# Analytical Network Process for the On-line Dispatching

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***Abstract*-Analytical network process (ANP) is usually used for solving the complex multifactor problems when search for the rational decisions is made in stationary operating conditions with a large resource of time. In this paper, we propose the idea of development the ANP as applied to operational dispatching. The developed method is based on reducing the amount of information that is introduced into the decision support system via man-machine dialogue in the real time. Much of the data on the state of infrastructure and its adjustments comes from neighboring information systems. These data are used to specify the weights of the links between the elements presented in the ANP-model of the object. This algorithm simplifies the process of filling the estimated supermatrix and saves a lot of time. Also, simplified variants of interface are proposed to serve the operative data entering through the dialogue of operator with the DSS. The paper provides an example of applying the modified ANP in solving the problem of railway traffic dispatching.**

***Keywords-Intelligent transport system; real-time management; railway dispatching; decision making; analytical network process (ANP)***

## I. INTRODUCTION

Decision making to overcome the complicated nonstandard situation is interrelated with processing a large amount of information. The expert analysis of an object or a process in its development is usually carried out over rather a long period of time. A lot of documentary sources and opinions of various experts are referred to, when analyzing the object. There are a number of effective methods to solve the specified problems, which are based on the use of special evaluating scales or the pairwise comparisons. The Analytical Hierarchy Process (AHP) and the Analytical Network Process (ANP) are the most often used expert methods [1].

In many operational cases there is a problem of solving a difficult situation when little time is allocated to find a rational solution. Many problems of operational management of such large systems as railways or power system relate to the tasks of this kind. Nonstandard situations regularly arise in these systems and there are no ready-made algorithms to find a way out. In these cases a large effect is obtained by using methods of expert assessments mentioned above. The expert analysis methods can be effectively applied in solving the railway traffic dispatching problems. Their properties make it possible to obtain a compromise solution when there is a conflict among managers of the control center [2].

Section 2 of this paper provides an overview of the well-known publications on the problem of expert analysis, which allows solving complex multifactor problems. Section 3 considers the emerging problems of railway dispatching. Section 4 offers a modified ANP method in application to the task of operative dispatching. It also presents the idea of forming such an interface which would significantly simplify the process of estimating the factors in the phase of information input into the Decision Support System (DSS). Section 5 sets out the conclusions and directions for further research.

## II. OVERVIEW OF THE RELATED LITERATURE

At present there are a number of methods in decision theory, which make it possible to analyze the multifactorial problems. Based on these methods, the algorithms produce decomposition of the object into its elements through the pairwise comparisons; next, a calculation of the matrix which includes the weights of these elements. Most of the works that develop these expert methods consider only the algorithm for calculating the priority vector [3]. Other works improve the technique for handling the input (primary) data while retaining the scaling mechanism [4]. Most of the publications are devoted to the use of classical techniques AHP / ANP in solving practical problems [5][6]. These techniques are also implemented in the decision support systems: Technique of Order Preference by Similarity to Ideal Solution (TOPSIS), Cognitive Hierarchy Process (CHP), Fuzzy Cognitive Hierarchy Process (FCHP) [7]-[9], and others. We are not aware of familiar with any studies, which would formulate and solve the problem of sharing algorithms that improve the data entry and processing in the expert determination of the optimal solutions.

Many researchers work at the real-time technical conflict resolution problem in a railway [10]. Most of them use determinate modeling of the railway traffic. This approach allows accurate predicting the future evolution of the traffic on the basis of the actual train positions and speeds, as well as the signaling and safety system constraints. Assessing the possibility of using the algorithm of expert evaluations in

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the process of object management in real time, Kabir et al. [4] have the opinion that it is impossible to solve the multifactor problem in a few short steps, as this will result in unacceptable inaccuracy. In our present paper we attempt to overcome this difficulty by means of using a priori information which comes through auxiliary channels. Besides, we try to create a rational construction of exchanging data between the operator and the DSS. Our goal is to create the DSS that allows dispatcher to get the intellectual and quick help in difficult cases of the railway traffic control, i.e., to obtain the solution of multifactor problem as soon as possible (within a few minutes).

## III. ANP-MODEL FOR THE RAILWAY DISPATCHING

Selection of the decision on trains flow management is a typical problem of the railway dispatching. This is often a difficult task since we must take the priorities of the trains, the wagons, the work time of locomotive crews and a lot of other factors into account. Such difficult tasks are the typical multifactor scheduling problems.

Technical, commercial and organizational factors are taken into account in the decision-making process for the rational traffic management of trains. In addition, issues of providing the train traffic safety are constantly in sight of the manager. There are deviations from the normal operation that regularly occur on the railroad. These deviations often have a unique character because every time their reason is a peculiar combination of different factors. In many cases, simulation model is a poor description of the work of the railway section, as the relevant information about the process may be absent or tardy. In this case, operating decisions are made by the dispatcher. Intelligent DSS gives the opportunity to build an integrated dynamic model of the process by combining the actual data, which come on-line from the rail section, and the information that is entered by the operator. It is possible to use an efficient algorithm to determine the adjustments' priorities vector, based on the expert ANP-analysis.

ANP-model contains a number of technical clusters that correspond to the work of the stations, the train locomotives and the service divisions: power, signaling, communications and others. The separate cluster reflects the commercial weights of trains. The chief dispatcher of a railway line estimates the size of arcs which are directed to elements of this segment. Duty managers, who control the sets of locomotives, cars and other equipment, determine the intensity of the links between other specialized elements of the model. The common work of managers and the DSS is made in a dialogue mode that gives synergistic effect when determining the management decisions.

## IV. MODIFIED ANP-MODEL AND RATIONAL MAN-MACHINE INTERFACE

ANP-model is created by decomposition of the goals, the function conditions of the system and the results of the process execution. The elements of a decomposed problem are grouped into the clusters, each of which reflects one of the components of the large structural elements of the object under analysis. The elements are connected by the links, and movement along the links leads, ultimately, to the final alternative solutions (see Figure 1). Each dispatcher assesses the elements which relate to his duties.

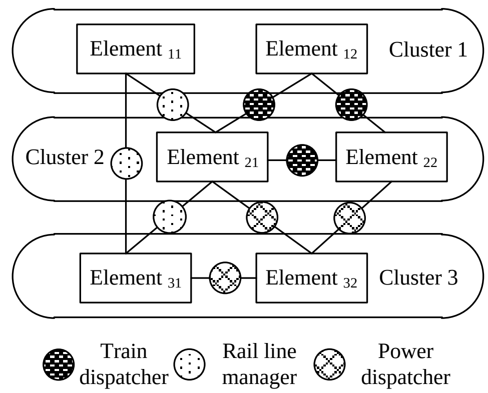


Figure 1. Fragment of network model

The corresponding weight of each of the final decision is formed on the basis of transition matrix, which is called the supermatrix in the ANP-approach. Controller of the certain object (we call him the rail line manager) introduces the values of DSS components, i.e., intensity of the links, which reflect the assessment of the importance of each of the factors. Herewith, he is using a certain estimating scale, mostly - from 1 to 9.

The process of scaling becomes very consuming in the case of multifactor model and the presence of cross-links between the elements. The expert makes his judgments and enters the relevant data into the DSS by using a technique of pairwise comparisons. When solving the multifactor problem, this process becomes very time-consuming and laborious. Similar problems can go quickly in the work of the manager, one after another, which leads to a significant increase of the facts and paired comparisons together with psychological strain. In the present research we propose to reduce the number of operations that are performed by the dispatcher in the estimation process in on-line mode. These reductions are made in the following way.

At the first stage, the dispatcher selects the type and location of the scenario which is considered in determining a specific decision, e.g., appointing the locality and time of the implementation of the adjustment and its type. This selection is reflected in the fact that the process model is simplified. Simplification is due to the fact that some of the

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elements are excluded by the dispatcher from the model as well as their respective links. These excluded elements have little influence on the result of the adjustment in this particular situation.

The second stage is represented by two sub-stages. In one of them part of the data, relating to commercial priorities, is entered by the rail line manager, who is responsible for this range of issues. Information that reflects the state of the infrastructure is introduced by the dispatchers of the relevant services: locomotives, power supply and others (fatty links). Considering the fragment of the model it is evident that the number of links (dotted links) that require estimation by the dispatcher is significantly reduced (see Figure 2).

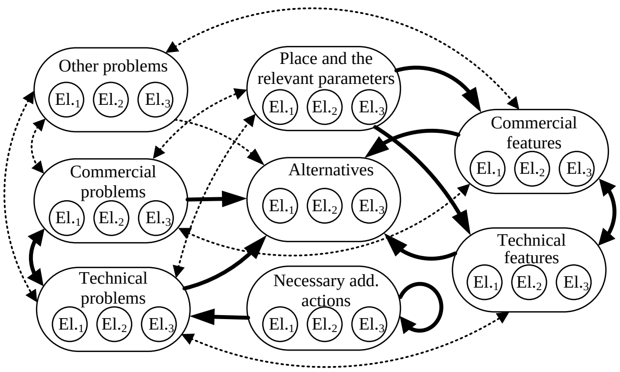


Figure 2. ANP network with some a priori and a posteriori cluster links

The volume of work that is performed in this second sub-step, is significantly reduced. This will ensure the achievement of the goal, namely, relieving the rail line manager from the large volume of non profile work. This allows him to focus on finding the most rational solution, which leads to conflict prevention or mitigation of its consequences.

The numerical estimation of intensity in each of the factors is used in the classical scheme of expert analysis. Furthermore, the operator has difficulty in establishing the consistency between different acts of pairwise comparisons. In the on-line method, which is proposed in this paper, non-standard ways of presenting the operator's judgments are used.

One way assumes that operator selects a point in the area which is bounded by the axes of intensity relationships between elements using an interactive pen (see Figure 3). This example shows the pairwise comparison of elements from the estimation position based by two criteria. Intensity axes are the criteria for comparing the elements (e.g., technical and economic criteria). Curved lines show the mutually beneficial nature of the interaction of the criteria by which the operator compares elements.

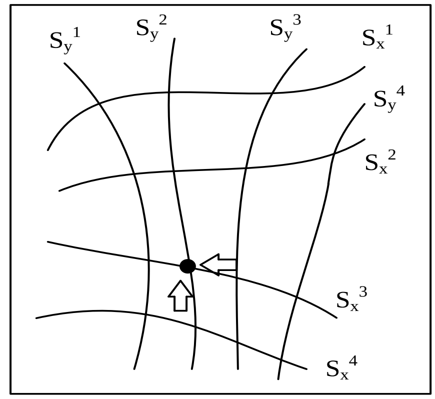


Figure 3. Existence domain of particular solution

The intensity value of the corresponding connection between a pair of elements is plotted on each axis. When the rail line manager compares the elements, he marks the point with these coordinates, which corresponds to his intuitive understanding of the features intensity. The second way is that a bar graph should be displayed on the screen for the use by the manager. A specific zone in the diagram is given for the each link (Figure 4).

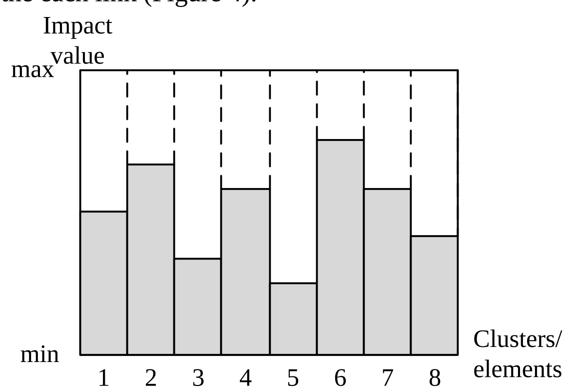


Figure 4. Mechanism of interlocking ratings

When making judgments on the intensity of features, the dispatcher makes mark in the certain areas corresponding to each connection between elements. This enables the manager to clearly see the ratio of their intensities, which speeds up the process of the data entering. Using these methods allows a person who makes the judgments, to connect the image thinking and, thus, simplify and accelerate the dialogue with the DSS.

## V. CONCLUSION AND FUTURE RESEARCH

The article describes the ANP-model which is designed for the determination of rational solutions in terms of lack of time. The decision making process is accelerated due to obtaining estimates from adjacent experts and their use in a single supermatrix. Furthermore, the volume of the

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processed information is reduced due to the fact that the dispatcher indicates the type of scenario and other information that reduces the dimensionality of the model. The paper also offers a convenient interface that simplifies the process of making dispatcher judgments.

In the future, we are planning to show how to solve the particular problems of railroad dispatching using the new ANP model. Development of the ideas in this work is expected in the direction of collective decision-making in conditions that require a compromise.

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