and CAAC. At lower priority we could add spam filtering, data encryption, and selective Android permission mechanisms. Finally, remote management, VPN and login solutions would be a significant advantage when targeting corporate customers.

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METHODS OF FUZZY LOGIC TO MINIMIZE THE RISKS OF IT-PROJECTS

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МЕТОДИ НЕЧІТКОЇ ЛОГІКИ ПРИ МІНІМІЗАЦІЇ РИЗИКІВ ІТ-ПРОЕКТІВ

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МЕТОДЫ НЕЧЕТКОЙ ЛОГИКИ ПРИ МИНИМИЗАЦИИ РИСКОВ ИТ-ПРОЕКТОВ

This article describes the selection of an IT project using fuzzy sets and project risk management. Proposed for determining the most effective use of fuzzy logic project «worst-case method», which is based on the principle of fuzzy intersection Bellman criteria-Zadeh and 9-point scale linguistic evaluations Saaty.

Key words: *fuzzy set, fuzzy logic, fuzzy variable, linguistic variable, IT project risks IT-project management standards IT-projects.*

Розглянуто вибір ІТ-проекту за допомогою нечітких множин та управління ризиками проекту. Запропоновано для визначення найбільш ефективного проекту використання нечіткої логіки «метод найгіршого випадку», основу якого складають принцип перетинання нечітких критеріїв Белмана-Заде і 9-бальна шкала лінгвістичних оцінок Саати.

Ключові слова: *нечітка множина, нечітка логіка, нечітка змінна, лінгвістична змінна, ІТ-проект, ризики ІТ-проектів, стандарти управління ІТ-проектів.*

Рассмотрен выбор ИТ-проекта с помощью нечетких множеств и управления рисками проекта. Предложено для определения наиболее эффективного проекта использования нечеткой логики «метод наихудшего случая», основу которого составляют принцип пересечения нечетких критериев Беллмана-Заде и 9-балльная шкала лингвистических оценок Саати.

Ключевые слова: *нечеткое множество, нечеткая логика, нечеткая переменная, лингвистическая переменная, ИТ-проект, риски ИТ-проектов, стандарты управления ИТ-проектов.*

Statement of Problem. At the present stage of information technology (IT) is considered as one of the main tools for the implementation of the strategic objectives in various fields.

Management in the economy lead to the use of increasingly complex IT in process automation control government agencies and large companies. Increase the value and significance of data to be processed in turn leads to the need for effective it management. Introduced new principles of organization and management, new IT - services to users. Constantly modified and supplemented by the requirements of modern IT. In turn, the complexity of managing leads to qualitative and quantitative growth of their providing component - information and communication system (ICS). It is known that most of the projects on the development of information systems is currently not completed in time, exceed the budget or dealt with the lack of functionality to the system can be used. According to the Chaos Report on the status of the development of IT - projects conducted by Standish Group [1], every fifth project fails, every second is not able to meet the deadline or is of lower quality or incomplete functionality.

Analysis of previous investigations and articles. One of the reasons for this situation are the wrong decisions made by project managers, in particular wrong decisions during the execution phase of the project. So, project managers can delay the time of replacement of less efficient developer more efficient. One of the objectives for the management of IT- projects is the task of managing the execution of the project [2]. The complexity of this task, due to the fact that, as a rule, something goes not according to plan, for example, violated time and budget, the reasons could be other factors, such as the underestimation of the complexity of the tasks, the low productivity of developers, and so on [3]. For decisions to be taken at this stage, characterized by increased subjectivity. Making incorrect decisions can lead to violation of the terms of the project and / or over budget. Very rarely one project is superior on all criteria. Usually each of them has its advantages and disadvantages. To choose the best variant of the project are various methods of calculating changes in the value of money over time [4]. The main idea of these methods is to calculate how profitable is each variant at a given time interval. When such calculations are unavoidable errors due to inaccurate forecast indices - for example, future bank interest rates, annual profits, revenues from the project in three, five, ten years, etc.. For brand projects are very difficult to accurately predict financial flows, because they strongly depend on the subjective reactions of many people, therefore, the practical application of such methods in the analysis of real brand projects limited. The article discusses the implementation of multicriteria analysis of brand projects based on fuzzy decision theory. The initial data used by the expert pairwise comparison of alternatives for each criterion.

Bold unsolved aspects of the general problem. It is impractical to choose a project only on economic criteria (given profit, the profitability index investment, etc.) without taking into account the complexity of its implementation, degree of maturity, risk, and other factors. As the source data assumes the use of expert pairwise comparisons of alternatives on each criterion.

Aim of the article. When deciding the most important thing is to choose the best option. Therefore, the main thing is not to predict what indicators will ensure the implementation of a project, and to determine the advantage of one option over the other. Also, a method for sensitivity analysis of the decision to variations of the expert comparisons of alternatives.

The main part. The choice of intelligent information systems. Assume that known:

$P = \{P_1, P_2, ..., P_k\}$ is the set of projects for the creation of intelligent information systems (IIS);

$G = \{G_1, G_2, ..., G_k\}$ is the set of quantitative and qualitative criteria for evaluation of projects.

Multicriteria analysis of alternatives consists in the ordering of elements of the set P according to the criteria G. taking into account published data management projects highlight the following evaluation criteria IIS:

– G_1 – degree study of the project;
– G_2 – expected effect;
– G_3 – risks;
– G_4 – speed output IIS on the market;

– G_5 – future development IIS;

– G_6 – cost of the project.

Multitude of the selected criteria is open – it can be supplemented with regard to specific information intelligent systems. In addition, each criterion can be viewed as a set of individual indicators at a lower level in the hierarchy. For example, risks (G_3) may include legal, financial, fashion risks, risks of loss of competitive advantage for the "cloning", risks of changes in legislation and etc.

Most of the methods of multi-criteria analysis converts a vector of individual criteria, which assesses the alternatives in the scalar integral criterion. With this approach it is difficult to take into account qualitative criteria, which are assessed by experts. One of the well-proven themselves in the management of mathematical methods of work with quality information is the theory of fuzzy sets, which is an effective mathematical tool for dealing with uncertainty.

To build the decision model used method of fuzzy multi-criteria analysis [5], which allows to take into account the peculiarities of the development of intelligent information systems. The method is based on the following principles:

1) criterias are considered as fuzzy sets defined on the universal set of alternatives using a membership function;

2) the membership functions of fuzzy sets are determined by expert paired comparisons of alternatives;

3) the coefficients of importance of the criteria used to concentrate the appropriate fuzzy sets;

4) the decision shall be made by the scheme Bellman – Zadeh [6] by the intersection of fuzzy sets of criteria that corresponds to the option that is better than others simultaneously satisfies all criteria.

We denote as number from the interval [1], which project is evaluated according to criteria : the greater the number , the better the project P_j criterion , , . Then the criterion can be represented by fuzzy set on the universal lot of information intelligent systems *P*:

(1)

where - the degree of membership of element fuzzy set .

Find the degree of membership of a fuzzy set (1) will the method for construction of membership functions on the basis of pairwise comparisons. For each pair of projects expert criterion evaluates the advantage of one option over another. Paired comparison it is convenient to specify this matrix:

$$\boldsymbol{A} = \begin{array}{c} \\ P_1 \\ P_2 \\ \dots \\ P_k \end{array} \begin{array}{c} \begin{array}{cccc} P_1 & P_2 & \dots & P_k \end{array} \\ \begin{bmatrix} a_{11} & a_{12} & \dots & a_{1k} \\ a_{21} & a_{22} & \dots & a_{2k} \\ \dots & & & \\ a_{k1} & a_{k2} & \dots & a_{kk} \end{bmatrix} \end{array},$$

where - the advantage of the project before project ( ), is determined by the whole scale Sahati[6]:

1 – if the advantage is absent;

3 – if the advantage of the weak;

5 – if a significant advantage;

7 – if a distinct advantage;

9 – if the absolute advantage;

2, 4, 6, 8 – intermediate comparative evaluation.

Matrix of pairwise comparisons A is diagonal (a_{ij} = 1) and back symmetrical $a_{ij} = \frac{1}{a_{ij}}, i,j = \overline{1,k}$. The degree of fuzzy membership (1) correspond to the coordinates of the eigenvectors $W = (w_1, w_2, \dots, w_k)^{\mathrm{T}}$ of the matrix A: $\mu_G(P_j) = w_j, j = \overline{1,k}$. Own vector is found using the following equations:

$$\begin{cases} A \cdot W = \lambda_{max} \cdot W \\ w_1 + w_2 + \cdots + w_k = 1 \end{cases} \quad (2)$$

where λ_{max} is the largest eigenvalue of the matrix A.

According to the principle of Bellman-Zadeh, will be the best alternative, which is to the greatest degree simultaneously satisfies all the criteria. Fuzzy decision is the intersection of individual criteria:

$$\widetilde{D} = \tilde{G}_1 \cap \tilde{G}_2 \cap \dots \cap \tilde{G}_n = \left\{ \frac{\min_{i=\overline{1,n}}\left(\mu_{G_i}(P_1)\right)}{P_1}, \frac{\min_{i=\overline{1,n}}\left(\mu_{G_i}(P_2)\right)}{P_2}, \dots, \frac{\min_{i=\overline{1,n}}\left(\mu_{G_i}(P_k)\right)}{P_k} \right. \quad (3)$$

In accordance fuzzy solution of (3) is the best project with the maximum degree of membership:

$$D = \arg\max \left(\mu_D(P_1), \mu_D(P_2), \dots, \mu_D(P_k)\right) \quad (4)$$

The choice of intelligent information system for multi-criteria analysis. Improving the effectiveness of the implementation of information systems in various sectors of activity is closely related to their level of intellectuality. At the present stage of development of information systems and technologies most routine operations to transform the information is already automated and further increasing efficiency requires automation of intellectual and creative activity of man.

The creation of intelligent information systems, which would provide the company with modern methods of data analysis, generation of alternative solutions, evaluation and selection of the best, is an extremely important and urgent task. The introduction of mobile and the use of expert systems is a necessity, which would help to navigate in a changing environment.

In the work it was decided to compare three of the project for the creation of intelligent information systems, namely Oracle, SAP, and author's elaboration based on genetic algorithm.

Oracle and SAP - the world leaders in the segment of enterprise management systems. The products of both suppliers belong to the class of large integrated systems and broad functionality that allows you to meet the needs of businesses in virtually any industry. However, the high cost of licenses, consulting services and support solutions from Oracle and SAP is often a key issue when choosing IIC. For this reason we are together with them compared authoring, to visualize on the defined criteria of their advantages or disadvantages.

The calculated values of all components of the criterion G_i each alternative P_1, P_2, P_3 set P of IIS variants are presented in table 1.

Table 1

Evaluation component criteria for each alternative

Criterion component	**Alternatives**		
	P_1 – Oracle	**P_2 – SAP R/3**	**P_3 – author's development**
G_1 – extent of study of the project	90 %	95 %	50 %
G_2 – the expected effect	75 %	75 %	75 %
G_3 – risks	25 %	10 %	60 %
G_4 – speed of entry IIS into the market	35 %	50 %	10 %
G_5 – development prospects of IIS	55 %	70 %	70 %
G_6 – project cost	high	high	low

Expert paired comparison projects *P1 ÷ P3* criteria *G1* to *G6* are given in table 2.

Table 2

Paired comparison projects

Criteria	**Pair comparisons**
G_1	absolute advantage P_2 over P_3
	clear advantage P_1 over P_3
	weak advantage P_2 over P_1
G_2	essential advantage P_1 over P_3
	essential advantage P_2 over P_3
	відсутня перевага P_1 над P_3
G_3	essential advantage P_2 over P_3
	weak advantage P_1 over P_3
	there is no advantage P_1 over P_2
G_4	weak advantage P_1 over P_3
	essential advantage P_2 over P_3
	there is no advantage P_1 over P_2
G_5	essential advantage P_3 over P_1
	weak advantage P_3 over P_2
	weak advantage P_2 over P_1
G_6	absolute advantage P_3 over P_2
	absolute advantage P_3 over P_1
	weak advantage P_2 over P_1

Based on the results table 2, the resulting matrix of pairwise comparisons, which, being diagonal and having property of transitivity and reverse symmetry are the following:

$$\mathrm{A}(G_1)=\begin{bmatrix}1 & 1/3 & 7\\ 3 & 1 & 9\\ 1/7 & 1/9 & 1\end{bmatrix} \qquad \mathrm{A}(G_4)=\begin{bmatrix}1 & 1 & 3\\ 1 & 1 & 5\\ 1/3 & 1/5 & 1\end{bmatrix}$$

$$\mathrm{A}(G_2)=\begin{bmatrix}1 & 1 & 5\\ 1 & 1 & 5\\ 1/5 & 1/5 & 1\end{bmatrix} \qquad \mathrm{A}(G_5)=\begin{bmatrix}1 & 1/3 & 1/5\\ 3 & 1 & 1/3\\ 5 & 3 & 1\end{bmatrix} \qquad (5)$$

$$\mathrm{A}(G_3)=\begin{bmatrix}1 & 1 & 3\\ 1 & 1 & 5\\ 1/3 & 1/5 & 1\end{bmatrix} \qquad \mathrm{A}(G_6)=\begin{bmatrix}1 & 1/3 & 1/9\\ 3 & 1 & 1/9\\ 9 & 9 & 1\end{bmatrix}$$

In each matrix the three elements correspond to paired comparisons with table. 2. Other items found based on the properties of the diagonal and the inverse of the symmetry of the matrix of paired comparisons. Applying the formula (2) to the matrix (5), we obtain the following fuzzy sets:

$$\tilde{G}_1=\left\{\frac{0{,}24}{P_1},\frac{0{,}69}{P_2},\frac{0{,}06}{P_3}\right\}$$
$$\tilde{G}_2=\left\{\frac{0{,}45}{P_1},\frac{0{,}45}{P_2},\frac{0{,}09}{P_3}\right\}$$
$$\tilde{G}_3=\left\{\frac{0{,}43}{P_1},\frac{0{,}45}{P_2},\frac{0{,}11}{P_3}\right\}$$
$$\widetilde{G}_4=\left\{\frac{0{,}43}{P_1},\frac{0{,}45}{P_2},\frac{0{,}11}{P_3}\right\}$$
$$\tilde{G}_5=\left\{\frac{0{,}11}{P_1},\frac{0{,}23}{P_2},\frac{0{,}65}{P_3}\right\} \qquad (6)$$
$$\tilde{G}_6=\left\{\frac{0{,}08}{P_1},\frac{0{,}1}{P_2},\frac{0{,}82}{P_3}\right\}$$

After crossing $\tilde{G}_1 \cap \tilde{G}_2 \cap \ldots \cap \tilde{G}_6$ we obtain the following fuzzy set:

$$\widetilde{D}=\left\{\frac{0{,}08}{P_1},\frac{0{,}1}{P_2},\frac{0{,}06}{P_3}\right\} \qquad (7)$$

which shows the advantage of the project P_2 over the other. Thus, the project P_2 are better than others at the same time satisfies all the criteria according to their importance.

This algorithm, based on fuzzy sets, implemented in Microsoft Excel and universal for evaluation to select the best projects.

Optimization of the decision-making process on the choice of intelligent information systems. In practice, the question often arises: "What needs to change in this project, to become the best?". To answer this question it is necessary to know how "anxious" resolved expert paired comparisons. Below is a proposed approach to the study of the sensitivity, the idea of which is to define what will be the solution, if you change one of the pairwise comparisons. When you change one of the paired comparisons of the options necessary to ensure the consistency of the other. For illustration depict the histogram, which will reflect the best project in the appropriate criterion.

1) Consider projects on their degree of elaboration, SAP R/3 has a clear advantage over the author's development. To improve the author's design based on genetic algorithm (GA) is often necessary to not only Finance, but also experience, business communication successful investors in the creation and development of business.

2) Further analyzed the projects expected effect, a clear advantage is the project of SAP R/3. To change the level of benefits the other two projects should:

- ensuring management efficiency;
- to improve the accuracy of incoming and outgoing information;
- increase productivity of managerial personnel;
- reduced operating expenses;
- increase the scientific validity of the initial information.

3) The most risky is the project authoring on the basis of GA, for changes in the level of benefits of the project under this criterion must:

- to anticipate problems instead of reacting to them after they occur;
- to do preventive measures wherever possible;
- to prepare plans for the solution of problems before problems arise;
- to study the root causes of risk, and not their manifestations;
- use clear, structured and repeatable process for solving problems.

4) Improvement of advantages over other projects requires author's elaboration based GA for this need:

- creation, development and utilization of new products and processes;
- improvement of the quality level of technical and technological base of production;
- improvement of the quality level of the research and development base;
- increase the efficient use of personnel and information potential;
- improving the organization and management of innovative activity;
- rationalization of the resource base;
- the achievement of competitive advantages of an innovative product over similar products on the domestic and foreign markets.

5) Author's elaboration based on GA is the most promising, because it aims to take a leading position in the market. For the long-term prospects in the development of the IIS must conduct ongoing analysis of the adequacy and appropriateness of the existing market structure, functions, tasks, skill level of staff in a particular economic situation.

Having estimated IIS at their cost, we see that author's development on the basis of GA has absolute advantage before other projects as is the cheapest project. To increase the level of preference for other projects it is necessary to reduce the price.

Summarizing the above, determine that it is necessary in order to make the author's elaboration on the basis of GA was the best. After analyzing the project determined that to improve

its will on the criteria G_1 (degree of elaboration of the project) and G_2 (expected effect), as the criterion G_1 is the worst.

For improving the level of study and the expected effect of the project should: o new financial services market, their standardization across the enterprise, improving the quality of customer service and transparent tracking performance, it is necessary to provide a unified platform for the delivery of of financial services. This platform should provide the ability to quickly rebuild automated business processes without compromising the reliability, safety and quality of their provision.

To enable planning and optimization of logistics network, tracking the passage through it of cargoes and shipments must provide a unified logistics system planning and accounting. This system should provide the ability for strategic planning of the logistics network, the solution of optimization problems, as well as full support for the operational functioning of logistics enterprises. In addition, the system should provide the ability to quickly change in order to market new customization services.

As currently IIS occupy one of the key places in the enterprise, the quality of provision of it services, their reliability, consistency with the business requirements and the flexibility to change come to the fore. This IIS should accelerate the process of adaptation to changing business requirements and to ensure consistent settings of providing it services.

Having fulfilled all the necessary conditions to improve and identifying new benefits before projects are (table 3):

Table 3

Paired comparison projects

Criteria	**Pair comparisons**
G_1	essential advantage P_2 over P_3
	weak advantage P_1 over P_3
	weak advantage P_2 over P_1
G_2	there is no advantage P_1 over P_3
	there is no advantage P_2 over P_3
	there is no advantage P_1 over P_3

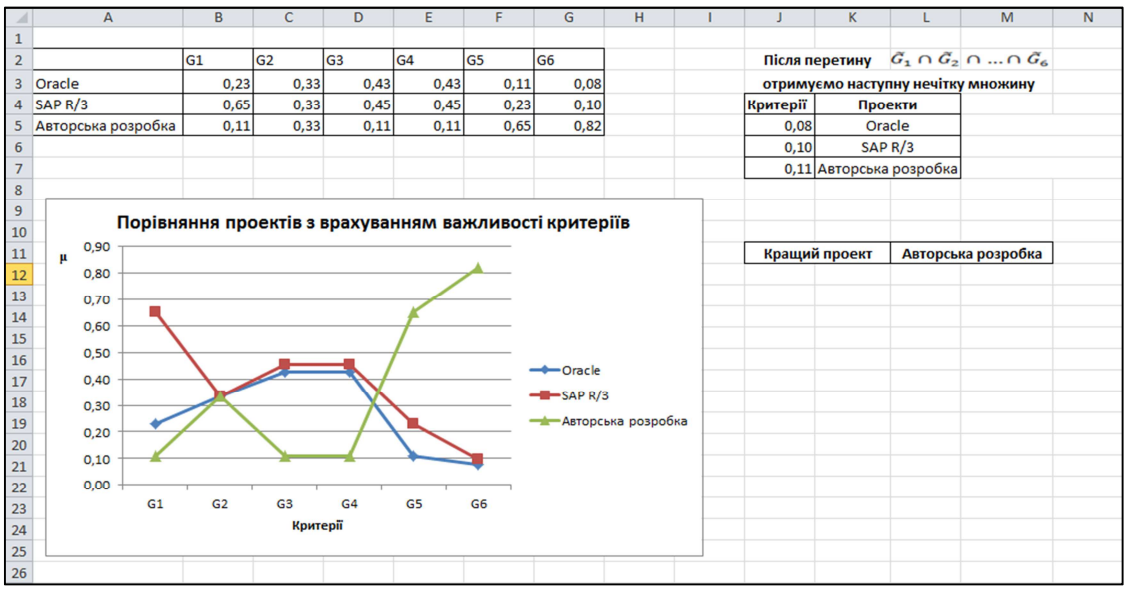

Fig. Optimization of the choice of intelligent information systems

Elaborating the project authoring that based of development GA, are the results of calculations are presented in Fig., namely, the IIS is the best, thanks to the improvement of the criteria of the degree of elaboration of the project and the expected effect.

The economic effect when optimizing the decision-making process. Any information intelligent systems designed to meet any need, get the effect. Use IIS directly affects the economic performance of the user (for example, an automated quality control system significantly reduces losses from defects, resulting in lower costs of production, and thus increase profits). The economic effect is easily valuation and must be calculated under the economic rationale.

These projects make use of the following indicators:

1) Cost of the software (SA) – fixed cost set of programs of the information processing system and software documents required for operation of these programs.

2) Cost of means of computer equipment – fixed cost on office equipment and computer accessories that will satisfy the needs with the introduction of the IIS.

3) Costs of training of the personnel – the success and efficiency of it projects depends on the skill level of the personnel involved in the administration and improvement of IT-systems and the training of end customers, project managers and employees, it is therefore necessary funding for this area, for maximum results.

4) Cost of maintenance is one of the most expensive components, as is the process of ensuring that it works IIS, changes in the detection of errors, adaptation IIS to the new operating environment, as well as increase productivity or improve certain characteristics.

5) Cost of the extension of the project cost which includes expanding the range of tasks and services that are delegated to the remote offices, and further development of the network of these offices.

6) Cost of the communication system – managing information communication in the organization includes actions necessary to ensure timely receipt, collection, dissemination, storage and ultimate disposition of information. It provides a very important link between people to exchange ideas and different kinds of information, which ultimately is necessary for the successful completion of the project. Any person involved within the organization must be ready to send and receive information through the information system through the established channels. Communication management organization should be focused on group interaction in the framework of the management of the organization and includes:

– information of development project information links an organization that is collected, processed and distributed data, including both raw data and those obtained from direct calculations, analytical processing, expert assessments, and others;

– means for processing information, i.e. information technologies based on modern software products;

– communication tools based on modern means of communication, focused on ensuring the timely collection, generation, distribution, storage and transmission of the necessary project information;

– documentation of work – collecting, processing and preservation documentation on the project (table 4).

Table 4

The cost of key indicators

Criteria of an assessment	Oracle, $	SAP R/3, $	Author's development, UAH
Cost of the software	700 000	800 000	200 000
Cost of means of computer equipment	75 000	100 000	100 000
Costs of training of the personnel	2 500	5 000	10 000
cost of support of the software	30 500	50 000	25 000
cost of extension of the project	200 000	350 000	50 000
Cost of communication systems	6 000	10 000	20 000

Each organization determines the level of profitability IIS, and then based on it and on the basis of the amount of development costs to determine the selling price IIS and to offer its cus-

tomers. If the offered price is below average prices for similar programs at other conditions being equal, the customer will prefer to buy IIS from this developer. Therefore more efficient for the customer to choose author's elaboration based on genetic algorithm, and the development of IIS for risk analysis of it projects is suitable for enterprises and small businesses.

Conclusions and recommendations. The implementation of it projects without analysis of alternatives results in an increase of its value, increases the level of possible risks, and the results are far from expected. Errors in risk assessment can lead to incorrect management decisions, it is important to identify and assess all project risks.

In this graduation project achieved the goal: developed IP that improve the quality of decisions on the selection of it projects (in terms of inaccurate and uncertain expert information based on the use of fuzzy linguistic variables) and allows you to take the appropriate and informed decisions using subjective quality expert information provided, including, in the form of interval estimates.

For her achievements have been solved such basic tasks:

– Peculiarities of evaluation projects it projects

– Conducted the selection and assessment criteria assessment of the risk of it projects

– Conducted the selection and sorting of risk it projects

– Feasibility of using the method of fuzzy multi-criteria analysis in choosing the best it project

Using these rules, you can identify ways of improving the efficiency of an it project that will ensure its dominance over the other options.

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