functions that enable them to integrate with both the processes of portfolio projects and programs management, and with the management processes of the project-oriented enterprise themselves. A method of coordination of project and operational processes is proposed. It is based on simulation of operational and project processes, with the choice of an order of material resources production, which shortens the execution time of all projects. The method allows to consider not individual portfolio projects, but all projects simultaneously. And to find the necessary solution at the expense of a long-term search of various options for implementation of both operational and project processes. A similar method has not been implemented in any project management system.

Keywords: Project Activity, Operational Activity, Project and Program Portfolio, Project-Oriented Enterprise.

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Introduction

Traditional approaches to project and program management are based on the implementation of relevant methodologies (PMBOK, PRINCE 2, Agile and etc.) and information technologies (MS Project, Oracle Primavera, Clarizen, Trello and etc.) [1-10]. When there is a need to extend the management horizons to the projects and programs portfolio (PPP), the problem of adapting the above-mentioned methodologies and technologies to the conditions of PPP management arises. An even greater problem arises when the operational processes of the enterprise are interwoven with the project ones [11-13]. Then none of the above methodologies, like any software tool, can solve this problem.

For example, often project-oriented enterprises produce components, details, which are then used in their own projects. For example, in aircraft engineering, each aircraft can be considered as a separate project. Especially when customers are different and require different modifications. On the other hand, such enterprises produce components, units for their own aircraft. And here it is very important to integrate the operational and project activities.

Another problem of modern project management is that usually in enterprises for project management various software tools are used to solve various functional tasks: scheduling, control, economic and financial evaluation, etc. Traditionally, the tasks of information integration in such systems are considered in the ways of managing information communication in projects. But with the increase of the level of project-oriented enterprises informatization, the use of various information systems (IS) to solve functional problems is not sufficient. This task becomes even more complicated when it is required to manage large-scale programs or portfolio projects and programs. New challenges emerged - coordination of activities, allocation of resources, prioritization of projects and programs, formation of teams, performance of production or managerial functions of the enterprise not in the context of individual projects, but on the portfolio as a whole.

The lack of systems that provide effective management of enterprises, projects, programs and project portfolios leads to ineffective management decisions, unnecessary work or uncoordinated implementation, losses, major contract failures, and numerous problems.

To solve this problem, it is necessary to transfer some of the functions that are not implemented by the software tools in a certain functional environment - the functional add-on of these tools. And develop a software and information system that will implement functions that are not reflected in the tool software both in terms of the operational and in the context of the project activity of the enterprise.

Proceeding from this, the task of creating a unified functional environment for managing projects, programs, project and program portfolios and a project-oriented enterprise (4P-environment), which would include tools involved both in the project activity and in the operational activities of the enterprise, is at the forefront and provided a systemic (synergistic) effect from solving a set of tasks of managing portfolios of projects and programs as a single system of functions.

2 Functional 4P-environment of project and operational processes

The main purpose of the functional 4P-environment is to implement the functions of managing the project, program, portfolio and project-oriented enterprises, in terms of project activity. But the main resource of management functions is the information needed for such management. Therefore, we can say that the functional 4P-environment "immersed" in the information space, which provides the necessary information.

In general, the information space contains all the information that is needed to manage it. First of all, it is the knowledge of managers and specialists, the knowledge of senior management regarding the strategy and goals of realization of project-oriented businesses, performance indicators of the enterprise, its financial status and logistics, project and technological documentation, feasibility studies, estimates, financial calculations, project charters and project management plans, project plans, risk management measures, need for logistical resources and services, and procurement plan, etc.

All this information is an information resource of the project-oriented enterprise.

The issue of information resource management (hereinafter referred to as IP) is very important from the point of view of building a 4P-environment, as it will cover the information network needs of all functions of this environment. The introduction of 4P-environment allows to solve this problem. In this environment, information resource is considered not only as a source of implementation of functions, but also as an object of management. After all, in 4P-environment management functions are performed by the software-information environment of modern computers using the information that is fed to the input of such functions.

Definition 1. A functional 4P-environment (or simply 4P-environment) is a systematic set of functions of management of project, programs, project and program portfolios, and a project-oriented enterprise (in terms of project, programs, and portfolios management) that use a single information resource and provide a systemic (synergetic) effect from solving a set of tasks of management of project-oriented businesses of enterprises (fig.1) [14-15].

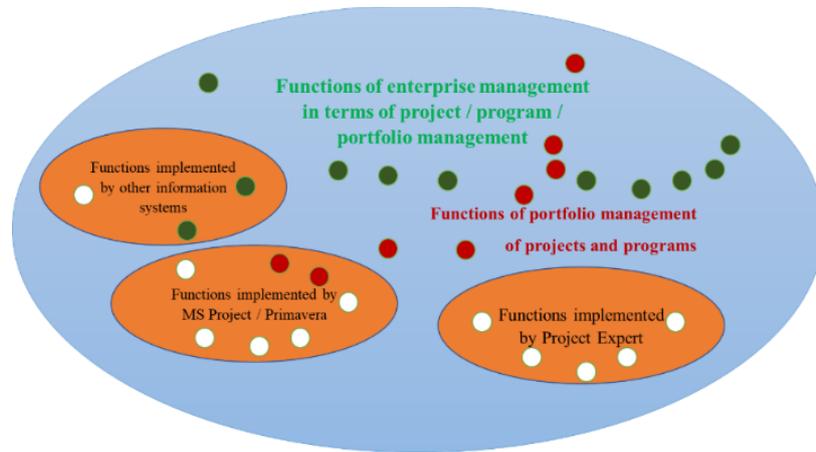


Fig. 1. A functional 4P-environment

As can be seen from figure 1, some of the project / program / portfolio management functions are implemented with modern project management tools, some with different information systems. And part of it is performed by employees of the enterprise without the use of specialized programs. For example, when budgeting an enterprise, information is collected from both projects and units that carry out operational activities. Modern project management software tools do not allow to form the enterprise budget (in the part of project implementation) according to the standards adopted by the enterprises. That is why most of the enterprises have to combine all the information on individual projects and operations into a single spreadsheet, using the well-known MS Excel office product.

To solve this problem, it is necessary to migrate some features not implemented by the toolkit to some functional add-on on these tools. And to develop a software-information system that will implement functional operators for functions that are not reflected in the tool software. Such a software-information system can be created both by the tools of the software systems themselves, as well as by ordinary means of programming.

Unlike enterprise resources planning (ERP) systems, where enterprise resource management capabilities are supplemented by project management modules, the creation of a functional 4P-environment consists of complementing the software tools for project management by functions that enable them to integrate with both the processes of portfolio projects and programs management, and with the management processes of the project-oriented enterprise themselves. This, on the one hand, will reduce the cost of project management tools and on the other hand, will increase their functional completeness.

The scientific and methodological basis of construction of 4P-environment is necessary in order to create structures, algorithms, tools and processes of functional add-ons over project management tools at project-oriented enterprises on the basis of the developed models and methods. In fact, such a basis will create many functional op-

erators that will satisfy the need for project management in modern management information technology.

3 The practical Side of the Problem

Solving the task of creating a unified functional environment for managing projects, programs, project and program portfolios and a project-oriented enterprise could be solve by exist information technologies of project management. Today, the Oracle Primavera [7] is the most complete in the functional sense according to the set task. But authors had a practice experience of implementation of Primavera in a project-oriented production enterprise that produced light aircrafts and there the next issues were raised:

1. It was necessary to do about 2700 operation for creation production enterprise product. As far as there was a necessity to manage the projects and the production it was necessary to put all these operation into Primavera database. Also, links between operations should be set, and resources assigned to tasks. Wherein it was produced in parallel a few products that shared the same labor resources. As the result it was obtained a complicated and hard manageable project portfolio schedule plan.

2. There was a big variance in order of resources production and so it was able to use different optimizations models for schedule plan, but it was impossible when project plan was created by hands.

3. Constant changes in project portfolio lead to changes in portfolio schedule plan which was pretty hard make by hands. For example, CEO decided to change priorities and there became situation when it was needed to push one product forward and the schedule plan was changed pretty much and these changes demanded a hard work.

4. Often details were produced not one by one but by packages. This helped to reduce time wasted for equipment setup. As the result part of produced resources were sent to warehouse. These resources were used in the next products and did not have to be produced again. Information about warehouse contained in accounting system. And for quality planning there was necessity to exchange information between Primavera and accounting system.

5. It was unclear in Primavera project model how to manage resources which change their state.

6. It was necessary to manage procurements in project portfolio and often it is convenient to group purchases from different projects. Also, there was needed to purchase resources in advance. The time for purchase depended of resource. It was tricky to manage such things in Primavera.

So, such software as Primavera did not cope with the task to project and production management of the enterprise. There was presumed that with MS Project and the other similar products there will be similar problems. Considering this there was a variant to implement ERP system, but after marketing analysis it was defined that ERP system have a weak project management module and these class of system also can solve all planning issues and as result can't be used for management of project and production activities of the enterprise.

And as a solution it was decided to develop add-ons for Primavera. And in the process of development it becomes clear that easier would be develop an independent information system that add-ons for Primavera. Such information system should allow to manage resources like an ERP system and manage projects like Primavera and will connect information systems are involved in project and production activities. But creation of the such system was needed some theoretical base – methods of project and operating processes integration in the activities of project-oriented enterprises based on functional 4P-environment [14].

4 Method of Integration of Project and Operational Processes in the 4P-Environment

To solve the formulated tasks a method of coordination of project and operational processes in the 4P-environment is proposed. It is based on simulation of operational and project processes, with the choice of an order of material resources (MR) production, which shortens the execution time of all projects

$$\sum_m \frac{1}{l_m(R_m^T)} \cdot \pi_m \rightarrow \max (1)$$

where R_m^T – pool of work resources for the project Π_m ;
 π_m – priority (importance) of the project Π_m ;
 $l_m(R_m^T)$ – duration of the project Π_m , if a resource R_m^T is allocated to it.

with constraints:

- resource pool;
- technology of project execution.

1. Of course, when in the project thousands of MRs are produced at different stages of its implementation, it is impossible to optimize the allocation of resources. Therefore, the method will be based on the accumulation of information on the various stages of the decision making, followed by an assessment of the results of the projects and the statistical determination of the influence of this solution on the results. This is the intellectual part of the method.

2. The description of resources in this method will also be different from the traditional, performed in the means of the project management. Resources in the method for coordinating project and operational processes in 4P-environments are described by a tree. Which shows the occurrences:

MR→Detail→Assembly→Subproduct→Product

At each stage, the production of a higher-level resource from the lower-level resources takes place. And they can be used in various projects.

3. Each detail is characterized by the minimum quantity included in the kit. For example, washers are produced in quantities of 10 units or greater.

Stages of the method of coordination of project and operational processes in 4P-environment:

1. Formation of scheduled network diagram (SND) of projects.
2. Formation of operational processes for producing details, assemblies, subproducts and products.
3. Attachment of operational processes to the works of the SND.
4. Setting the initial simulation conditions (time of modeling, use of the intellectual block, constraints on resource allocation and product producing).
5. Setting the model number $n = 0$.
6. Check if the simulation time has expired. If so – go to the end.
7. Increase the model number: $n = n + 1$.
8. Setting the start time of projects $t = 0$. Cleaning the SND from execution.
9. Verify that all the work is done. If so, go to item 6. If not, increase in the time of execution of projects for 1 day: $t = t + 1$.
10. Selection of SND works for which fulfillment conditions are fulfilled (available resources and completed / missing work-predecessors).
11. If the set is empty go to item 9.
12. Random selection for work on its priority. The priority and probability of the selection is calculated as follows:

12.1 For each pair of works the priority coefficient is calculated:

$$\alpha(W_{kj} / W_{mi}) = \frac{\beta(W_{mi} / W_{kj})}{\beta(W_{mi} / W_{kj}) + \beta(W_{kj} / W_{mi})} \quad (2)$$

$$\alpha(W_{mi} / W_{kj}) = \frac{\beta(W_{kj} / W_{mi})}{\beta(W_{mi} / W_{kj}) + \beta(W_{kj} / W_{mi})} \quad (3)$$

$$\alpha(W_{mi} / W_{kj}) + \alpha(W_{kj} / W_{mi}) = 1 \quad (4)$$

- where
- $\alpha(W_{mi} / W_{kj})$ – priority coefficient of the work W_{kj} of the project Π_k relative to the work W_{mi} of the project Π_m ;
 - $\alpha(W_{mi} / W_{kj})$ – priority coefficient of the work W_{mi} of the project Π_m relative to the work W_{kj} of the project Π_k ;
 - $\beta(W_j / W_i)$ – penalty on models, in which in the multitude of alternative works were works W_{mi} and W_{kj} , and here work W_{kj} was chosen;
 - $\beta(W_i / W_j)$ – penalty on models, in which in the multitude of alternative works were works W_{mi} and W_{kj} , and here work W_{mi} was chosen.

12.2. Model penalty is calculated as the sum of the difference between the target project finish and the finish obtained in the model

$$\beta = \sum_{n=1}^N \sum_{m=1}^M [l_m^0 - l_m^n] \quad (5)$$

- where
- β – model penalty;
 - l_m^0 – target finish of the project Π_m ;

- l_m^n – finish of the project II_m in the model n ;
 N – number of calculated models;
 M – number of projects.

12.3. Calculation of the probability of the work selection:

$$p(W_{mi}) = \frac{\sum_{k=1}^M \sum_{j=1}^k \alpha(W_{mi} / W_{kj})}{\sum_{k=1}^M \sum_{j=1}^{L_k} \sum_{m=1}^M \sum_{i=1}^{L_m} \alpha(W_{mi} / W_{kj})} \quad (6)$$

where $p(W_{mi})$ – probability of selection the work W_{mi} .

12.4. Random selection of the work with probability of choice (6).

13. Calculation of the number of MRs that need to be produced for work.

13.1. Warehouse stock balance of MR:

$$\forall R^j, t_i \rightarrow v_i^j \quad (7)$$

where v_i^j – MR R_j warehouse stock balance at the time t_i .

13.2. Calculation of the MR volumes for the periods in which they must be purchased based on the balance of resources in the warehouses.

$$\Theta(\tau^j) = \sum_m \sum_j V_{mi}^j \sum_{mi}^j (t_{mi}^j \leq \tau^j) \quad (8)$$

where $\Theta(\tau^j)$ – volume of resource R_j need by the time τ^j .

13.3. Realization of the function of comparison of balances in warehouses with the needs of projects. If for resource R_j

$$\Theta(\tau^j) \leq v_0^j \quad (9)$$

then there is no need to purchase a resource R_j . Finishing calculation for the resource R_j .

13.4. Determining the time t_{minmax}^j , to which resource R_j will suffice

$$\{ t_{minmax}^j \mid \sum_m \sum_i V_{mi}^j (t_{mi}^j < t_{minmax}^j) \leq v_0^j \} \quad (10)$$

where

- t_{minmax}^j – moment of time to which the stock will have enough MR R_j ;
- $V_{mi}^j (t_{mi}^j < t_{minmax}^j)$ – volume of resource R_j , which is need for the project II_m for execution the work W_i by the time t_{minmax}^j ;
- v_0^j – warehouse stock balance of MR R_j at the current time.

13.5. Calculation of expenses for realization of procedure of a resource purchase practically does not depend on its volumes. It is the cost of processing applications, conducting tenders, concluding contracts, delivery (within the scope of delivery costs may vary by volume). But due to the fact that the total volumes of delivery are not

variables, we will assume that the cost of delivery does not depend on their number. In other words, to deliver twice on 50 tons of sand, the same thing that once delivered 100 tons of sand.

Cost of storage of the resource in the warehouse:

$$S_1^j(\tau_0^j, \tau^j) = \Theta(\tau^j) \cdot (\tau^j - \tau_0^j) \cdot s_1^j \quad (11)$$

where $S_1^j(\tau_0^j, \tau^j)$ – cost of storage of the resource R_j from time τ_0^j to time τ^j .

13.6. Optimization of the amount of the resource to be purchased, based on the terms of the execution of the relevant project works.

13.6.1. Determining the time to which amount of resources in stock will suffice $t_{\min\max}^j$. Formula 7 is used.

13.6.2. Set the iteration number $k=0$.

13.6.3. Set the amount of resources that is need to purchase $V^j=0$.

13.6.4. Increase iteration number to 1: $k=k+1$.

13.6.5. Selection of the project and the work with the smallest point of time, which requires the resource R_j , which is insufficient in stock:

$$\min_{m,i} (t_{mi}^j) | t_{mi}^j > t_{\min\max}^j \quad (12)$$

If resource already is not needed - ending the calculation.

13.6.6. Calculation of procurement benefits in the initial time. If

$$s_0^j - (\Theta(t_{mi}^j) \cdot (t_{mi}^j - t_{\min\max}^j) \cdot s_1^j) > 0 \quad (13)$$

where s_0^j – cost of procedures for ordering, purchasing and delivery of MR R_j .

then the resource must be purchased. Then

$$V^j = V^j + V_{mi}^j \quad (14)$$

Otherwise, end of review of resource R_j .

14. Fixing the completion of work at the estimated time (start + duration).

Go to item10.

The method allows to consider not individual portfolio projects, but all projects simultaneously. And to find the necessary solution at the expense of a long-term search of various options for implementation of both operational and project processes. A similar method has not been implemented in any project management system.

5 Conclusion

For today production enterprises has specific features in business processes, organizational structure and etc. which should be included when project management system is implemented and traditional methodologies and information technologies of project management not suitable for management of project and production activities of the enterprise, because these systems could not support all processes of project

resource management and a lot of information is lost in project management processes.

In the paper it is shown that the main purpose of the functional 4P-environment is the implementation of project management functions / programs / portfolios and enterprises, in part of the project activity, which are not available in instrumental software tools. The method of coordination of project and operational processes in 4P-environment is developed. The basis of the method is the simulation of the producing process of components for the work of the project with the selection of time and number of MR, which allows minimizing the time of portfolio projects execution. The method allows to combine project and operational processes into a single management system on a project-oriented enterprise, which in turn reduces the timing of projects, organizes operational activities, optimizes the allocation of resources.

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