Radio-Frequency Identification Systems on Set of Quality Parameters

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Abstract – **General methodical approach to a choice of the best variant of radio-frequency identification (RFID) systems on quality parameters set is considered.**

I. Introduction

Modern RFID systems constantly become complicated, to them make inconsistent technical and economic demands which are characterized by set of indicators of quality. Now there is final and rather small set of RFID technologies [1], the final set of components of various firms for construction of RFID systems is considerable more, but besides (readers, antennas of readers, radio-frequency tags (RFT), RFT antennas, the software). However ready variants of RFID systems for variety of cases initially do not exist. It is connected by that there is a set of RFID systems of different function, for example, for monitoring systems and management of personnel access, for the safety control on highways, on the railway and many other things. Thus each RFID system has the specific lines and features and consequently is in own way unique.

At the big variety of components (hardware-software means), capable to provide performance of set of the technical and economic requirements shown to RFID systems, there is a problem of their rational choice. All available components are characterized by variety of the various indicators inherent in each of them which can influence in the various image system effectiveness RFID as a whole. Degree of influence of these indicators also is various. Thereupon there is a problem of a choice of the most rational variants for construction of RFID systems of different function. For the decision of this problem development of the general methodical approach to a choice of the best variant of RFID system from set of admissible variants is required.

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II. Statement of problem

As starting positions for development of the methodical approach all set of factors of is standard-legal, technical and economic character, including documents of federal and departmental levels should be considered. To their number the governmental order of the Russian Federation from 28.11.2011 №977 «About federal state information system» Uniform system of identification and authentification in an infrastructure providing information-technological interaction of information systems, state for granting state and municipal services in the electronic form belongs, for example, etc.

The methodical approach includes: a substantiation of the list of requirements $T - \{t_i\}$, shown to RFID system from its customers; definition of set of initial conditions $U = \{u_i\}$ for designing, including possibilities and tendencies of development of RFID systems; working out of the general variants of construction and RFID system functioning, including its formalized representation as the difficult multicomponent system, allowing to describe its set of parameters X = {xi}; a choice of set of indicators of efficiency $Q = (q_1, q_2, \ldots, q_m)$ most influencing a choice of the best variant of RFID system from set of admissible variants.

RFID system choice represents a multicriterion choice problem of alternative from some set of admissible alternatives on the basis of estimations criteria conformity of the given alternatives of the set of technical and economic requirements. Thus the main initial stage of a choice of a variant of RFID system is the proved formation of set of technical and economic requirements to chosen system. Then in a general view statement of a problem of a choice of a variant of RFID system on set of indicators of quality can be formulated as follows.

Let the choice of a variant of RFID system is made from set of alternatives $A = \{A_i, i = 1,2,\ldots,n\}$ on the set of technical and economic requirements or criteria $Q = \{q_j, j = 1,2,\ldots,m\}$. It is necessary to choose such alternative which in the best way corresponds to set of technical and economic requirements Q from admissible set of RFID systems.

It is necessary to notice, that modern RFID systems are characterized by set of indicators of technical and economic character [2]. Thus for various types of systems of degree of importance of these indicators are various. It is necessary to note also, what not all indicators can be estimated quantitatively. The decision of the formulated problem includes two basic stages: formation of set of admissible alternative variants of systems; an estimation of alternative variants and a choice of the best variant.

In practice to find the strict decision of a task in view as optimizing in a general view it appears the extremely inconvenient. Therefore at a choice of the best variant of RFID system it is expedient to use the known hierarchical approach [2] consisting, first, in decomposition of the general problem on a number private, secondly, in proved application of various indicators of efficiency with the account of features of solved private problems. RFID system model in this case is represented in the form of hierarchy of models a component (systems, subsystems, elements) and models of relations a component. The choice of an optimum variant of system on model is carried out by means of consecutive search of optimum variants separate a component at different levels of hierarchy of system and their coordination for a finding optimum, from the point of view of the global purpose of system, combinations of variants a component. The hierarchy allows describing RFID system at various levels of abstraction, which is detail of reflexion of elements, properties and characteristics. Higher level differs more aggregation of system descriptions, and more bottom - more detailed elements of the description

At the description of a tree of subsystems most often use the functional approach: the general function of system is divided into the separate minorant functions solving private problems. Allocation of subsystems, thus, is carried out according to they should carry out what function. In other words, what way the subsystem carries out the given function the description of properties, characteristics of these elements and the description of signs and properties of all process is defined by model of a subsystem which includes the separate elements participating in process.

As root of a tree of subsystems the system of higher order, than the considered subsystem including also systems of environment, relevant in relation to chosen system can act. The tree is formed at the expense of consecutive decomposition of subsystems on more and more small subsystems. At decomposition each subsystem generates the subtotal. The generating subsystem is as though "parent", and the subsystems making a subtotal, - "affiliated".

Thus, it is possible to present hierarchical model of RFID system, as set of models of the subtotals connected by the treelike relation. Formation of any subtotal can be carried out by means of decomposition operation. The example of decomposition for RFID system is resulted on Fig. 1.

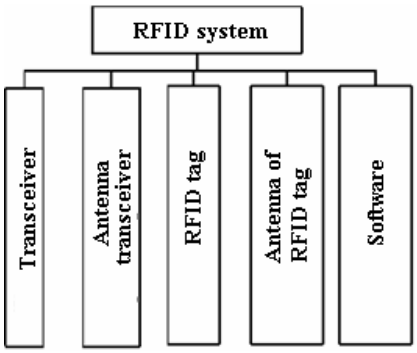

Fig. 1. Hierarchical representation of RFID system

It is obvious, that 1 basic components of RFID system presented on fig., in turn, by decomposition are represented by elements of hierarchy of lower level. For example, the transceiver divides on the receiver and the transmitter, etc.

RFID system consideration on any of hierarchy levels assumes not only allocation of subsystems, but also interrelations between them. For example, subsystems can be compatible among themselves or incompatible. Therefore besides models of subsystems in hierarchical model it is necessary to include model of interrelations, for example, in the form of compatibility model. As at transition from top levels to bottom the quantity of subsystems grows, so, the number of interrelations between subsystems grows also, consideration of all communications between all subsystems strongly complicates model. To avoid excessive complexity it is often expedient to consider only interrelations of subsystems of one subtotal. To each subtotal we will compare one or several models of relations of affiliated subsystems. Thus, the subtotal model includes set of models of affiliated subsystems and model of relations of subsystems.

III. Formation and Choice of the Best Variants of RFID Systems

Formation of alternative variants of RFID systems when their decomposition on components is set, in a considered case is carried out by a method of the morphological analysis [2]. The method of the morphological analysis is characterized by following features: the strict formulation of a problem; revealing of as much as possible full list of the basic functions of system and decomposition on components to a functional sign; definition of various alternative ways of realization of each of a component and all morphological variants of considered system. Each of system variants as a whole consists of a chain containing on one way of realization of each subsystem (components).

Let functional decomposition of RFID system on some final set of subsystems (components) is executed

$$\{A_j, j = 1,2,\ldots,L, \bigcup_{j=1}^{L} A_j = A\}.$$

In the assumption that there is some set of alternative ways of realization of each subsystem A_{lk}, $k = 1,2,\ldots,K$, $l = 1,2,\ldots,L$, some morphological table (tab. 1 see) can be set.

TABLE I. THE MORPHOLOGICAL TABLE

System components	Possible methods of realizations of components of system	Number of methods
1. Reader	$[A_{11}], A_{12},\ldots, A_{1K_1}$	K_1
2. RFID tag	$A_{21}, [A_{22}],\ldots, A_{2K_2}$	K_2
3. Antenna reader	$A_{31}, A_{32},\ldots, [A_{3K_3}]$	K_3
4. Antenna tag	$[A_{41}], A_{42},\ldots, A_{4K_4}$	K_4
5. The software	$[A_{51}], A_{52},\ldots, A_{5K_5}$	K_5

In turn it is possible to present each subsystem of considered system in the form of the morphological table. Morphological tables are an effective remedy of representation of knowledge of RFID system. They allow systematizing enough great volume of knowledge of morphology of RFID systems in a compact kind. Working out of the morphological table gives the chance to formalize process of ordering of set of prisoners in it of alternative variants of systems.

The purposes of the morphological approach at the decision of problems of formation and a choice of a variant of RFID system are:

1) System research of all possible variants of the decision of the problem, following from laws of a structure (morphology) of improved RFID system that allows considering, except known, unusual variants which at simple search could be lost sight the designer.

2) Realization of set of operations of search on morphological set of variants of the description of the functional systems corresponding to initial requirements, i.e. problem conditions.

In morphological tab. 1 by a chain of the connected alternatives in square brackets one of variants of considered system is shown. The general number of the every possible variants *N* forming morphological set, is defined as the Cartesian product of sets of the alternatives formed in each line of the morphological table:

$$N = \prod_{l=1}^{L} K_l . \qquad (3)$$

In the resulted expression (3) following designations are accepted: K_l - number of ways (alternatives) of realization *l*-th functions (components) or the generalized subsystem; *L* - number of all functions. The generated variant of system (subsystem) represents sample of alternatives on one of every line morphological table and in a general view registers as follows:

$$A_i = \{A_{1i}, A_{2j},\ldots, A_{Ln}\}, \qquad (4)$$

where $i = 1,2,\ldots,K_1$; $j = 1,2,\ldots,K_2$, …, $n = 1,2,\ldots,K_L$.

Rules of generation of variants of investigated systems it is that, that each complete variant differs from any other variant of considered morphological set at least one alternative A_{lm}. For example, for typical RFID system with RFT on surface acoustic waves (SAW) known ways of realization of components of system define $5\times3\times5\times4\times3 = 900$ various variants of construction of system, i.e. alternatives.

Now in the foreign and domestic markets there is a considerable quantity of various components for construction of RFID systems. Saturation of the market by foreign and domestic element base, the big variety of conditions in which work RFID systems, specificity of the requirements, shown to them, reliability and durability questions, presence of the big number of constructive types complicate a choice of the best variant of these systems for concrete conditions of operation. Besides, in practice such choice very often becomes complicated also because of impossibility to receive trustworthy information about indicators of quality of components, for example, or because of unwillingness of manufacturers to estimate production on offered indicators of quality, or because of concealment or deliberate distortion of real indicators for the purpose of deception of competitors. Therefore in a considered case a multicriterion choice problem (MC) RFID system variant to have to solve in the conditions of uncertainty.

IV. CHOICE OF RFID SYSTEM VARIANTS

For the decision of MC problem of variants of RFID systems in [2] the complex of the algorithms constructed on a basis is offered: the modified method of the analysis of hierarchies (MMAH); theories of indistinct sets (IS); the modified method of streamlining of preferences through similarity to the ideal decision (MMSID); estimations of necessary and possible levels of conformity (MENPLS) variants to the set requirements.

The basic features of the specified algorithms are following possibilities: for MMAH algorithm - simultaneously to work with quantitative, qualitative and interval criteria; for algorithm on the basis of the IS theory - use of the accessible expert information on quality of variants in the form of pair comparisons on Saati scale; for algorithm on the basis of MMSID - a choice of the alternative having the shortest distance to the positive ideal decision (the leader of the market) and the greatest distance to the negative ideal decision (the outsider of the market); for algorithm on the basis of MENPLS - an alternative choice in which decrease in superfluous requirements occurs at the expense of increase of the requirements realized not enough.

The technique of a choice of variants системотехнических decisions of construction of RFID systems consists of following basic steps.

Step 1. A substantiation of the list of technical and economic requirements shown to RFID system by the customer.

Step 2. Allocation of some typical alternative RFID technologies $V = \{V_i\}$, $i = 1,2,\cdots,r$ which are applied to construction of modern RFID systems.

Step 3. A choice of possible indicators for comparison purposes technologies.

Step 4. Carrying out of a comparative estimation of RFID technologies and a choice of the best variant MMAH [3].

Step 5. For chosen the best for the given concrete case of a variant of RFID technology sets of alternative components of various firms - manufacturers are defined.

Step 6. We range components of each class in decreasing order of preference on set of their indicators of quality, and then it is deleted the components worst and-or not meeting set requirements in each class of components.

Step 7. We form the morphological table from remained alternative a component.

Step 8. We delete from the morphological table incompatible variants of RFID systems.

Step 9. From all turned out set of variants of RFID systems set $G = \{G_i\}$, $i = 1,2,\ldots,n$ such variants which are capable to provide performance of shown technical and economic requirements is defined.

Step 10. From all set of the indicators characterizing chosen variants of RFID systems, a number of technical and economic indicators $Q = \{q_j\}$, j = 1,2,...,m is defined having paramount value at a choice of the best variant [4, 5].

Step 11. We solve a problem of a choice of a variant from set of admissible alternatives and the best variant [6] is defined.

The offered approach is used at a choice of variants of RFID systems on set of indicators of quality.

Thus, at the initial stage of designing of modern RFID systems there is a problem of a choice of the best variant of their construction. It is difficult enough system problem, the important place at which decision occupies a choice of criteria of efficiency. Such criteria should be clear enough and allow to carry out unequivocal quantitative and the quality standard of a system effectiveness reflecting, on the one hand, degree of performance of problems assigned to it, and with another - financial expenses on creation, introduction and system development. As such criteria the most important indicators of technical and economic character with which the system should satisfy, as a rule, are used. For various types of RFID systems in connection with their specificity such indicators will be various.

Besides, not all indicators give in to a quantitative estimation.

V. Conclusion

The offered approaches to a choice of variants of RFID systems on set of indicators of quality and the considered technique of a choice constructed on their basis, allow enough reasonable with attraction of knowledge of the qualified experts to solve at the initial stages of designing a problem of a rational choice of the best variant of these systems.

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