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ALGORITHM OF SOLVING GOAL IN TOURISM FOR HIERARCHICAL MANAGEMENT WITH LIMITED NECESSARY RESOURCES

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Annotation

This paper is concerned to the development of tourism companies, which occurs through their merger and the creation of a complex branched structure. Management should be carried out with a scientific justification of the merger processes. This situation requires the development of new approaches to the management of such companies to build management using digital technologies. Since in recent years, tourism in Kazakhstan has become one of the fastest growing sectors of the economy, and has become more leading, it is necessary to coordinate the actions of the structure on the basis of developed digital methods based on the construction of mathematical management models, which taking into account the various structural components of business processes. Thus, to analyze the state of tourism in Kazakhstan, it is necessary to justify the use of numerical methods and, above all, mathematical approaches to many processes of the tourism business, the algorithm of hierarchical management decisions in the case of limited resources needed for the tourism industry, to give a general description of the content and a formal statement on the allocation of resources.

Key words: tourism industry, hierarchical management, expert system, focal point, tourism, financial condition, user tourist, algorithm

Introduction

The analysis of the activities of travel companies showed that there is a tendency towards their consolidation at present. The main reason consists of a number of economic reasons, with completion between touristic firms, especially local firms. So, it is needs to

make the structure of hierarchical management with account of touristic firms different location and different level, taking into account the detailed development interaction of different touristic units. The enlargement of travel companies occurs through their

merger and the creation of an extensive structure of agent networks, including regional structures, the acquisition and construction of hotels, sanatoriums, tourist centers, the creation of their own car parks, shops, clubs, fitness clubs, etc. In the context of the increasing complexity of the structure of developing companies, it is necessary to scientifically understand the ongoing processes and develop new approaches to managing such companies. It is possible through the development of new digital technologies that will be created using detailed mathematical models based on the developed mathematical description. This will be done in this paper. In recent years, tourism in Kazakhstan has become one of the fastest growing sectors of the economy and has become more leading sector [1]. The analysis of the state of tourism in Kazakhstan is based on the use of numerical methods and, first of all, mathematical approaches to many processes of the tourism business, an algorithm for hierarchical management decisions in the case of limited resources required for tourism production. There is a general description of the content and a formal statement of resource allocation. This article discusses the two types of statements and makes a statement about the type and nature of the dependency required for the following evidence to be used to report. Using the established features and the general model of hierarchical management, the theorem on finding the sum under equilibrium conditions is proved [2]. The direction of resources management is divided into classes, and deterministic tasks are posed with a

known demand, a possible distribution of demand and dependent demand. The possibility of using different models for each class of tasks is analyzed and recommendations for their use are given. Tourism is a socio-economic system, production with links between its components. Thus, the successful functioning of the tourism industry is directly related to the quality of its financial and economic activities. It is important to make real economic decisions based on a comprehensive financial analysis [3]. The importance of financial analysis is increasing due to the availability of demand for indicators of examination results (including, of course, indicators of financial condition), not only by the leadership of the tourism industry, but also by its existing and potential partner tourists, customers, suppliers, etc.) [4]. The analysis of the state of financial security of the tourism industry is a very complex and time-consuming hierarchical process, which can be characterized by two main aspects [5]: select a survey method that meets the needs of a specific tourist user, clarity of the possibility of integrating indicators of the financial condition of a tour operator by a tourist user. The first aspect ensures the completeness and transparency of decisions made as a result of establishing the impact on the assessment of the financial situation in practice [6]. The second aspect is reflected in the user's interpretation of the decisions made. Depending on the way it is presented, the user must be able to use the information according to his needs, and the user's needs should not be limited to the actual capabilities

of production. The issues under

Research methodology

Let us formulate the main problems of managing complex organizational and economic systems in the tourism industry. To implement effective management of large tourism enterprises, it is necessary to use a systematic approach, considering such enterprises as complex systems. At the same time, it is necessary to solve a number of important problems of system analysis: carry out the optimal division of the system into subsystems, choose a method of decomposition management, determine the models of subsystems, develop effective algorithms for solving local problems and build a coordination procedure. Management problems for the objects under consideration are complex and diverse. Let us consider the hierarchy of such tasks in tourism [7]. At the first level of the hierarchy, it is advisable to distinguish four main areas of optimal management in the tourism business, which include tourism business planning, inventory management, mass service and transportation.

Each of the proposed directions consists of global and local tasks. Therefore, at the second level of the hierarchy, we define the classes of tasks for each of the selected areas [8]. The direction of tourism business planning includes the main task of management - the allocation of resources, as well as forecasting the flow of tourists to holiday destinations, including both inbound, domestic and outbound tourism. The direction of resources management can be divided into the following classes: deterministic problems with a known demand, with a probabilistic distribution of demand,

consideration will be comprehensive.

with a dependent demand. For each class of problems, it is necessary to analyze the possibility of using different models and give recommendations for their use [9]. Mass service in the tourism industry has a variety of different forms of implementation. For this reason, several classes of tourist flow management tasks can be distinguished: single-channel service, multichannel service, service tasks with an arbitrary distribution of input flows and flows for service. Transportation of tourists includes two main classes of tasks. The first class includes the determination of the optimal route for the tour being developed. The second class solves the tasks of implementing the optimal transportation of tourists.

At the third level of the hierarchy, the main types of tasks for each class are defined. The fourth level determines the methods for solving the tasks under study. Thus, the proposed hierarchical structure of management tasks determines the algorithm for studying complex systems in the tourism business.

One of the defining sets of issues that are considered at tourism enterprises are the tasks of distributing limited resources between individual subsystems. Here the concept of resources is used in the most general sense and can take various forms, such as financial, material, informational, etc. Recreational resources, which are necessary as a basis for the development of various tourist programs, are of great importance in the development of tourism. The characteristic tasks of using such

resources are the tasks of determining the routes of tourist tours. For the recreational characteristics of a tourist

Main part

The parallel structure of a multi-element system [10] is considered, where each element performs some identical activities. The relationship between these subsystems occurs through a common input parameter $X=(x_1, x_2, \dots, x_n)$, which is a certain resource, and through the output parameters $Y=(y_1, y_2, \dots, y_n)$.

Consider a diagram of one element of such a systems, let the system consist of the i^{th} subsystem. Here x_i is an input variable, a resource that is allocated for processing to the i^{th} subsystem ($i=1, 2, \dots, n$); y_i ; y_i is a product that can be calculated based on the model of the relationship between y_i with x_i ; u_i - some control action that is used to implement economic processes in the subsystem; $y_i = f(x_i, u_i)$ - mathematical model of the i^{th} element. Designating the amount of resources allocated to hierarchical tourism systems through the vector $A=(a_1, a_2, \dots, a_n)$. In general, for such a complex system, there are global constraints in vector form $\sum_{i=1}^n x_i \leq A$,

where n is the total number of subsystems, A is the total resource that needs to be distributed between individual subsystems [11]. The total quantity of the output product can be presented as a sum $Y = \sum_{i=1}^n y_i$. There are various terms for determining the optimization criterion: benefit function, quality criterion, goal function, satisfaction function, and others. We

route, it makes sense to use expert assessment methods.

Mathematically, this planning tasks can be formulated as follows.

will use all these terms, considering them unambiguous.

The general problem of resource allocation can be formulated as follows.

It is required to find such a vector $X^*=(x_1^*, x_2^*, \dots, x_n^*)$ that satisfies the condition $\sum_{i=1}^n x_i \leq A$, under which the goal function reaches its maximum value, that is $\sum_{i=1}^n y_i \Rightarrow \max$, the Managing action u_i ($i=1, \dots, n$) allows the central body to influence subsystem, given its activity. Condition to the state $\sum_{i=1}^n x_i \leq A$,

in the general case is a nonstrict inequality, however, most often in the tasks under consideration, strict equality is satisfied, since if an inequality is specified, then an undesirable remainder of some resource may arise. The tasks set belongs to the class of static optimization nonlinear programming tasks, since it assumes that X and Y either do not depend on time, or are considered at a certain time interval $[0, T]$, where these variables can be considered unchanged.

For organizational and economic systems, various economic categories can act as goals, such as a minimum cost or a maximum income from the sale of products and (or) services. In the tourism industry, target functions can also be the quality indicators of tourist service. We will consider a limited resource as a scalar value, that

is, one specific type of resource, for example, finance, office equipment or specialist managers, etc. In the case when it is necessary to distribute several types of resources, it is required to solve a more complex vector tasks.

In addition to global restrictions, there are restrictions specific to each individual subsystem. They are determined by the availability of their own resources, the peculiarities of technological methods of production, the production conditions of each subsystem, etc. Without specifying local constraints we write them in

$$x = (x_1, x_2, \dots, x_n) \in Q_0 = \{x : \sum x_i \leq A, x_i \in Q_i, i = \overline{1, n}\}$$

In most practical cases, it is not possible to solve the task W directly, since this approach does not take into account the existing management structure and the interests of the subsystems that use the allocated resources in the course of their economic activities [12]. For this reason, the subsystems are not interested in the implementation of the decisions made, and therefore the distribution plan, determined without taking into account the interests of consumers, cannot be implemented in specific conditions. The interest of the subsystems is a reflection of the factor

$$\max_{x_i} f_i(x_i); \quad x_i \in Q_i.$$

Since this task was compiled taking into account only local constraints, it is natural that when resources are scarce, applications can significantly exceed the amount of resources distributed, which is confirmed by our research of resource allocation tasks in ACS at various levels. Now, suppose that the

general form as $x_i \in Q_i \quad i = \overline{1, n}$, where Q_i is an admissible set of local constraints of the i^{th} subsystem.

Thus, the task of allocating limited resources can be formulated as the following mathematical programming task W: to find a resource allocation plan, i.e. a set of vectors x_1, x_2, \dots, x_n , which delivers the maximum of the objective function $G(x_1, x_2, \dots, x_n) = \max$; when fulfilling the conditions

of modern market relations in the production sphere. Let the objective function of the i^{th} subsystem be described by the scalar function $f_i(x_i)$, which we will call the local objective function (LOF). For the distribution task, such an objective function can be, for example, the volume of output, the profit of a subsystem, which depend on the amount of resources received. Then the task of the ACS to determine the demand of the i^{th} subsystem in resources (drawing up) of the application can be represented as the task of maximizing the LOF taking into account local constraints, i.e.

coordinating body (CB) acts on the subsystems in the preparation of applications by introducing additional restrictions for each of them. In other words, the CB informs the i^{th} subsystem some managing parameters $U_i \quad i = \overline{1, n}$ and the subsystem, when drawing up requests for the allocated resource, must take into account not

only local, but also additional constraints determined by the values of the parameters $\{U_{ij}\}$.

Then the task of the i^{th} subsystem can be denoted by $\Lambda_i(U_i)$ and represented as $\max f_i(x_i); x_i \in \bar{Q}_i(U_i)$, where $\bar{Q}_i(U_i)$ is the set of local and additional constraints of the i^{th} subsystem. The managements $\{U_{ij}\}$ set by the CB must correspond to the actual scarcity of resources and the goal that the CB faces in the allocation. Thus, the task of allocating limited resources can be formulated as follows.

The coordinating body must find such values of the managing parameters $\{U_{ij}^*\}$, for which the resource allocation plan determined by the subsystems as a result of solving tasks $\{\Lambda_i(U_{ij})\}$, satisfies the global constraints and maximizes the objective functions, i.e. is a solution to the task W. The solution of the formulated task can be carried out only by organizing multiple exchange of information between subsystems and the central body, as a result of which the resulting distribution plan will correspond to the solutions of local and global tasks. With this approach, the task of allocating limited resources will be solved at two levels of the hierarchy, which reflects the existing management structure that implements the solution of the task under consideration in industry. In this case, the resource allocation plan is determined by the subsystems themselves as a result of solving local tasks and, therefore, will satisfy their interests. The coordinating body develops management actions in accordance with global constraints and the purpose of the distribution.

This approach to solving management tasks is usually called a decentralized or decompositional management method. Note that such a control system is analogous to a feedback control system, in which the variables $\{U_{ij}\}$, act as a control action, and the output variable is a set of vectors x_1, x_2, \dots, x_n . The management object in this system is a set of subsystems, the behavior of which is described by the solution of the set of extreme tasks $\{\Lambda_i(U_{ij})\} i = \overline{1, n}$, and the management body of the CB is the ACS, which implements the solution of the distribution tasks.

Similar analogies can be extended to other concepts that characterize management systems, in particular, the concept of system equilibrium and its stability. However, to explain these concepts in the management systems of industrial complexes, a more precise definition of all components of the task under consideration is necessary, which will be done in the subsequent sections of the work.

Thus, we considered one very common and typical production task and noted the important features associated with its solution in the ACS. These features, first of all, include the existence of global and local tasks, as well as the iterative nature of obtaining the desired solution. As will be shown below, these features are typical for most other management tasks of a complex organizational and economic organizational system of tourism. The tasks of optimal resource allocation, for the solution of which it is advisable to use a hierarchical approach, are encountered in practice quite often. So, in relation to the complex

organizational and economic systems, which are considered in this work, they can be attributed to the main of the typical tasks of the ACS. At the same time, similar tasks are common in other industrial and technological complexes [13]. Such tasks are among the tasks of organizational management of production. However, they are also relevant for the optimal allocation of resources in tourism. In particular, in cases where it is necessary to distribute several types of raw materials or prepack products between the processing and service industries related to the service of the tourist complex. In this sense, it is a

$$X = x_1(m) + x_2(m) + x_3(m)$$

The Yana decomposition method was used to solve the original distribution task. In this case, to solve local tasks, either the golden section method or the scanning method was used. The choice of a specific method is carried out when assessing the type of functional dependence that describes the experimental data for a specific type of cost.

This tactic of solving the cost optimization task allows you to quickly approach the point of global solution compared to simply scanning the entire area of acceptable solutions. It should be noted that in this task one more important task arises, which can be overcome when using decomposition methods - this is the need to look for integer solutions [14]. There is a whole class of integer programming tasks where some, and possibly all, of the variables must be integer. It can be assumed that the integer programming task can be solved without taking into account the integer conditions, and then the resulting solution can be rounded

generalization of the well-known task of load distribution between parallel operating units. To solve the task of resource allocation using a hierarchical approach, experimental studies were carried out using the example of the task of optimal cost allocation. In the general case, experimental data on the distribution of costs of three types (x_i) by months are given. It is required to find the minimum total costs (X) and the corresponding value of the argument (m) with the condition that the total costs are a scalar quantity, i.e. they can only be calculated as an algebraic sum of the individual cost elements

with excess or deficiency. This results in some integer solution. However, using this approach requires checking the acceptability of the obtained solution. In practice, we can conclude that this method can be used when the values of the variables are so large that round-off errors can be neglected. However, when solving tasks in which integer variables take small values, rounding can lead to an integer solution that is far from the true optimum. In addition, when solving tasks of large dimensions, this method requires too much computer time. For example, if the optimal solution to a low-dimensional task (for two variables) has the form $x_1 = 3, 4; x_2 = 4, 5$, then to obtain an approximate optimal integer solution, it is necessary to consider four options (3; 4), (3; 5), (4; 4), (4; 5) and choose among them an acceptable point with the best value of the target functions.

It should be noted that if the task has 10 integer variables, then it is necessary to consider $2^{10} = 1024$

solution options, but even considering all options does not guarantee an optimal integer solution to the task. In some cases, the value of one of the variables may differ by more than one in one direction or the other, while the value of the other variable may differ by the same number in the opposite direction. The branch-and-bound method is widely used to solve integer programming tasks in most commercial programs. The method is essentially an efficient enumeration procedure for all feasible integer solutions. Thus, if we solve this task using a general approach for solving integer programming tasks, it is necessary to enumerate many options, while obtaining an exact and unique solution is not guaranteed.

The program for choosing the optimal distribution developed on the basis of the above algorithms consists of two modules. The first is the implementation of the method of quadratic approximation and serves to solve local tasks. It includes a block for checking the set of feasible solutions to tasks and a block for evaluating the search efficiency. The second module is designed to solve a global task, the coordination parameters are changed taking into account the set of admissible management. The stopping conditions in this program are the receipt of such a value of the global criterion that cannot be improved in three subsequent iterations.

Based on the results of a series of calculations using the developed program, it can be concluded that the method of solving the task of optimal distribution using decomposition allows obtaining a stable solution. The decomposition of the cost allocation task allows, when solving local tasks,

not to take into account the integer condition of variables, and at the last stage, with the already found global optimum, to carry out the rounding operation. Such a procedure greatly simplifies the general solution, and a computational experiment has shown that in this case a stable global solution is guaranteed.

The simplest case of scalar problems arises when the functions $y_i = f(x_i)$, $i = 1, 2, \dots, n$, are linear functions. For the case when resource X is a scalar value, this task has an elementary solution, which can be described by a simple algorithm:

1. a subsystem is found in which the output is maximal at given values of X,
2. the next subsystem is selected for which the output from the remaining subsystems is maximal,
3. the next subsystem is selected according to the same rules, etc.

The choice is made until the worst subsystem in the sense of the chosen criterion remains. In this case, the condition is checked at each step. This task can be written in terms of linear programming as follows. It is required to find non-negative values of the variables x_1, x_2, \dots, x_n , which optimize the objective functions $y_i = f_i(x_i)$. In this case, the restrictions on the resources used must be met. Consider an algorithm for allocating resources between parallel subsystems with linear objective functions. Let $f_i(x_i) = a_i x_i + b_i$, $i = 1, 2, \dots, n$, and the general optimization criterion is an additive separable function. Then the task is to determine the maximum of the global linear objective function

$$F(X^0) = \max \left(\sum_{i=1}^n a_i x_i + \sum_{i=1}^n b_i \right), \text{ when resource}$$

constraints are fulfilled $\sum_{i=1}^n x_i - X^0 = 0$ and technological constraints $x_{imin} \leq x_i \leq x_{imax}$ или $x_{imi} - x_i \leq 0, x_i - x_{imax} \leq 0$. This task can be solved by linear programming methods. However, Minsker's book proposes a simpler algorithm that takes

$$x_1 = x_{1min}, \quad x_2 = x_{2min, \dots}, \quad x_{i-1} = x_{(i-1)min},$$

$$x_i = X^0 - \sum_{j=1}^{i-1} x_{jmin} - \sum_{j=i+1}^n x_{jmax}, \quad x_{i+1} = x_{(i+1)max}, \dots, x_n = x_{nmax} \quad (1)$$

Moreover, the fulfillment of the optimality condition is obvious. It can be shown that this distribution is optimal. Let $k > i$ and $l < i$. Let us transfer a part of the resource Δx from the k^{th} subsystem to the l^{th} subsystem. This will change the global objective function $\Delta F(\Delta x) = (a_l - a_k) \Delta x$. Since $a_l < a_k$, the criterion value will decrease, i.e. distribution is optimal. The algorithm for optimal resource allocation can be represented as follows:

1. Distribute resources between subsystems as much as possible, that is, put $x_i = x_{imax}$ and check the condition.

2. Reduce the amount of resources for the first subsystem until the condition of optimal distribution is fulfilled. Then either the condition $x_{1min} \leq x_1 \leq x_{1max}$ is satisfied or the condition $x_{1min} - x_1 \leq 0$ is violated. We accept $x_1^0 = x_{1min}$, then the optimality condition is not yet satisfied.

3. Reduce the amount of resources for the second subsystem according to the rule described in paragraph 2, etc.

More complex tasks of mathematical modeling, when mathematical models are nonlinear functions. If at least one of the

into account the specifics of the task. To do this, we assign numbers to the subsystems in ascending order of the coefficients $a_1 \leq a_2 \leq a_3 \dots \leq a_n$ and distribute the resources as follows:

functions $y_i = f(x_i), \quad i = 1, 2, \dots, n$, describing the object, is nonlinear, then we have a nonlinear programming task. To solve such problems, both analytical methods, such as the method of indefinite Lagrange multipliers, and various numerical methods can be used. These circumstances make it actual to create a system of complete and reliable financial analysis based on economic and mathematical methods that comprehensively assess the financial condition of production. At the same time, important concepts need to be introduced that describe the principles of hierarchical management.

The aim of the work is to create an expert system based on a hierarchical model for managing the financial analysis of tourism production, based on economic and mathematical methods. It provides a comprehensive test and assessment of the main aspects of the financial performance of the tourism industry.

To achieve this goal, it is necessary to solve the following theoretical and practical issues in the work:

- analysis of generally accepted methods for assessing the financial condition of the tourism industry;

- justify the need for methods that analyze the financial condition of the tourism industry and provide comprehensive solutions that can meet the needs of the main types of users;
- selection of indicators of the financial state of tourism production and determination of methods for their assessment;
- justification of the need to use an expert system for a qualitative assessment of the financial condition of the tourism industry;
- analysis of methods for filling in undefined areas of the database used in the analysis of the financial condition of the tourism industry;
- development of conceptual and mathematical models for the analysis of the financial condition of the tourism industry;
- development of methods for presenting expert decisions at different levels of analysis of the financial condition of the tourism industry;
- development of algorithms for combining solutions obtained at different levels of the hierarchy, and creating a database;
- creation of a hierarchical architecture of an expert system for analyzing the financial condition of the tourism industry and assessing its effectiveness.

In this regard, let us analyze the hierarchical management models considered in the financial analysis of tourism production [7], using the example of the distribution of raw materials and substances that require additional production costs in the case of limited resources for a particular direction of tourism production.

$$z(p, s) = \left\{ x : x_i^* = \text{Arg max } f_i(x_i(p, s)), \sum_{j=1}^m p_j x_{ij}^* \leq s_i, x_i^* \in Q_i \quad i = 1, \dots, n \right\}$$

Considering the important concepts that characterize the principles of hierarchical control [8], we will consider the basic rules and algorithms of hierarchical control associated with decision and equality in hierarchical systems.

Introducing functional notation, $f_i(x_i) i=1, \dots, n$ we draw the following conclusions about the objective functions and the set of necessary solutions:

- each system component of the hierarchical structure corresponds to only one circular objective function $f_i(x_i) i=1, \dots, n$, constant function;

- the objective function $f_i(x_i) i=1, \dots, n$ is continuous on intervals, and its graph R_+^m is bent upward;

- if $x \succ y, x, y \in X$, then $f_i(x) \succ f_i(y) i=1, \dots, n$.

- necessary finance in the interval $Q_i, i=1, \dots, n$, the technological set in R^m is a closed set with a zero element.

If $x_i^* \in Q_i i=1, \dots, n$, are the selected elements of the calculation of the required turnover $u = \{p, s\}$ for the provision and management of tourism production [9], which satisfies the allocated budget limit, then let us consider the function $z(p, s)$, which characterizes the relationship with this set [10].

This function is called the demand function $z(p, s)$ and is used to describe the specifics of each component of the system and the consumer association in a hierarchical structure. It is also determined by the following formula:

Next, let's focus on describing and exploring the resource allocation model used in relation to the branched hierarchical management process.

Suppose we find a set of vectors describing the equilibrium state of the system $p^*, y_1^*, y_2^*, \dots, y_n^*$ that determines the quantitative production plan for tourism production Λ_0 , which is a solution to the problem that

$$\Phi_1(y_1, y_2, \dots, y_n) = \sum_{i=1}^n f_i(y_i) \rightarrow \max_y \quad (2)$$

$$y = (y_1, y_2, \dots, y_n) \in G_0 = \left\{ y : \sum_{i=1}^n h_i(y_i) \leq A, \quad y \in G = G_1 \cdot \dots \cdot G_n \right\} \quad (3)$$

Where the quantitative price vector p^* is the Lagrange multiplier.

$$\sum_{i=1}^n h_i(y_i) \leq A \text{ solution } \Lambda_0.$$

Hereinafter, we call the function $F(y_1, y_2, \dots, y_n)$, the equality objective function (EOF).

Let us consider the problem $\Lambda_i(p^*)$. According to the definition of the equilibrium problem y_i^* is the solution to this problem, we write the following concept:

$$f_i(y_i^*) - (p^*, h_i(y_i^*)) \succ f_i(y_i) - (p^*, h_i(y_i)) \quad (4)$$

For all types in $y_i \in G_i$ taking into account (3), (4) inequalities, adding according to i and taking into account that on the right and on the left (p^*, A) , we obtain:

$$\sum_{i=1}^n f_i(y_i^*) - (p^*, \sum_{i=1}^n h_i(y_i^*) - A) \geq \sum_{i=1}^n f_i(y_i) - (p^*, \sum_{i=1}^n h_i(y_i) - A) \quad (5)$$

According to the definition of equality $y^* = (y_1^*, y_2^*, \dots, y_n^*) \in G_0$, since it can be written like this: $\sum_{i=1}^n h_i(y_i^*) - A \leq 0$. We obtain these inequalities by multiplying each positive vector $p > 0$ by: $(p, \sum_{i=1}^n h_i(y_i^*) - A) \leq 0$.

At the same time, according to the definition of equality $(p^*, \sum_{i=1}^n h_i(y_i^*) - A) = 0$ equality must be performed. Then one more part can be added to inequality (5) and it can be written as:

$$\begin{aligned} \sum_{i=1}^n f_i(y_i^*) - (p, \sum_{i=1}^n h_i(y_i^*) - A) &\geq \sum_{i=1}^n f_i(y_i^*) - (p^*, \sum_{i=1}^n h_i(y_i^*) - A) \geq \\ &\geq \sum_{i=1}^n f_i(y_i) - (p^*, \sum_{i=1}^n h_i(y_i) - A) \end{aligned} \quad (6)$$

for all $y \in G_0$ sets. Thus, inequality (6) $\{p^*, y^*\}$ shows that the set of vectors Λ_0 , the problem is a saddle point of the Lagrange function, which indicates that y^* is a solution to the problem based on the algorithm for

solving the Lagrange problem. This relationship between balance and efficiency leads to the following conclusions. If the task of the Coordination Center (CC), which manages the optimal functioning of the

hierarchical management system, is to determine the production plan that will increase the income of the system, then the CC can do this in a distributed manner. Management with such an effective plan is determined by actions within the upper hierarchy, while the CC can perform management functions by changing the cost of resources allocated as a result of interactive communication with parts of the system or groups at the lower level of the hierarchy, or by changing resource allocation tactics. It should be borne in mind that such a product release plan and effective coordination of production is beneficial not only for the CC, but also for each department, which is part of the entire system and creates the structure of this system. Thus, each system operates on the basis of the instructions of the focal point, which directs the optimal functioning

Discussion of the received data

An algorithm for seeking equality of interests, which is interesting from the point of view of economic content, is considered in [18]. This algorithm is conventionally called "auction".

Its essence is that CC voluntarily allocates resources within the system to implement a global limit. The task of the system participants is to determine a production plan that will increase the income of those in the system, taking into account the allocated funds. Conventionally for the i -th system, the following can be determined:

$$f_i(y_i) \rightarrow \max_{y_i}, y_i \in G_i,$$

$$h_i(y_i) \leq x_i,$$

where x_i is the number of identified resources in the i^{th} system.

of the hierarchical control system and seeks to implement it.

We have developed algorithms presented in models [15], which allow us to implement in practice the method of optimal distribution of hierarchical control systems [16]. It is shown that if Λ_0 is in the solution of a problem of mathematical orientation, then two different solution methods can be used to search for equality [11], the essence of which is that the price vector p is looking for its objective function, therefore the maximum EOF is optimal only for hierarchical control that manages the creation of the fund will only be realized during environmental restrictions are implemented, without global restrictions on the funds distributed. CC also checks compliance with global restrictions and varies according to the difference between price, demand and offer $\sum_{i=1}^n h_i(y_i) - A$.

Each system y_i , finds the effective release plan, and α_i , determines the level of centralized resource deficit, which is defined as the Lagrange multiplier for the limit $h_i(y_i) = x_i$. The reason this method is called an auction is because the vectors of the variable α_i , can be viewed as the price paid for resources in the i -th system. CC distributes resources taking into account $\alpha_i, i=1, 2, \dots, n$ vectors. Here part of the j^{th} resource k is given from the system α_{kj} at a low-level 1 inside the system is large α_{lj} . As a result, α_i , the values of the vectors $i=1, 2, \dots, n$ becomes equal. The distribution [19] can be expressed as follows. Here the intrasystem values

$\{\alpha_{ij}\}$ are equal and equal to the value

Conclusion

Thus, the described model meets the requirements of specific economic decisions on the basis of a qualitative assessment of financial and economic activities and a comprehensive financial expertise. The allocation of resources for hierarchical management in the model takes into account the requirements of the system, and secondly, the decentralized management method allows minimizing the amount of information entering the CC from the system and from the CC to the system [20].

The results of the analysis of generalized models and methods of hierarchical management allow us to formulate the following main conclusions [21]:

- when applying the methods of hierarchical control during allocation of resources, the solution of the problem is close to finding the equilibrium state of the system, in which a balanced distribution can also be effective for the CC system;

-equilibrium distribution is the effective point, and the maximum of

defined above.

the type of the global goal function $F(f_1(x_1), f_2(x_2), \dots, f_n(x_n))$ must reach the effective point in the admissible set Q_0 .

Here, for each effective point, one can find the vector $\mu=(\mu_1, \mu_2, \dots, \mu_n)$, $\mu_i \geq 0$, $i=1, \dots, n$, thus maximum of $\sum_{i=1}^n \mu_i f_i(x_i)$ function lies on all $x \in Q_0$ effective set point or

$$F = \sum_{i=1}^n \mu_i f_i(x_i) \quad \mu_i \geq 0 \quad i = 1, \dots, n,$$

where, μ_i , $i=1, 2, \dots, n$ are selection coefficients defined in CC for each system [22].

If we consider the problem of resource allocation within the system as a multicriteria problem, which is considered as a set of criteria, then this expression is the convolution of the component objective functions and it is accumulation of the vector efficiency problem to the scalar efficiency problem [23]. Here the main objective function in the form of an additive function is not the only possible type, but one of the most convenient, satisfying all the requirements [24].

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ALGORITHM OF SOLVING GOAL IN TOURISM FOR HIERARCHICAL MANAGEMENT WITH LIMITED NECESSARY RESOURCES

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Summery

This investigation was conducted according to the analysis of the activities of tourist companies in Kazakhstan and the identification of many economic reasons that create the foundation of the formation in the tourism industry. This paper was based on the construction of a mathematical description of the market of tourist services, in the conditions of competition between firms. It is shown that the analysis of the state of tourism is based on the application of numerical methods and, above all, mathematical approaches to many processes of the tourism business, the algorithm of hierarchical management decisions in the case of limited resources required for tourism production. There is a general description of the content and a formal statement about the allocation of resources. This article discussed the two types of claims and made a statement about the type and nature of the dependency, required for the following evidence, which were used to compile the report. Using the established features and the general model of hierarchical control, the theorem on finding the sum in equilibrium conditions is proved. Since the direction of inventory management was divided into classes, and deterministic tasks were set with a known demand, the possibility were shown of demand distribution and the functional dependence of demand. The possibility was given of using different models for each class. The tasks for different class was analyzed and recommendations for their use. The results obtained can be applied to the creation of digital technologies based on the Trace mode software and applications, for example, Low-code.

Key words: tourism industry, hierarchical management, expert system, focal point, tourism, financial condition, user tourist, algorithm

ТУРИЗМГЕ ҚАЖЕТТІ ШЕКТЕУЛІ РЕСУРСТАРДЫҢ ИЕРАРХАРЛЫҚ БАСҚАРУ АЛГОРИТМІ

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Түйін

Бұл зерттеу Қазақстандағы туристік фирмалардың қызметін талдау және туристік индустрияның қалыптасуына әсер ететін көптеген экономикалық себептерді, фирмалар арасындағы бәсекелестікті анықтау бойынша, туристік қызметтер нарығының математикалық сипаттамасын құруға негізделген.

Туристік өндіріс үшін қажетті ресурстар шектеулі болған жағдайда иерархиялық басқару шешімдерінің алгоритмі көрсетілген. Туризм жағдайын сандық әдістерді қолдана отырып, туристік бизнестің көптеген процестерін математикалық тәсілдер негізінде талдау мүмкіндігі көрсетілген.

Шектелген жағдайдағы ресурстарды бөлудің жалпы сипаттамасы және ресми мәлімдемесі келтірілген. Екі түрлі жағдай қарастырылып, есеп қойылымындағы дәлелдемелерді қолдану үшін қажет тәуелділіктің түрі мен сипаты туралы мәлімдеме жасалады. Белгіленген ерекшеліктер мен иерархиялық басқарудың жалпы моделін пайдаланып, тепе-теңдік жағдайындағы теорема дәлелденді.

Тауарлы-материалдық қорларды басқару бағыты сыныптарға бөлінгендіктен және белгілі сұраныспен детерминирленген мәселелер қойылатындықтан, сұранысты бөлу мүмкіндігі мен сұраныстың функционалды тәуелділігі көрсетілген. Проблемалардың әр класы үшін әр түрлі модельдерді қолдану мүмкіндігі талданып, оларды қолдануға ұсыныстар берілген. Алынған нәтижелерді Trace Mode режиміндегі бағдарламалық жасақтама мен қосымшалар негізінде, мысалы, Low-code негізінде цифрлық технологияларды құру үшін пайдалануға болатындығы қарастырылған.

Кілтті сөздер: туризм өндірісі, иерархиялық басқару, эксперттік жүйе, координация орталығы, туризм, қаржылық жағдай, қолданушы турист, алгоритм

АЛГОРИТМ РЕШЕНИЯ ЗАДАЧИ В ТУРИЗМЕ ДЛЯ ИЕРАРХАРИЧЕСКОГО УПРАВЛЕНИЯ С ОГРАНИЧЕННЫМИ НЕОБХОДИМЫМИ РЕСУРСАМИ

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Резюме

Согласно проведенному анализу деятельности туристских фирм Казахстана и выявлению множества экономических причин, влияющих на формирование туристической индустрии, было проведено данное исследование, базирующееся на построении математического описания рынка туристских услуг, в условиях конкуренция между фирмами. Показана возможность анализ состояния туризма на применении численных методов и, прежде всего, математических подходов ко многим процессам туристического бизнеса, алгоритма иерархических управленческих решений в случае ограниченных ресурсов, необходимых для туристического производства. Есть общее описание содержания и формальное заявление о распределении ресурсов. В этой статье обсуждаются два типа утверждений и делается заявление о типе и характере зависимости, необходимой для следующих доказательств, которые используются для составления отчета. С использованием установленных признаков и общей модели иерархического управления доказывается теорема о нахождении суммы в условиях равновесия. Так как направление управления запасами делится на классы, и детерминированные задачи ставятся с известным спросом, показана возможность распределения спроса и функциональная зависимость спроса. Проанализирована возможность использования разных моделей для каждого класса задач и даны рекомендации по их использованию. Полученные результаты могут применены при создании цифровых технологий на основе программного обеспечения Trace mode и приложений, например, на основе Low-code.

Ключевые слова: индустрия туризма, иерархическое управление, экспертная система, координационный центр, туризм, финансовая состояние, турист пользователь, алгоритм