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## INFORMATION TECHNOLOGY OF A STATIC MODEL SOLVING FOR QUALITY IMPROVEMENT OF THE SOFTWARE DEVELOPMENT PROCESS BASED ON THE CMMI MODEL

Пропонується інформаційна технологія для вирішення задачі короткострокового планування (статична постановка задачі) покращення якості процесу розробки програмного забезпечення на основі моделі CMMI, що представляє собою модель зрілості. Використано модель задачі короткострокового планування поліпшення якості процесу розробки програмного забезпечення. Рішення даного завдання визначає цільовий профайл, який уточнює профайл, отриманий в результаті вирішення динамічної задачі та є для неї вхідною інформацією для подальшого використання.

**Ключові слова:** інформаційна технологія, короткострокове планування, якість процесу розробки програмного забезпечення, CMMI, модель зрілості.

Предлагается информационная технология, для решения задачи краткосрочного планирования (статическая постановка задачи) улучшения качества процесса разработки программного обеспечения на основе модели CMMI, представляющей собой модель зрелости. Использована модель задачи краткосрочного планирования улучшения качества процесса разработки программного обеспечения. Решение данной задачи определяет целевой профайл, который уточняет профайл, полученный в результате решения динамической постановки задачи и является для нее входной информацией для дальнейшего использования.

**Ключевые слова:** информационная технология, краткосрочное планирование, качество процесса разработки программного обеспечения, CMMI, модель зрелости.

Information technology that is proposed to solve the problem of a short term planning (static problem statement) for quality improvement of the software development process based on the CMMI model, which is a maturity model. The model of the short-term planning for quality improvement of the software development process is used. Three statements of static tasks for this model are proposed. The solution to this task determines the target profile, which specifies the profile that is obtained as a result of the dynamic task solving and the target profile is in itself the input information for dynamic task that can be used in further work.

**Keywords:** information technology, short-term planning, quality of the software development process, CMMI, maturity model

**Introduction.** Nowadays, the software development process (SF DP) has reached a high level of complexity. It consists of a large number of sub-processes, each of which has a great complexity in itself. Therefore, there is a problem of support and improvement of the development process quality. It was invented a lot of ways to make the SF DP modular, which were designed to reduce its complexity and provide an opportunity to assess its current state. A striking example of this approach is the CMMI [1, 2].

CMMI is the technology of maturity models that provides a description of how the SF DP should look, but does not answer the question: "How to achieve a specified maturity level?" Unfortunately, currently this area of knowledge does not have appropriate level of formalization. One of the problems that needs to be solved for improving the quality of SF DP within the context of CMMI is to get the optimal trajectory for improving the quality of SF DP. The presence of such a trajectory makes it wise for a company to invest resources. To date, there are different approaches for determining the quality of SF DP, such as the standard ISO 9001, ISO / IEC 15504 TR (Software Process Improvement and Capability Determination (SPICE)), CMMI, and others. They allow only verbal level to assess the maturity (quality) of SF DP. Therefore, scientific works aimed at formalizing these models are relevant.

**Problem statement.** In the dynamic formulation of the problem [3] the trajectory of the SF DP is solved. But the dynamic model is simplified and does not allow the manager of the organization to determine accurately the direction of the resource contribution. Therefore, in [4], a static model was proposed that more exactly solves the problem in the first planning sub-period in the dynamic

formulation of the problem (used as the first approximation).

When setting the static task based on the initial state of the SF DP, target profile and resource constraints, the optimal variant of the company promotion to the set goal is determined or a compromise decision is found between the degree of achievement of the goal and the necessary resources. The quality is characterized by alternative options for moving SF DP to a higher level of maturity in the work.

The aim of the research is to develop information technology of planning for improving the quality of the SF DP based on a static model.

**Short-term planning model for static problem statement.** From the point of view of decision making theory, each alternative quality improvement option is determined by three generalized indicators: the degree of the goal achievement, the resources needed to achieve the goal and the time necessary for the task the solution.

Usually, in the decision-making theory, a static task statement that does not include time is analyzed. This approach is justified for consideration in the near future. According to the structure of the CMMI model [5], which is presented in the form of a hierarchy of concepts, the practice is characterized by the level of opportunity at the lowest level. A set of practices forms a goal. A set of goals is formed into a focus area. Each focus area contributes to reaching the maturity level of the SF DP. All focus areas are categorized, which, in turn, are distributed according to the maturity levels of the SF DP.

There are two types of resources described in the paper: financial costs and time. The first criterion is based on two components: the necessary expenses for additional technical, informational, program and methodical support

and financial expenses for company employees' payment.

The second criterion is actually linked to the second component of the first criterion and is determined by the time that the company employee needs to spend, during which the employee will not be engaged in the main activity related to the software development.

Since the more resources are invested, the more extent of the goals can be achieved and vice versa. So the task of defining a rational (compromise) solution arises. Three statements of static tasks are used in this paper.

1. It is necessary to find a compromise solution for different categories of CMMI modules and two groups of utility functions.

2. It is necessary to find a compromise solution regarding the utility function groups  $V_1$  and  $V_2$  (the target profile achievement degree and the integrated resources).

3. To find the optimal value of the linear convolution of all individual utility functions.

Geometric interpretation of the second problem statement is shown on the fig.1 as the domain of admissible solutions  $\Omega$  in the space of the target utility functions without taking into account the constraints of financial resources. Curves  $BCD$  and  $\overline{BCD}$  are received, respectively, by maximizing and minimizing the  $V_1$  function for actions for  $V_2$ : 0.25; 0.5; 0.75. The vector  $\bar{\rho}$  determines the weighting factors of the importance of the target functions  $V_1$  and  $V_2$ . The results of solving test cases for the third task statement are given below.

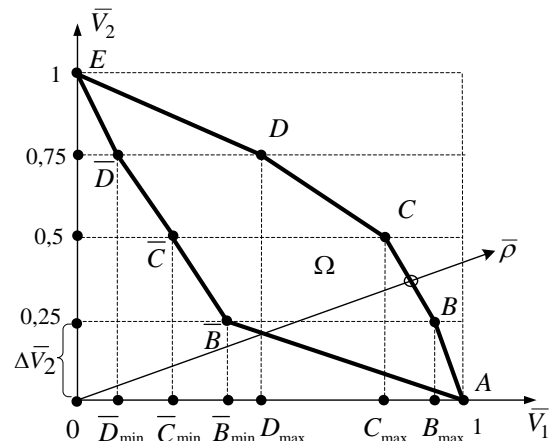


Fig. 1 – The admissible values solutions domain in the utility function space

**Information system development.** The process description of forming the set of optimal strategies was formed based on requirements presented as diagram IDEF0 (fig. 2). As described on the diagram, the solution process consists of three stages: the formation of the model (based on the data obtained in the first sub-period of the dynamic problem solution), the solution of the static task (based on the model obtained in the first stage) and changes of the task conditions. The last two stages form a cycle, the result of which is the multiplication of admissible solutions of the static problem.

Non-functional requirements were defined for the developed software component.

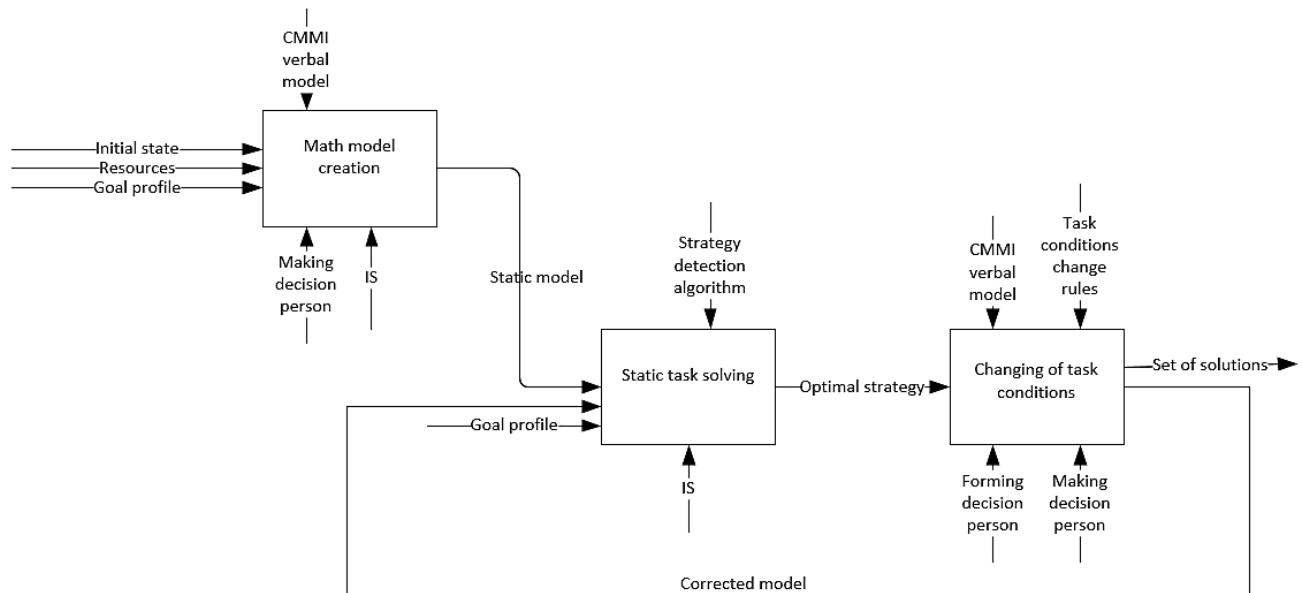


Fig. 2 – The process of forming a set of optimal strategies

1. Convenience of the user interface. The interface should be ergonomic, intuitive and easy to use.

2. The program code should contain comments explaining its structure.

3. The component should be designed in such a way that it would be possible to expand its capabilities without any noticeable effect on the systems that will use it.

4. There must be documentation for the construction of the code.

Deployment diagram is a model of the physical architecture of the system. It reflects the hardware configuration of the information system (fig. 3).

As can be seen from the diagram, the system has a three-tier architecture. The first level is the DBMS (MS

SQL Server), which is required for centralized data storage. There is the web server at the second level (WebServer), which is responsible for the processing and validation of data, as well as for the implementation of the model and algorithm for solving the static problem [6, 7].

There is a client application at the third level (Client), which purpose is to present the data and the results of the task solution to the end user, and also provides an opportunity for the user to enter easily the initial data of the task.

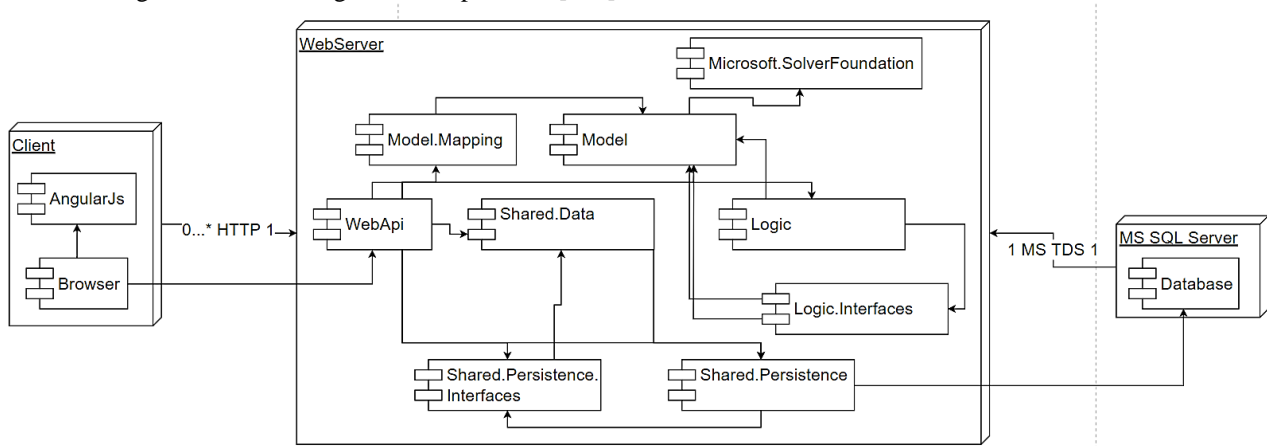


Fig. 3 – Deployment diagram of the programm system components

**An example of system work on test data.** The test case from IT company N was taken. The data that was obtained during the solution of the dynamic task statement in the first period was considered. The data of the current state of this period is given in table 1, which shows the

practice of focusing areas. The objective is to obtain the results of solving a static problem with different resource constraints.

25 000 USD were allocated for the first period in the dynamic task.

Table 1 – Initial state of the SW DP of company “N”

Maturity level	2				
Category	Project management				
Focus area	SAM – Supplier Agreement Management				
Goals	SAM1		SAM2		
Practices	1		6		
Initial state	0		0		
Goal state	2		2		
Resources	1000 / 2200		1000 / 2200		
Coefficients	0.5		0.5		
Focus area	CM – Configuration Management				
Goals	CM3				
Practices	7				
Initial state	1				
Goal state	2				
Resources	2200				
Coefficients	1				
Focus area	PPQA – Process and Product Quality Assurance				
Goals	PPAQ1		PPQA2		
Practices	2		3	4	
Initial state	2		2	2	
Goal state	3		3	3	
Resources	4300		4300	4300	
Coefficients	0.5		0.3	0.2	
Focus area	MA – Measurement and Analysis				
Goals	MA1		MA2		
Practices	1	2	6	7	8
Initial state	0	0	0	0	0
Goal state	2	2	2	2	2
Resources	1000 / 2200	1000 / 2200	1000 / 2200	1000 / 2200	1000 / 2200
Coefficients	0.25	0.75	0.3	0.3	0.4

Following results were obtained based on the initial data. With a resource limit of up to 25 000 USD, we have the following result, that is shown in fig. 4. Target function is 1.

With a resource limit of up to 20 000 USD, we have the following result, that is shown in fig. 5. Target

function is 0.93.

As can be seen from the results of the program, with various resource constraints, the increase in practice is attributed to those practices that have larger coefficients of importance, and as a result give greater importance to the function of the profile.

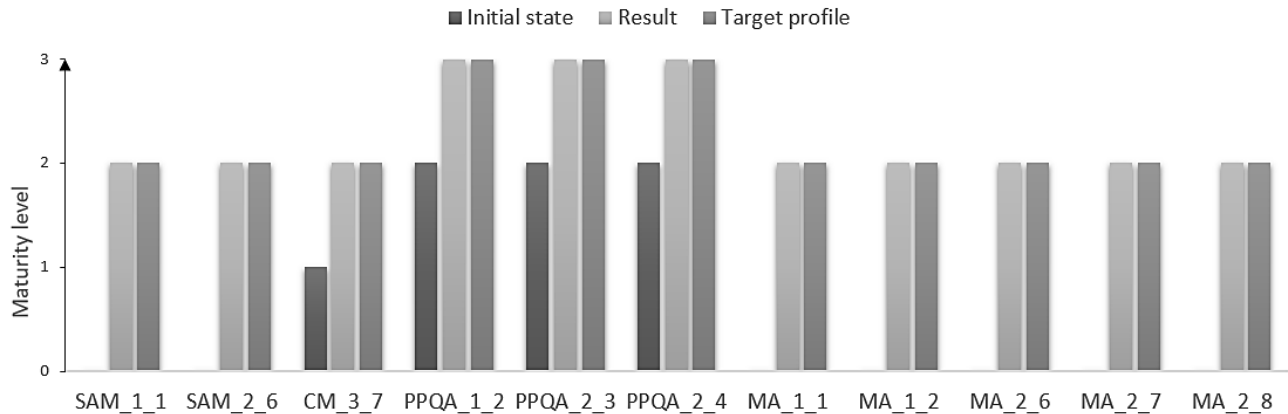


Fig. 4 – Calculation results (restrictions: 25 000 USD)

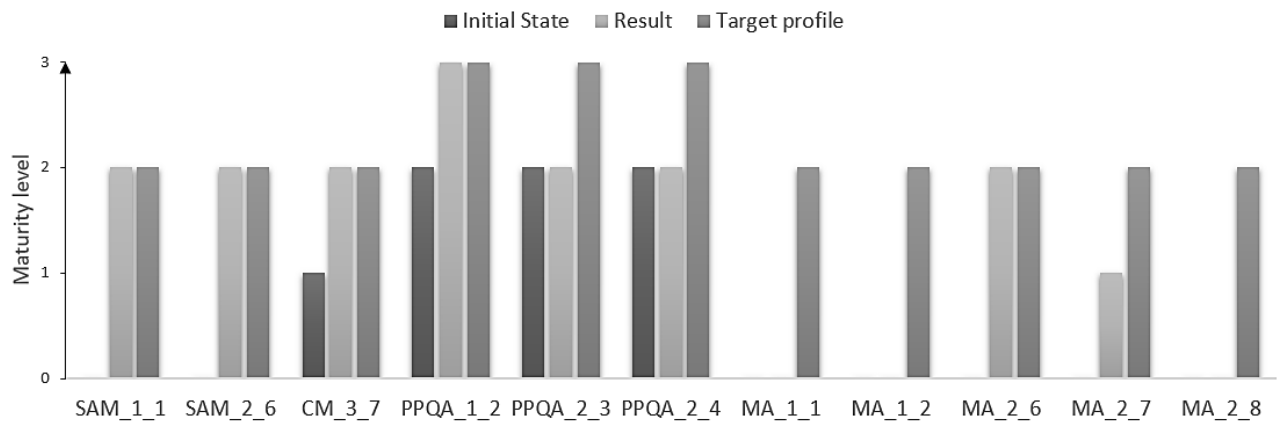


Fig. 5 – Calculation results (restrictions: 20 000 USD)

The obtained results confirm that the information system works correctly, giving the expected result, taking into account the factors of importance and the constraints on resources.

**Conclusions.** The software component was designed and implemented, which allows to calculate the optimal trajectory of improving the quality of SW DP in the short-term planning period, based on the incoming state, financial constraints, and the factors of the importance of particular practices, focus areas, etc.

Also, information technology has been tested for compliance with the declared functional and non-functional requirements and IT company data.

In the future it is planned to investigate the work of information technology on data volumes, which are close to the actual data conditions of the task data for determining the maximum amount of data on which the information system can find a solution.

Also, in the further development of this topic it is planned to design and develop informational technology, which automates the interaction of the considered

software system with a system that solves the dynamic formulation of the planning task.

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