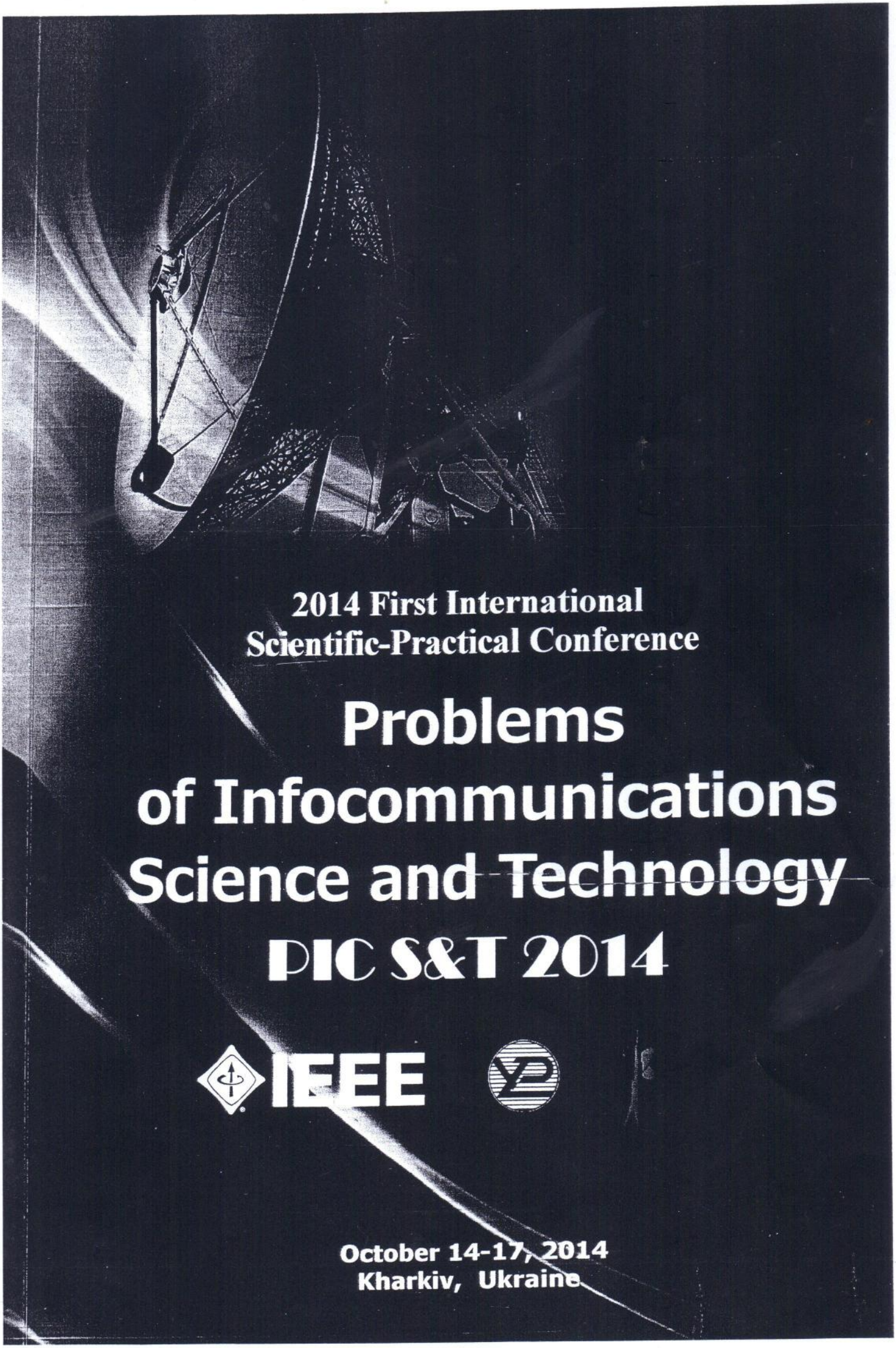

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Choice of Preferred Telecommunications Means on the Basis of the Hierarchy Analysis Method

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Abstract – **Telecommunication means (devices, technologies, etc.) are important components of modern ICT. In their design requirements appear contradictory set of strict accounting quality scores. This determines the need for multi-criteria optimization methods in selecting optimal design solutions from the set of admissible. Problem solving multiobjective optimization is to find, in general, rather than one of a set of Pareto-optimal solutions, which can be used in the design. Often for further stages of creating infocomm it is needed to select only a project option of telecommunications. The report proposes to select a single project option of telecommunication means using hierarchy analysis method (MAH).**

Keywords – optimization, hierarchy analysis method, telecommunication means.

I. Introduction

When designing the optimal means of telecommunication with the given set of quality scores initially formed a subset of the Pareto-optimal design choices. Then it is necessary to select a single preferred option for subsequent phases of the design [1]. This may be applied to various methods based on the use of additional information from an expert. One of these methods is the hierarchy analysis method (MAH) [2]. This method is to decompose the problem of selecting a preferred embodiment of a system design into simple component parts and obtaining expert judgment for paired comparisons of various elements of the problem of choosing the design version of the system. Treatment of the resulting matrix of pairwise comparisons uses some mathematical procedures, a vector of global priorities. The maximum value of the component of this vector is determined by the preferred embodiment of the designed system.

The report deals with the theoretical and practical aspects of application of the hierarchy analysis method to select the preferred project option based on aggregate indicators of quality for different means of telecommunications. Examples of tasks comparative analysis and selection of a preferred embodiment, in particular, different variants of a mobile communication network of the 3rd generation, as well as for different wireless access technologies in a mobile communication network 4 th generation.

II. Some Features of the Hierarchy Analysis Method in the Selection of a Project Option of Telecommunications Means

Decomposition principle involves structuring the problem of choice in the form of a hierarchy of levels, which is the first step in the application of the MAH (Figure 1).

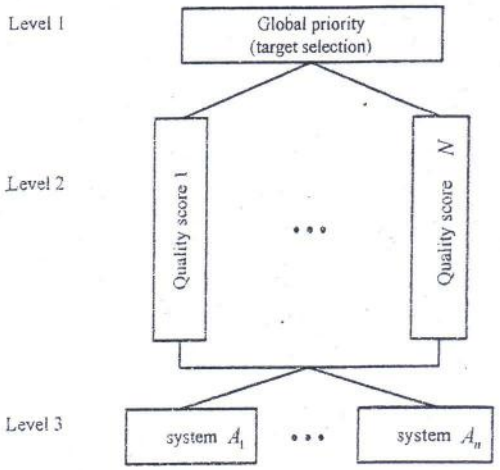

Fig. 1. Decomposition of the problem of choosing a hierarchy of levels

Hierarchy problem of choice is built from the top (target selection) through intermediate levels (indicators of the quality of the system) to the lowest level (alternative construction of the system).

The principle of comparative judgments of experts in the MAH is that the problem of selecting the objects are compared pairwise experts in importance. Pairwise compared the importance of the different versions of systems (Level 3) and different quality parameters (level 2). The results of pairwise comparisons are to the matrix form (Figure 2).

$$\begin{pmatrix} a_{11}a_{12}...a_{1j} \\ a_{21}a_{22}...a_{2j} \\ ... \\ a_{i1}a_{i2}...a_{ij} \end{pmatrix}.$$

Fig. 2. Matrix of pairwise comparisons elements of the problem of choice

Estimates of pairwise comparisons of elements a_{ij} are using subjective judgments of experts, which is numerically defined on the scale of the relative importance of the elements. Next performs some processing of paired comparisons matrix elements hierarchies levels 2 and 3 From the mathematical point of view, these processing tasks can be reduced to the calculation of the principal eigenvector, which after a certain normalization becomes a priority vector elements at the appropriate level of the hierarchy.

The main components of the eigenvector of quality indicators are calculated as the geometric mean in the row of the matrix of pairwise comparisons of elements at each level [2]

$$V_n = \sqrt[n]{\prod_{ij=1}^{n} a_{ij}}, \quad i,j = \overline{1,n}. \qquad (1)$$

Components of the vector of priorities of quality indicators are calculated from the principal eigenvector as

$$P_n = \frac{V_n}{\sum_{ij=1}^{n} V_n}, \quad i,j = \overline{1,n}. \qquad (2)$$

Initially, based on the matrix of pairwise comparisons of quality (Figure 2) obtained at level 2, the main components of the calculated eigenvector (1) and the vector of priorities (2) of quality systems $\vec{P}$.

Similarly, there are evaluating options for paired comparisons matrix systems at the level of 3 separately with respect to each indicator of quality system. On the basis of these matrices are calculated components of the corresponding eigenvectors and principal vectors of priorities $\vec{P}_i$ in relation to indicators of quality. Using these data, calculate the values of the vector components of global priorities [2]

$$C_j = \sum_{i=1}^{n} P_i P_{ij}, \quad j = \overline{1,N}, \qquad (3)$$

where n – number of quality indicators, N – number compared variants systems.

The maximum value of the vector components of global priorities (3) selected a preferred embodiment of the system.

III. Selection Example of the Preferred Project Option for Constructing a Mobile Communication Network 3rd Generation

We consider the practical aspects of using the method of MAH on examples selection of a preferred project option of telecommunications means from a set of valid options with the set of quality indicators and taking into account the subjective judgments of experts [3-5]. In particular, for a comparative analysis of options for building mobile networks of 3rd generation (MN) of UMTS selected the following network parameters: the probability of blocking $P_{бл}$, density of subscribers N_a/S_0, define the number of base stations in the network N_{BTS}. These parameters characterize the quality of the network and can be used as indicators of the quality of the network K_i [1]. Table. I shows the raw data for $P_{бл}$, and calculated parameters N_a/S_0 and N_{BTS}.

TABLE I. Initial Data For Comparative Analysis And Select MN

№ MN	K_1	K_2	K_3
	$P_{бл}$	N_a/S_0	N_{BTS}
1	0,1	166	11
2	0,07	192	21
3	0,04	142	15
4	0,02	183	18
5	0,02	189	22

The initial values of quality indicators K_1, K_2 and K_3 normalized to the maximum value and reduced to a comparable form. Then, taking into account the judgments of experts formed the matrix of pairwise comparisons of these quality indicators, as well as different options for systems with respect to each indicator of quality. For these matrices are calculated principal components eigenvalues and vectors of priorities according to (1), (2) and (3) using the software package that was created in an environment EXEL. The obtained values of the components of the vector systems priority options in relation to indicators of quality, as well as the components of the global priorities are given in Table. II.

Maximum value of the components of the vector $\vec{C}$ corresponds to a preferred embodiment of MN (number 4), which is characterized by the minimum allowable blocking probability of 0.02, a density serviced subscribers 183 subscr. per km^2 or more base stations 18.

TABLE II. Results Of Calculation Of The Components Of The Vector Of Global Priorities MN 3rd Generation

№ MN	P_{1j}	P_{2j}	P_{3j}	C_j
1	0,03	0,07	0,51	0,1779
2	0,04	0,45	0,07	0,0863
3	0,11	0,04	0,26	0,1498
4	0,47	0,16	0,12	0,3418
5	0,35	0,29	0,04	0,2551
P_i	0,62	0,09	0,3	

IV. Example of Selection of a Preferred Project Option of Wireless Access Technologies in Mobile Networks 4th Generation

For comparative analysis and selection of a preferred embodiment was chosen wireless access technology of mobile communication: HSPA, WiMAX and LTE [3,4]. Table. III shows the initial values of the qual-

ity of different technologies: K_1 - spectral efficiency (downlink), K_2 - range, K_3 - baud rate.

For the considered technologies based on expert judgment formed the matrix of pairwise comparisons of these indicators of quality and technology options in relation to indicators of quality.

TABLE III. INPUT DATA FOR THE COMPARATIVE ANALYSIS OF TECHNOLOGY MOBILE NETWORKS

Data quality	HSPA		WiMAX	LTE
	Release7	Release 8	Release 1.5	
K_1, bit / Hz / s	0,87	1,75	1,59	1,57
K_2, km	30	40	50	5
K_3, Mbit / s	21	35	48	75

The calculated values of the components of the priorities of technology options with respect to each of the indicators of quality in accordance with (1), (2), as well as the components of the global priorities $\vec{C}$ according to (3) are shown in Table. IV.

The maximum value of the components of the global priorities C_j corresponds to a preferred embodiment of mobile communication technology - the number 4 is the LTE mobile communication technology with data rates 75 Mbit / s, the spectral efficiency 1,57 bit / Hz / s and the radius of action of 5 km.

TABLE IV. RESULTS OF CALCULATION OF THE COMPONENTS OF THE VECTOR OF GLOBAL PRIORITIES MN TECHNOLOGY

№ MN	P_{j1}	P_{j2}	P_{j3}	C_j
N_1	0,057	0,13	0,043	0,0553
N_2	0,494	0,279	0,093	0,2158
N_3	0,285	0,548	0,359	0,3586
N_4	0,165	0,043	0,505	0,3704
P_i	0,26	0,1	0,64	

V. CONCLUSION

Hierarchy analysis method allows the construction of strictly formalized procedure for selecting a single preferred project option of telecommunications means with the set of indicators of quality and more subjective judgments of experts. The mathematical description of the method, as well as practical aspects of using the method for the selection of a preferred project option examples for different types of telecommunications means. This method, as well as its implementation can be used in computer-aided design of telecommunications means with the set of indicators of quality.

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