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Индивидуальные стратегии в управлении проектами: модели и методы формирования

Individual strategies in project management: models and methods of formation

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Аннотация. *В статье обосновывается необходимость индивидуального подхода к планированию и распределению ресурсов в управлении ИТ проектами. Выполнен анализ целесообразности применения типовых моделей, предложены подходы к управлению проектами, учитывающие вероятностный характер связей в комплексе работ, влияние возмущающих воздействий.*

Ключевые слова: ИТ-проект, комплекс взаимосвязанных работ, планирование, распределение ресурсов, степень риска, типовые модели

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Abstract. *The article substantiates the need for an individual approach to planning and resource allocation in IT project management. The analysis of the feasibility of using standard models is carried out, approaches to project management are proposed, taking into account the probabilistic nature of the connections of the complex of works, the influence of disturbing influences.*

Keywords: an IT project, a complex of interrelated works, planning, resource allocation, degree of risk, standard models

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Introduction. Project management, the founder of which is considered to be Gantt, who proposed an original tool for managing a complex of interrelated works, is today positioned as a relatively new direction in the system of management sciences. It is interesting that in modern project management methodology (project management) classical management methods based on a qualitative, non-formalized description of the order of planning, management and control of work processes are inferior to formal modeling methods, that is, changes have occurred not only in terminology, but also in the content. Formal, mathematical, modeling as a tool for planning, analyzing and monitoring the progress of interrelated work provides the decision maker with a set of ready-to-use behavioral strategies. Today, in the wake of interest in project activities, in individual studies devoted to the history of the issue, it is proposed to begin counting the history of project management with the advent of the PERT and CPM packages, citing foreign developments as examples [1].

Paying tribute to the inquisitiveness and curiosity of the authors, I would like to note that domestic scientists made a significant contribution to the development and implementation of network planning methods in management practice: Professor R. F. Zhukov (P. Tolyatti Leningrad Engineering and Economic Institute) [2] , IN AND. Rybalsky (Kiev Civil Engineering Institute) [3], a team of research scientists from the Leningrad Institute of Management Methods and Engineering, now the Academy as part of the St. Petersburg National Research University of Information Technologies, Mechanics and Optics (NRU ITMO), and this fact deserves attention when conducting a retrospective analysis of the prerequisites for the creation of a systemic ideology for managing project activities.

Materials and research methods. The current level of management science indicates the existence of fundamentally different approaches to management: an approach based on describing the management process in terms of natural language and the formation of general ideas about management methodology; an alternative methodology that involves the use of a specific thesaurus and modeling methods as the main tool for drawing up specific recommendations for managing projects/complex systems.

A separate position is occupied by management practitioners who, as a rule, rarely participate in scientific discussions and, distancing themselves from scientific and pseudoscientific polemics, have their own opinions. The assessments of project management practitioners often do not coincide in their fundamental assessment of classical approaches with the opinion of management theorists, but they have common positions in understanding the importance and value of an integrated approach to project management, the idea of which is to integrate the positive ideas of different authors and adapt this symbiosis to the real situation [4 -6].

The author, having some experience, takes the position of a systematic approach to management, which is based on the principles of value-oriented management; value in this context is determined at the planning stage: time, finances, results, etc.

The use in the study of system analysis, abstraction from the subject area and comparative analysis of the most popular theoretical, methodological and practice-oriented approaches to project management made it possible to justify the priority of the approach based on modeling methods. The purpose of the article is to expand the understanding of the possibilities that operations research methods provide for improving management efficiency, to justify the feasibility of applying modeling methods to the processes of forming individual project management strategies.

The formation of a project management strategy is proposed to be presented in the form of a sequence of actions, some linear algorithm that reflects the project life cycle (Figure 1).

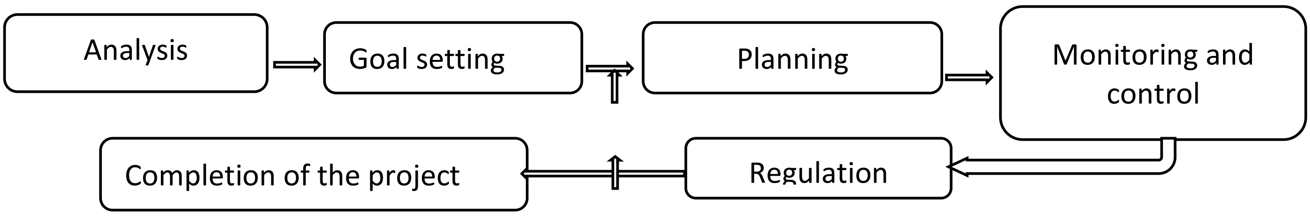

Figure 1. Project life cycle

This simplified approach is just a sketch of a comprehensive project management work plan, a certain framework, a framework representation of the sequence, which identifies the main stages of the management process and shows the possibility of returning to the planning process (dashed arrow) if monitoring and control of this will be required.

The question is quite logical: if a project, by definition, is a type of activity the result of which will be a unique product, then how legitimate is the use of standard methods of structuring the process, is it possible, from the standpoint of classical management, to choose the optimal strategy for the implementation of an original project? Considering the first two stages - situation analysis and goal setting – we will determine the key factors and participants in these procedures. The project is usually initiated by the customer; The project manager conducts self-determination regarding the goals, position, situation and makes a decision on the feasibility of the work, that is, the project manager must make a decision related to the analysis of the situation, determination of the goal/mission of the project, and a list of tasks to be solved in the process of project activities. Obviously, the success of the project is assessed by a set of criteria (timing, cost, compliance with requirements, etc.). Methods and algorithms for solving multicriteria selection problems are presented in sufficient detail in the works of V.V. Podinovsky. [8], Zyuskina A. A. [9], Klimenko I. S. [10]. The subject of this study is the search for algorithms for planning behavioral strategies that ensure effective management of project activities under conditions of uncertainty in the management process

The theory and practice of modeling management processes [11, 12] classifies plans according to their functional purpose (financial, production, marketing, etc.), planning horizon (short-term, medium- and long-term), degree of influence of random factors (deterministic and probabilistic), degree of detail (operational, tactical, strategic). The most interesting, from the author’s point of view, is the planning stage, at which the definition of goals occurs, since further work on setting the problem of resource allocation, choosing or developing a method for solving the problem depends on the formulation of the goal.

Research results and their discussion. In general, the formulation of the project management problem has the form: draw up a work execution plan X ($x_1, x_2, ..., x_j, ..., x_n$), providing under given conditions A ($a_1, a_2, ..., a_i, …, a_m$) maximum or minimum of the objective function W (1).

$$W=F(x_j, a_i) \to extr \qquad (1)$$

Here W is the objective function, the efficiency criterion; for project activities, the efficiency criterion is, in most cases, the timing of the work and the amount of funding

F – functional / type of dependence (analytical, statistical) of the target function on significant factors determining the effectiveness of the project;

x_j - a set of controlled variables;

a_i - conditions for the implementation of the project: a system of restrictions on time, number and composition of performers, amounts of funding, etc.

The planning horizon and degree of detail are determined by the complexity of the work to be done and the customer’s requirements; the probabilistic nature of the factors influencing the timely implementation of the plan depends on the composition and structure of available resources (personnel, time to develop a project idea, the effectiveness of solving the problem of assigning performers to types of work, etc.), as well as on weakly formalized external disturbing influences (disruptions supplies, the need to make changes at the request of the customer, etc.).

Despite the fact that project activities, as a rule, are original in nature and each project is unique, nevertheless, in the project team, as a rule, there is specialization in the functions performed (developers, designers, testers, HR manager, project manager), therefore, at first glance, it is quite reasonable to apply classical optimization models such as the ordering problem and the assignment problem.

Statement of the ordering problem: there is a certain project, for the implementation of which it is necessary to perform a set of works/technological operations X ($x_1, x_2, ..., x_j, ..., x_n$), while resources A i are used to perform the work, the supply of which is limited . It is necessary to appoint performers, draw up a project schedule that ensures passage through all technological operations and completion within the specified time frame. To solve this problem, it is advisable to use the network planning method or the already mentioned Gantt charts [13], which provide a graphical representation and visualization of the plan execution process.

Statement of the assignment problem: there are m types of resources (work performers) A1, A2, …, Am, in quantities a1, a2, …, am, respectively; There are n types of work to be performed B1, B2,…, Bn, in volume b1, b2,…, bn, respectively. The specific costs of performer Ai for performing work Bj are known - Cij. It is necessary to draw up a work execution plan that ensures the timely completion of all work and the employment of performers. Taking as controlled variables xij - the amount of work of type j performed by the i-th performer, we will build a mathematical model (formulas 2–5) of this problem:

a) objective function – cost minimization

$$W = \sum_{i=1}^{m} \sum_{i=1}^{n} C_{ij} X_{ij} \rightarrow \min \qquad (2)$$

b) restrictions on the employment of performers:

$$\sum_{i=1}^{m} x_{ij} = b_j \qquad (j = 1, 2, ..., n) \qquad (3)$$

c) restrictions on the mandatory performance of all work:

$$\sum_{j=1}^{n} x_{ij} = a_i \qquad (i = 1, 2, ..., m) \qquad (4)$$

d) boundary conditions

$$x_{ij} \geq 0 \qquad (5)$$

A possible version of the problem statement: the objective function is to maximize the volume of work performed, then Cij is the productivity of the i-th performer when performing work of type j.

The models presented are analytical models; To solve scheduling problems using models of this type, both traditional methods and modern software are used. The deterministic nature of models of this type creates certain difficulties when using them in managing project activities: the inability to take into account the probabilistic nature of relationships in a team at the level of performers, the influence of external disturbing influences increases the degree of risk when drawing up plans. Reducing the degree of risk, according to the author, is possible by using mathematical models that take into account the probabilistic nature of the behavior of a complex system, which is essentially every project.

It seems to the author quite promising from the point of view of practical value to consider three types of models that allow the formation of individual strategies for planning project activities: models based on a game-theoretic approach; dynamic programming based on the Bellman algorithm; planning on networks (critical path method).

Game-theoretic approach. The use of game theory to determine the norms of behavior of players with divergent interests allows us to develop recommendations for optimizing behavior. In managing project activities, it is proposed to consider two sides - the project manager with his own behavioral strategies A1, A2, ..., An and the changing conditions for the implementation of the project, the so-called "nature", which is indifferent, impartial, unpredictable, but not capable of deliberate tricks; probable states of nature P1, P2, ... , Pm

The game conditions are specified in matrix form (Table 1); →, at the intersection of rows and columns, the size of the payoff aij of the player who chose the strategy Ai for the corresponding state of nature Pj

Table 1. Payment matrix for "games with nature"

States of "nature"→ Project Manager Strategies↓	**P1**	**P2**	**….**	**Pm**
A1				
A2				
….				
An				

The element aij is equal to the payoff of player A if he uses strategy Ai, and the state of nature in this situation is pj.

We will determine the optimality of the player's strategy from the position of an unconditional pessimist, an unrestrained optimist, and from the position of a reasonable, balanced approach, i.e., taking into account the level of pessimism/optimism.

Pessimistic maximin Wald criterion: choose your behavior so that it is designed for the worst course of action for you on the part of "nature", the criterion allows you to determine the possible maximum gain W in the worst conditions (6):

$$W= \max \min a_{ij} \qquad (6)$$

The minimax (optimistic) Savage criterion (7) allows you to choose a strategy that provides minimal risk under the most unfavorable conditions

$$W=\min \max r_{ij} \qquad (7)$$

Here rij are the elements of the risk matrix, which are defined as the difference between the maximum possible payoff that the player could receive provided that he has information about the state of nature and the payoff that he would receive using strategy Ai.

Hurwitz criterion, which takes into account the level of pessimism of the player (8):

$$W= \max \{\lambda \min a_{ij} + (1 - \lambda) \max a_{ij}\} \qquad (8)$$

here λ- a characteristic determined empirically; the closer λto 1, the greater the share of the pessimistic approach.

As an example, let us consider the possibility of using a game-theoretic approach to choosing a strategy when solving the current problem of parallel import of computer equipment (CT). Market players have at least 5 strategies Ai (i=1,...,5): A1 - legalization of parallel imports, A2 - restriction of parallel imports; A3 - ban on parallel imports; A4 - investing in your own production; A5 – protection of competition and price control; probable states of "nature" Pj (j=1,...,5) of the HT market: P1-shortage of equipment, P2-increase in the cost of hardware; P3-increase in prices for IT services; P4-smuggling; P5 - decrease in the growth rate of industry development in the country. The payment matrix is presented in Table 2. The size of the player's winnings (an integer from 1 to 20) when he uses strategy i and the state of nature j was determined by the method of active sociological testing, analysis and control and expert assessments.

Table 2. Payment matrix for determining the optimal strategy

Market conditions→ Project Manager Strategies↓	**P1 (deficit)**	**P2 (we're standing)**	**P3 (price increase)**	**P4 (contra.)**	**P5(braking)**	**min aij**
A1 - legalization	1 3	14	el even	1 6	19	e leven
A2-restriction	e leven	9	10	8	12	9
A3-prohibition	9	7	7	el even	5	4
A4 - own production	1 6	ele ven	14	4	6	6
A5 - protection of competition and price control	1 8	16	12	7	9	7

Wald criterion:

W= max min aij ={11,9,5,6,7} = 11, that is, in the most unfavorable conditions of the market response to the player's behavior, a parallel import legalization strategy is recommended.

Savage criterion:

W =min max rij = {8,4,6,6,19} =4, that is, the player can minimize his risks by choosing a strategy, choosing strategy A2 - limiting parallel imports.

Hurwitz criterion for λ=0.5:

W λ= max { λmin aij + (1 - λ) max aij}={15,10,7.5,10,12.5}=15, which corresponds to strategy A1.

Thus, two of the three criteria predict a favorable outcome when choosing strategy A1.

As practice has shown, the integration of the game-theoretic approach, linear programming and simulation methods makes it possible to increase the efficiency of design solutions [14, 15].

Bellman's optimality principle. Dynamic programming is a special method for solving complex problems, which is based on the idea of decomposing a complex problem into simpler subtasks. In the context of project management, this idea can be interpreted as stage-by-stage planning, with each subsequent stage planned taking into account the results obtained in the previous stages.

Problem statement: determine the optimal control vector of a complex system X(x1,x2,…,xn), ensuring the transition of the complex system from the initial state S0 to the final/expected Sк in a fixed number of steps so as to achieve the extremum of the objective function (9):

$$W(S_0, X) = \max \{f_1(S_0,x_1)+ f_2(S_1,x_2) + \ldots + f_n(S_{n-1},x_n)\} \quad (9)$$

Here W is the objective function; So - initial state; Sn - final state (result); x_i – step control (i = 1,…, n); f_i – functional of the i -th step (i= 1,…, n).

Ordering problems were mentioned above, for which deterministic models can be used. It should be noted that for low-dimensional ordering problems, you can use the method of direct enumeration of options. As the dimension of the problem increases, direct enumeration requires a large number of calculations, that is, it becomes ineffective.

The following procedure for project management using the Bellman optimality method is proposed:

1. Determine the method of describing the project, fix the number of stages.
2. Identify the project states taken as the initial and final states
3. Formulate an efficiency criterion and make an assumption about the numerical value of the objective function at the last stage (formula 9).
4. Determine the transition operator f, which affects the change in the state of the project during the transition $S_0 \rightarrow S_n$
5. Make an assumption about the state of the system at step n -1, select step control of the last stage $x_{n;}$ similarly select step control at n -1, n -2, etc. stages; at each stage, make a decision taking into account its impact on the final result.
6. Construct a conditionally optimal control vector X (x_{n-1}, x_{n-2}, …, x_1).
7. Repeat the procedure in reverse order from 1 to n -step.
8. Select the optimal control vector from two conditionally optimal options.

The Bellman optimality principle is invariant with respect to the subject area in which the project activity is carried out: investment management, inventory management, resource allocation and the assignment problem - this is not a complete list of multi-stage projects, when planning which it is necessary to take into account the dynamics of the process, the degree of influence of the decisions made on overall result. It is advisable to consider the projects of legalization, restrictions, prohibition of parallel imports, investments in domestic production, development of a system of measures, including legislative ones, to control unreasonable price increases and protect competition discussed above, as independent multi-step tasks, for which it is quite possible to determine the initial and final states , choose a method of dividing into stages and conduct analysis and modeling with the involvement of experts from among practical project managers.

Planning on networks. Network planning is a system of methods that are used to draw up plans for project and/or operational activities that require the participation of a group of performers and the expenditure of resources. A mathematical model of network planning is a directed graph, the vertices of which are events, the arcs of which are real or "fictitious" work - an expectation that does not require labor, but does require time. Visualization of a mathematical model is a network diagram, the creation of which uses the concepts of "work", "event" and "path".

The network model must be focused on the global goal of the project and be integral to the environment. When planning project activities, as mentioned above, the goal is to formulate a behavior strategy that ensures the maximum of a given efficiency criterion and satisfies the set constraints (costs, staff availability, time frames, etc.). Network planning models can be deterministic; this is the case when the type of relationship between the work and the event is clearly defined, the reserves of resources, the norms and the order of their use are known. Obviously, this is an ideal option, rarely found in management practice, but a deterministic network diagram can be used as an initial, draft version of a project plan.

Real practice is projects, when planning which it is necessary to take into account the probabilistic nature of the relationships between events and work, the influence of disturbing influences, etc. It is proposed to distinguish between three types of plans:

– a fixed, rigid plan with precise start and completion dates; in essence, it is a deterministic, fallbackless option (Gantt charts, critical path method;

– a plan with fixed timing of the occurrence of events and allowing for maneuvering the timing of the start of work, that is, the coordination of the process of implementing the plan is carried out not by operations, but by events (PERT; matrix method);

– a free plan in which the start and completion dates of the project are fixed, the dates of intermediate events are not fixed, the network is considered as a probabilistic model, the work duration is estimated by experts and is set in the "minimum-maximum" range (Monte Carlo method).

Table 3 presents the sequence of modeling using the planning method on networks

Table 3. Stages of planning on networks

Item no.	Modeling stage	Expected result
1	Expert assessment of the project and its included works	List of works and events
2	Determining the sequence of work	Directed graph
3	Network model calculation	Determining the deadlines for completing work
4	Analysis of calculation results	Identification of reserves; identification of alternative works
5	Expert assessment of calculation and analysis results	Recommendations for optimizing the network model and work package

As an example: a project to develop a mobile application for iOS.

At the first stage, experts identify a set of interrelated areas (a branch of the network), each of which is, in fact, an independent project: personnel selection, determining the supply of resources in man-hours taking into account qualifications, drawing up an estimate; development and implementation of the project design concept; content creation; editing; coordination with developers and designers; actual application development; software product testing; interaction with customers and general management. The second stage - for each branch of the network, the sequence of work is determined, each work is assigned a serial number, an alphanumeric code, and the duration of the work is determined. The configuration of the network depends not only on the set of works included in the branch, but also on the order in which they follow, the connections between them, etc. It is these weakly formalized factors - the priorities of the works, connections between them, etc. - that are determined by a specific performer. The practice of real project management shows that for most jobs the duration of the work does not have an exact meaning; since if the project is original, then the laws of distribution of operation durations are unknown; To identify them, the method of expert assessments is used, which makes it possible to determine the minimum, maximum and most probable (mode) duration. If the project has analogues, then the laws of distribution of operation durations are known and the mathematical expectation of duration D and variance σ^2 can be determined· After the network is "linked" to the calendar, that is, the start and end dates of work are determined, the network is calculated.

Currently, there is a fairly diverse set of software products, both specialized in a specific subject area and universal, allowing you to perform network calculations [16]. After performing the calculations, it is necessary to analyze the results obtained, and in this case, if at the first stage an assumption was made about the determinism of the project, then at the stage of analyzing the results it is advisable to proceed to the search for an optimal solution in the interval formulation: the duration of the operation is specified by the function

$$y=f\ (a,\ x)$$

here $x = (x_{1}, \ldots, x_{n})$– vector of arguments, and $x_i \in X$, $i = 1, \ldots, n$; X – numerical set; a – vector of interval parameters; Each value of the argument x , $x \in X$, corresponds to one value of the function in the form of a certain interval. It is necessary to find the value of the argument x^*, $x^* \in X$, which corresponds to the extreme value of the function.

In this interpretation, the network planning task can be reduced to the following sequence of determining the calendar dates for the start (completion) of work for which the time expenditure is minimal:

1. The calculation of a deterministic network is carried out with the values of the start dates corresponding to the left extreme boundary of the interval, the corresponding set of solutions R_n is formulated;

2. The set of solutions corresponding to the upper boundary value problem R_o is formulated in a similar way;

3. The intersection R of the sets R_n and R_o is found.

At the final stage, an analysis of the project plan is made and recommendations are made that adjust the individual strategy

Conclusion. The proposed models for the formation of individual strategies expand the understanding of the role and place of mathematical modeling in project management; show the possibility of adapting planning methods on networks and dynamic programming to the iterative planning process, which makes it possible to give preference not to the trial-and-error method, but to a systematic approach using mathematical and simulation models for the analysis and optimization of design solutions.

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