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METHOD OF STRUCTURING BUSINESS MODEL AND MATHEMATICAL MODEL OF DSS OF IT COMPANIES

Abstract. The problem of creating a decision support system (DSS) for products/services in IT companies using an effective conceptual approach has been solved. The developed mathematical model of DSS for IT-business is represented. It-business is considered as a business focused on implementation and support of innovative projects. The mathematical model is intended for the use by an IT company as a separate IT project and a group of IT projects. Elements of graph theory and tensor analysis were used to create the mathematical model. DSS, with the use of the mentioned model, can be interactive and offer an effective solution by minimizing or maximizing the factor or group of factors that influence that decision. The search for the best DSS solution was reduced to the task of optimizing the integrated criterion, minimizing or maximizing the factor or group of factors influencing the decision. Since the possibility of negative values of the objective function for certain parameters of the weight of the edge of the digraph was clarified, the application of the Bellman – Ford algorithm for this reason was justified. The method of linear convolution was used for efficient operation of the algorithm. This allowed us to use the algorithm to solve multicriteria problems, in the absence of information about the form of the integral function. An adaptive algorithm was used to speed up the work. It is that the results of query processing form a database of templates. This will allow you to quickly find a solution for a similar query, even if you change the initial conditions. A universal approach to structuring the work of an IT-company has been developed. This allows formalizing requests to the DSS and to receive formalized responses both at the specific stage of the project, a separate type of work on the project and the project portfolio and the IT-company as a whole. This, in turn, allows optimizing the use of computer resources when working with DSS, reducing both the time to perform requests in the interactive mode, and for the formation of variants of the solutions for the tasks set by the user via DSS. Structuring according to the main features of the project allowed group the work of the IT company according to available resources and desired results. This will allow you to plan and organize the work of each employee to work not only in one project, but to perform work in different projects. It is also possible to plan and organize the work of working groups. Each of the executors of these groups is formally subordinated to their structural units and, at the same time, to the coordinator of the respective project. The proposed approach allows you quickly reorienting DSS to perform radically different

tasks, to fulfill a different purpose, to other areas of work of an IT company, other projects. It would only take time to update and replenish the DSS database.

Keywords: management, concept, optimal solution, algorithm, analysis.

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МЕТОД СТРУКТУРУВАННЯ БІЗНЕС-МОДЕЛІ ТА МАТЕМАТИЧНА МОДЕЛЬ СППР ІТ-КОМПАНІЙ

Анотація. Розв'язано проблему створення системи підтримки ухвалення рішень (СППР) продукції/послуги в ІТ-компаніях за використання ефективного концептуального підходу. Представлено розроблену математичну модель СППР для ІТ-бізнесу як бізнесу, орієнтованого на впровадження і супроводження інноваційних проєктів. Математична модель призначена для використання при реалізації ІТ-компанією як окремого ІТ-проєкту, так і групи ІТ-проєктів. При створенні математичної моделі було використано елементи теорії графів і тензорного аналізу. СППР, за використання вказаної моделі може працювати в інтерактивному режимі та пропонувати ефективне рішення мінімізацією чи максимізацією фактору чи групи факторів, що впливають на це рішення. Пошук найліпшого рішення СППР зведено до задачі оптимізації інтегрального критерію, мінімізацією чи максимізацією фактору чи групи факторів, що впливають на вказане рішення. Оскільки була з'ясована можливість від'ємних значень цільової функції за певних параметрів ваги ребра орграфу, обґрунтовано застосування для цього алгоритму Беллмана — Форда. Для ефективної роботи алгоритму використано метод лінійної згортки. Це дозволило використати алгоритм для вирішення багатокритеріальних задач, за відсутності інформації про вигляд інтегральної функції. Для прискорення роботи використано адаптивний алгоритм. Він полягає в тому, що результатами обробки запитів формується база даних шаблонів. Це дозволить швидко знайти рішення за аналогічного запиту навіть за зміни заданих початкових умов. Розроблено універсальний підхід до структурування роботи ІТ-компанії. Це дозволяє формалізувати запити до СППР та отримати формалізовані відповіді як за відповідним етапом проєкту, окремим видом роботи за проєктом, так і за портфелем проєктів і ІТ-компанією в цілому. Це, у свою чергу, дозволяє оптимальним чином використати комп'ютерні ресурси при роботі зі СППР, зменшити час як на виконання запитів в інтерактивному режимі, так і на формування СППР варіантів рішення поставлених користувачем задач. Структуризація за основними ознаками проєкту дозволила згрупувати роботи ІТ-компанії за наявними ресурсами та

бажаними результатами. Це дозволило планувати і організувати роботу кожного з працівників працювати не лише в одному проєкті, а виконувати роботи в різних проєктах. Також можливо планувати і організувати роботу робочих груп. Кожен з виконавців цих груп формально підпорядковуються і своїм структурним одиницям і водночас координаторові відповідного проєкту. Запропонований підхід дозволяє швидко переорієнтувати СППР для виконання кардинально інших завдань, виконання іншої мети, інших напрямів роботи ІТ-компанії, інших проєктів. Буде потрібен час лише на оновлення та поповнення баз даних СППР.

Ключові слова: управління, концепція, оптимальне рішення, алгоритм, аналіз.

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МЕТОД СТРУКТУРИРОВАНИЯ БИЗНЕС-МОДЕЛИ И МАТЕМАТИЧЕСКАЯ МОДЕЛЬ СППР ИТ-КОМПАНИЙ

Аннотация. Представлена разработанная математическая модель системы поддержки принятия решений (СППР) для ИТ-бизнеса. ИТ-бизнес рассматривается как бизнес, ориентированный на реализацию и поддержку инновационных проектов. Математическая модель предназначена для использования ИТ-компанией для управления как отдельным ИТ-проектом, так и группой ИТ-проектов. Для создания математической модели были использованы элементы теории графов и тензорного анализа. СППР с использованием упомянутой модели может быть интерактивным и предлагать эффективное решение путем минимизации или максимизации фактора или группы факторов, влияющих на это решение. Разработан универсальный подход к структурированию работы ИТ-компания. Это позволяет формализовать запросы к СППР и получать формализованные ответы как на конкретной стадии проекта, так и по отдельному виду работ над проектом и портфелем проектов или ИТ-компанией в целом. Это, в свою очередь, позволяет оптимизировать использование компьютерных ресурсов при работе с СППР, сократить как время выполнения запросов в интерактивном режиме, так и формирование вариантов решений для задач, поставленных пользователем через СППР. Предлагаемый подход позволяет быстро переориентировать СППР для выполнения радикально разных задач, для выполнения другой цели, на другие сферы работы ИТ-компания, другие проекты. Для обновления и пополнения базы данных СППР потребуется только время.

Ключевые слова: управление, концепция, оптимальное решение, алгоритм, анализ.

Формул: 3; рис.: 2; табл.: 0; библи.: 14.

Introduction. Integrated project management of IT companies, work planning, financial management are characterized by a significant influence evoked by the use of various software, sometimes uncoordinated, for managing individual subtasks, divisions, development teams. In practice, this leads to problems associated with the mismatch in the work of weakly interconnected software, different approaches and models in the core of their algorithms, and sometimes their inability to adapt to new tasks and new working conditions. That is why it is necessary to create a decision support systems (DSS) for the IT company in such a way that it will be able to support not only the company's business in all areas of activity as a whole, but could be also suitable for managing both project portfolio and individual projects. Unfortunately, such models of information processing, which thanking to their efficiency, flexibility, adaptability and informative nature, could've been satisfied all needs of Ukrainian IT companies, have not been created yet [1].

Analysis of research and problem statement. Such domestic scientists as Zaichenko, Klepikova, Vasilieva, Burkov [1], Maslii, Nitsenko [2; 3] and scientists from other countries Rasmusson, Rodriguez, Ortega, [4] etc. devoted their attention to the researches related to the management of IT companies. Today the practice of using DSS based on mathematical, statistical, simulation kernels for processing tasks having quantitative, qualitative or combined nature of information processing is widespread. One of the peculiarities of DSS in the IT sphere is the need of being adapted to drastic changes in projects, which are highly probable even at the stage of their implementation [4; 5]. These changes may relate not only to the terms of reference, the conditions of the project's financing, and the resources needed to execute the project, but even to the very purpose of the project. Still an effective methodology for the decision support system of an IT company, and for administration not even of groups of projects, but of one project is absent. The situation is complicated by the fact that Ukrainian IT companies are engaged not only in software development, but also in its support, testing, etc.

The purpose of the article. The purpose of the article is to study in more detail the value category in terms of economic, social, managerial, behavioural, cultural and integrative components. Achieving this goal involves solving the following tasks: to study the components of this definition that affect the formation of management processes of the enterprise; to justify the main stages of implementation of the value aspect in the processes of enterprise management.

Research results. Lets' consider the problem of choosing an effective integrated management solution, for example, project portfolio management. Obviously, the task of the DSS is to ensure each of the various stages of project work. For the purpose of our work structuring, we have identified the following features of the classification of workflows of an IT company: the type of decisions taken (general organizational and tactical), the level of decision making, the main purpose and tasks of decision making, technological decisions, stage of the life cycle. Obviously, the system of requests to the DSS of the IT company will be formed during the course of certain business processes of this company and in such a way as to correspond to the features of the conducted structuring. The technological features of doing business in accordance with its purpose or objectives will shape the architecture of building an IT company and the structure of its data flows (Fig. 1).

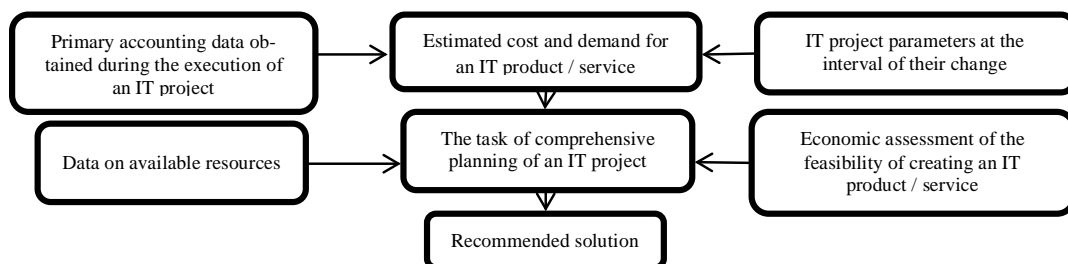


Fig. 1. Structuring the data flows of the DSS of IT company

Since it is not advisable to develop a DSS for the specific business of only one company — because then it may become unnecessary in case of changing the purpose of the business, and since

it will not be widely used, its cost will be as high as in case of an artificial product, we were considered a universal approach to structuring the company over the project life cycle (Fig. 2).

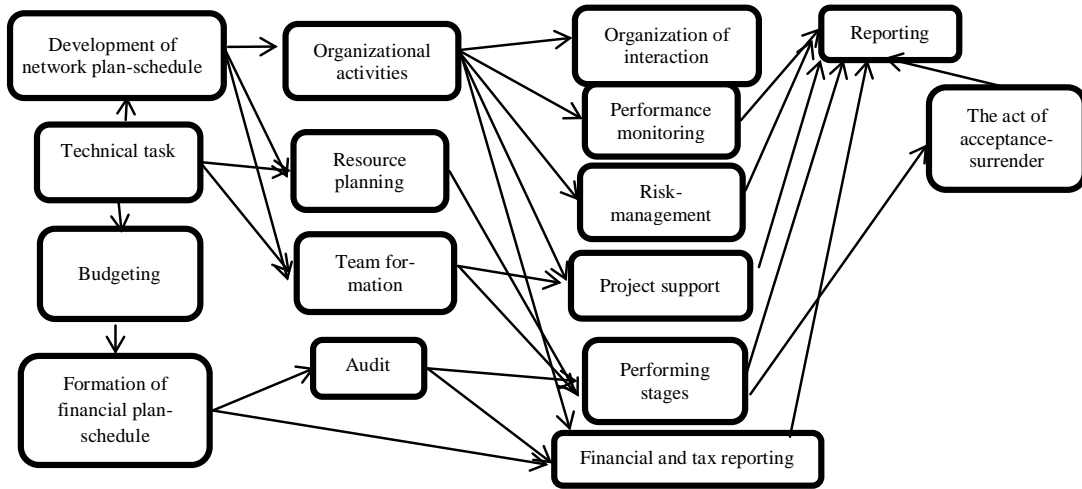


Fig. 2. Structuring the work on the project lifecycle

This approach was also designed to reduce the load of computer resources and to simplify the interactive interface of the DSS. This, in turn, improves the quality of the DSS itself, in particular, of its parameters such as the speed of request transactions and the ease of use of the interface. There is still no effective and universal method for building an integrated DSS model specifically created and tailored to the company, with the ability to implement a project-based approach to the organization of work characteristic of the IT business. The formation of an integrated DSS model is complicated by both the large amount of information specific to the IT business and the features of the IT industry and the great dependence of IT products on the market conditions and, in particular, the rapid changes in them. Rapid changes can affect all aspects of an IT company, including even its goals, target groups and business spheres. All this complicates the formation of a universal effective integrated DSS. Each project solution can be represented using the graph theory apparatus as an oriented graph (digraph). Company administration can be represented as a project group management system. In terms of graph theory, a group of projects is a system of digraphs whose vertices have edges connected to each other. The number of such edges between each pair of interconnected digits must be at least two. It is advisable to use tensor analysis for the algebraic representation of such a system of interconnected graphs [6, 7]. Then we can apply the tensor equation $V = W * A^T * M$, where V is the pointer tensor at decision vertices, W is the correction factor tensor, A is the incident tensor, T is the vector of required resources for each resource type, M is the variable of tensor parameters for each of the subproblems [8, 9]. The variable parameter tensor for each of the problems can be found in accordance with [10, 11], as:

$$M = \left[\begin{array}{ccc} \sum_{i=1}^{n-1} a_i * m_{i_1} & \cdots & \sum_{i=1}^{n-1} b_i * m_{i_1} \\ \vdots & \ddots & \vdots \\ \sum_{i=1}^{n-1} a_i * m_{i_z} & \cdots & \sum_{i=1}^{n-1} b_i * m_{i_z} \end{array} \right] \text{ provided } i \in (1 \dots l), \quad (1)$$

where a_i, b_i the weight coefficients of the corresponding parameter, m_i – the parameter value for each of the i subtasks, z – number of subtasks, n – number of parameters in the interval $(1, \dots, i)$. In the presence of parameters by the indices i and z , the variable parameter tensor for each of the problems M can be represented by a dimeric matrix of size $(1 \dots l) * (1 \dots z)$. Correction coefficients can be represented as trapezoidal functions. As you know, trapezoidal functions are defined by three numbers $w_{min}, w_{mid}, w_{max}$, where w_{min} – the lower limit of the change interval, w_{max} – upper

limit of the trapezoidal function change interval, w_{mid} – average or more likely coefficient value. Then, respectively, $w_{min} \leq w_{mid} \leq w_{max}$. For a particular argument value $x \in (w_{min}, w_{max})$ the value of the trapezoidal function of the correction coefficients can be found as:

$$w(x) = \begin{cases} 1 - \frac{w_{mid} - x}{w_{mid} - w_{min}}, & w_{min} \leq x \leq w_{mid} \\ 1 - \frac{x - w_{mid}}{w_{max} - w_{mid}}, & w_{mid} \leq x \leq w_{max} \\ 0, & \text{for all other cases} \end{cases} \quad (2)$$

where $(w_{mid} - w_{min}) = (w_{max} - w_{mid})$, of the correction coefficients will be symmetric, that is, as a consequence, uniquely defined by two parameters from the set of three values $w_{min}, w_{mid}, w_{max}$. This, in turn, results in a shorter calculation time. The problem of reducing the deviation of the factors from the desired values, which by other, auxiliary methods (for example, with the help of expert evaluation in the online mode) is considered the best, can be solved by the classical method of correlation-regression analysis - by finding the minimum value of the square of the differences: $w_j (m_{pr} - M)^2, j \in (1, n)$, where w_j – the current value of the correction factor, which is obviously an element of the tensor W , m_{pr} – the predicted desired parameter value. Estimated (desired) parameter value m_{pr} , in the general case, it can be considered not as a scalar, but as an element of a vector M_{pr} . In this case, the algorithm of the problem can be modified so that the coefficients will not be fulfilled by coefficients w_j , but by the elements of the vector M_{pr} . Then the problem of minimization or maximization of factors (finding the minimum can be replaced by finding the maximum of the corresponding factor by substituting the value of the sign +/-) will be formulated as $W, M \rightarrow \text{extr}, j \in (1, n)$. In the case of multicriteria formulation of the problem, not in the case of monocriteria, in the absence of information on the appearance of the functions of the corresponding criteria, the problem of correct definition of the integral criterion arises. We suggest using a linear convolution algorithm for this purpose. Then, after the step of separating the groups of factors by individual criteria, the linear convolution algorithm is formulated in accordance with [11], as:

$$\sum_{j=1}^{l_1} w_j (m_j - M_j)^2 + \sum_{j=l_1+1}^{l_2} w_j M_j - \sum_{j=l_2+1}^{l_3} w_j M_j \dots \rightarrow \min, \quad (3)$$

where $l_1, l_2, l_3 \dots$ – the limits of the intervals of isolation of groups of factors by individual criteria. Obviously, $l = l_1 + l_2 + l_3 + \dots$. The problem of finding the optimal solution using the apparatus of graph theory can then be reduced to the problem of optimization of the integral criterion [10—12] with the available constraints, that is, to find the optimal path on a weighted digraph. The Dijkstra algorithm is the most commonly used for this purpose. However, its use for the task is excluded, because the values of the weight of the edge of the digger can lead to negative values of the objective function. Then, the Bellman — Ford algorithm, which allows the use of negative values of edges, is most effective for solving this problem [11]. The implementation of the suggested mathematical model of DSS will allow appropriate formalization of information both on a separate project and for the IT company as a whole and to offer the user an effective variant of project implementation, even in the case of multi-criteria problem statement.

The next problem for forming an effective integrated management solution is the methodology for relevant structuring of the IT company. Structuring work is complicated by the contradiction between the need to enhance the specialization of work on individual projects and the need to coordinate them at the level of company management. The classic approach that would be useful for structuring the work of a company, the so-called departmentalization, it is impossible to use in a company without its modification. Usually, departmentalization is carried out by grouping works on projects and contractors according to their specialty, qualifications and abilities [13; 14]. However, the difficulty is that in an IT company, one employee can participate in several projects at one time. Therefore, it is suggested to group the planning and structuring of the work according to

available resources, work stages, main features of the project and the desired results by integrating all these types of departmentalization. To execute the project portfolio, several teams of contractors are created for each of the projects, which formally submit to their structural units and, at the same time, to the coordinator of the respective project. Therefore, it is also important to consider the possibility of structuring work across the project lifecycle (see *Fig. 2*).

Since the work of the company is based on a process-oriented approach in the implementation of each of the projects, therefore, the formalization of work on the implementation of projects throughout their life cycle is required. The project lifecycle works are formally presented in *Fig. 2*. As you can see these works are related to all aspects of work — organizational, financial, tax, risk management etc. Failure to perform work or poor performance at each stage results in disruption of the entire project work complex. The formation of a DSS also requires the existence of a structured model of IT company data flows (see *Fig. 2*). *Fig. 2* clearly illustrates what data flows are required to produce the recommended DSS solution.

Conclusions. The problem of creating DSS for products/services in IT companies has not yet had an effective conceptual solution. Therefore, it is important to create a mathematical model of purposeful search for the most effective solution for the administration of a group of projects aimed at the production of IT products/services. A mathematical model of DSS for IT business has been developed, it can be used both in the implementation of a separate IT project and a portfolio of IT projects. The mathematical model uses graph theory, tensor analysis and provides an online solution to support and make decisions effectively. The mathematical model allows us to formalize information, in particular, as well as on the project or on the specific stage of the project, on a particular type of work on the project, and on the project portfolio and the IT company as a whole. Finding the best DSS solution is the task of optimizing the integral criterion, minimizing or maximizing the factor or group of factors that influence that solution. As the possibility of negative values of the objective function for certain parameters of the weight of the edge of a digraph has been clarified, the application for this Bellman-Ford algorithm is justified. There is the probability of not only single-criteria, but multi-criteria problem, in the absence of information about the appearance of the functions of the corresponding criteria and, accordingly, the presence of the problem of correct definition of the integral criterion. Thus, it is suggested to use a linear convolution algorithm for this purpose. It is also suggested to group the planning and structuring of the company work according to available resources and desired results, using a combined departmental approach, applying each of its types or group of types if needed. We consider the ability of each of the employees to work not only in one project, but to perform work in different projects. In the presence of a portfolio of projects, working groups are created to execute them. The methodology of relevant structuring of the work of an IT company, the flow of data by individual units, types of work, stages of the project allows reducing the amount of computer resources during the operation of the DSS, reducing time for requests in the interactive mode and the formation of DSS options for solving the tasks.

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