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SECTION 9
INFORMATION PROCESSING

Multi-criteria selection of optimum means of telecommunications

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Abstract - **The theoretical and practical aspects of finding a subset of the Pareto-optimal means of telecommunication variants and narrowing to only a subset of the Pareto preferred variant, based on the analytic hierarchy process is done.**

Keywords – **telecommunications, Pareto optimization, selection of a preferred variant, the Analytic Hierarchy Process.**

I. Introduction

Means of telecommunications include encoders, modems, transmission, reception and processing of signals, and telecommunications technologies. Given the complexity and high cost of telecommunications, putting forward serious demands on the choice of design variants, the technical and economic the optimum parameters of quality. This determines the need for a multi-criteria optimization techniques selection of them from the set of feasible variants.

This raises the problem of optimization of design decisions on the aggregate parameters of quality, which are also called multicriteria or vector optimization tasks [1-3]. As a result of decision the multicriteria tasks is generally not only one but a subset of the Pareto-optimal variants system, which are non-dominated by unconditional preference criteria. If on the next stages of design only one preferred variant of the system, there is a need to narrow subset of Pareto should be select, involving some additional information from the experts. Selection of a preferred variant with the analytic hierarchy process was shows. The results of solution of the problem of multi-criteria select as an example of different types of telecommunications means was show [3-10].

II. Determining of the subset of Pareto optimal solutions and selection of single systems

Selecting a subset of the Pareto-optimal variants of systems Φ^o reduces to V subset corresponding Pareto optimal vector estimates $\vec{k}(\Phi^o) \in V^o = \mathrm{opt}_э V$ seening in the criterion space. A formalized procedure determined by the expression (1) that includes a subset of the Pareto non-dominated with respect to a binary $\geq$ vector estimates [2,3]

$$\mathrm{opt}_э V = \left\{ \vec{k}(\phi^o) \in V^o \middle| \nabla \vec{k}(\phi) \in V: \ \vec{k}(\phi) \geq \vec{k}(\phi^o) \right\}. \quad (1)$$

Selection of the Pareto-optimal estimates, no other evaluation, which would be dominated by their unconditional preference criteria. This excludes definitely the best vector estimation and appropriate variants for systems with allowance the aggregate parameters of quality. To narrow the subset of Pareto to a single preferred variant can be applied various methods based on the use of more subjective information about the preferences, which is obtained from the experts. Selection only the preferred variant of the system design using techniques based on value theory, fuzzy set theory, lexicographical relations and the Analytic Hierarchy Process was been [4]. The comparative analysis of these methods to choose a preferred variant of the system has shown that a more effective method of selecting in terms of the accuracy of decision-making group of experts is the analytic hierarchy process (AHP). Therefore, selection the preferred variant of telecommunication means will be used exactly this method in this paper.

The AHP of decomposition the problem of select a preferred variant of the system into simpler components and obtaining numerical data based on expert judgment on the pairwise comparison of various elements of the problem of select. The processing of the data are calculated evaluation components of global priorities, the importance of which is characterized by priority compared alternatives system. Decomposition includes structuring the problem in choice a hierarchy of levels, which is constructed from the top (target choice) through intermediate levels (parameters of the quality of the system) to the lowest level (alternative construction of the system) [5].

Subjective information gathered from experts in the AHP is obtained by pairwise comparison of the importance of the objects at different levels of the problem of selecting. The different variants of systems (level 3) and various parameters of quality (level 2) compared in pairs. The results of paired comparisons of elements are reduced the matrix form

$$A = \begin{pmatrix} a_{11} \cdots a_{1j} \cdots a_{1n} \\ a_{21} \cdots a_{2j} \cdots a_{2n} \\ \cdots\cdots \ a_{ij} \ \cdots\cdots \\ a_{n1} \cdots a_{nj} \cdots a_{nn} \end{pmatrix}, \quad (2)$$

where a_{ij} – evaluation of paired comparisons of selections that are using subjective judgments of experts are numerically defined on the scale of the relative importance of the elements. The diagonal of the matrix is filled with "1", and the matrix elements that lie below the diagonal, are filled with the corresponding inverse values.

The vector of global priorities compared variants of the system are processed matrix of pairwise comparisons of alternatives on every level of the hierarchy. The vector of global priorities calculating by the expression (2) and the vector of priorities P_i calculating by the expression (3) on each level of the hierarchy

$$P_j = \frac{V_j}{S}, \quad V_j = \sqrt[n]{\prod_{i=1}^{n} a_{ij}}, \quad S = \sum_{j=1}^{n} V_j \cdot \qquad (3)$$

With the vector of priorities P_i and vectors parameters of quality and the priorities of the system $\bar{Q}_j$ the components of the vector according to global priorities $\vec{C}$ is calculated

$$C_i = \sum_{j=1}^{n} P_j Q_{ij}, \quad i = \overline{1, N}, \qquad (4)$$

where n – the number parameters of quality, N - the number variants compared systems.

At the maximum value of the components of global priorities (4) choose the corresponding preferred variant of the system.

III. Example of choice of the preferred variant of telecommunication means

Selection of the preferred variant of the speech codec. The practical aspects of the AHP for the choice of a preferred variant of a subset of the Pareto-optimal variants of speech codecs based on aggregate parameters of quality. The data of different of types of speech codecs for IP-telephony network was use. The parameters of the quality is the technical characteristics of speech codecs, characterizing their consumer properties, in particular, the coding rate, the estimation of speech quality, implementation complexity, frame size, the total delay. From 23 variants speech codecs we get 12 speech codecs (1) after narrowing the subset of the Pareto-optimal, comprising. Next, the calculated vector global priorities (4), selection the maximum value of the component only the preferred speech codec. Thus a speech codec G.721, which is characterized by the following parameters of quality: coding rate - 32 kbit / s; quality speech coding - 4.1 implementation complexity - 7.2 MIPS, frame size - 0.125 ms total latency - 30ms [6-8].

Selection of the preferred variant a mobile phone. Selection different types of mobile phones and a preferred variant of mobile phone is done. 19 types of mobile phones with parameters of quality that characterize their properties, in particular, processor, screen, camera, random access memory, prices was use. Of the original set of mobile phones a subset of the Pareto-optimal, which included 9 variants is allocated in accordance with (1). A preferred embodiment of a mobile phone such as Samsung Galaxy Note Edge was choose, which has the following characteristics: the speed of the processor - 2.7 GHz, screen size - 5.6 " camera resolution - 16Mp, RAM - 3 GB and the price - 19000grn [7].

Selection of the preferred variant the modem digital communication systems. We have modems digital communication systems with different types of multi-position modulation - coherent and incoherent MFSK MPSK at various positions including multiposition modulation and bit error rate given. For selection parameters of the quality: efficient use of bandwidth R/W and signal/noise ratio E_b/N_0. The matrix of paired comparisons of these parameters of quality was formed with used the opinions of experts. The vector of global priorities are calculated with these matrices. A preferred variant of the modem in a digital communication system is: a coherent MPSK when the number of positions $M=16$, signal / noise ratio E_b/N_0 = 18dB, bandwidth efficiency R/W = 4 bits/s/Hz [9].

Selection of the preferred variant of a queuing system. Different variants for a single-channel model QS (queuing system) queue, which describes the processes of service applications in communication networks was considered. The parameters of quality: the average time of service applications; system load (traffic intensity); the likelihood of system downtime, it means, the probability that all the channels are free; the average waiting time in the queue of applications was choose. The matrix of paired comparisons of these parameters of quality was formed, and different versions of systems in relation to each parameters of quality. These matrices are calculated values of the components of the vector of global priorities and selection the preferred variant of the QS. So is QS, which has an average service time of applications - 0.2 seconds, load indicator system - 0.14, the probability of system downtime - 0.86, the average waiting time in the queue applications - 0.03 s [9].

Selection of the preferred variant of a mobile communication network of the 3rd generation. A comparative analysis of the different variants of the mobile network (MN) of UMTS at a stage of planning of the nominal is done. When selecting a preferred variant, parameters of quality: blocking probability density of subscribers, the area of the service area, the required number of base stations in the network were used. The vector of global priorities as a result calculated the matrices of paired comparisons. A preferred variant of MN is the variant of MN with characteristic by the minimum allowable blocking probability - 0.02, the density of subscribers - 183 ab./km^2 and the number of base stations - 18 [9].

Selection of the preferred mobile network technology 4th generation. Selection the mobile communication technology 4th generation we have: HSPA, WiMAX and LTE. Three areas of quality we have: the spectral efficiency (downlink), the range of the data rate. The matrix of paired comparisons with the application of AHP was built, treatment evaluation found that the components of global priorities. It was the preferred variant of MN 4th generation LTE is a technology with a data rate - 75 Mbit/s, the spectral efficiency - 1.57 bit/Hz/s and the radius of the base station - 5km [9].

Selection of the preferred embodiment of the system of television broadcasting. A preferred variant of television broadcasting in different standards was selection: DVB-T with multi-frequency modulation SOFDM and the ATSC 8-level frequency modulation. The 12 parameters of quality: Gaussian channel, hierarchical modulation, multipath reception indoor reception in motion, spectrum efficiency, impulse noise, harmonic interference, interference from analog TV systems in the co-channel, interference from digital television in co-channel, sensitivity to phase noise, analog interference was used. The matrix of paired comparisons of these parameters of quality with information gathered from experts is done. The best variant of system is European standard for digital television broadcasting DVB-T with multi-frequency modulation SOFDM [10].

IV. Conclusion

The theoretical and practical aspects of multi-criteria select of optimum means of telecommunications, taking into account the aggregate parameters of quality, and more information from experts is done. Examples of seening the Pareto-optimal variants and select of a preferred design variant using the analytic hierarchy process for different types of telecommunication facilities is done.

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