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LIFE CYCLE MODEL AND PROPERTIES OF THE INFORMATION RESOURCE OF THE AUTOMATED SYSTEM

M. A. Prokhorov, St. Petersburg Federal Research Center of the Russian Academy of Sciences, St. Petersburg, Russian Federation, mihan78@mail.ru

The article presents an original life cycle model of an information resource of an automated information support system for scientific research. This model is based on a system of private indicators, criteria and permitting procedures for the evolution of the lifecycle. The characteristic properties of the quality of an information resource are determined and a formalization of the model is proposed using the mathematical equipment of extended Petri nets.

Keywords: information resource; life cycle of an information resource; quality of an information resource; automated system.

Introduction

For high-quality information support of scientific research, various specialized automated information support systems are widely introduced and applied [1]. At the same time, the degree of compliance of such systems with their intended purpose, satisfying the information needs of users, is largely determined by the quality of the available set of scientific information materials that form the information resource of the system [2, 3]. The fundamental importance of the information resource for the effective functioning of the automated information support system defines it as a special control object, which requires analysis and modeling of its life cycle.

1. Model of the Life Cycle of the Information Resource of the Automated Information Support System

The concept of “life cycle”is one of the most important concepts in economics, systems analysis and systems engineering [4]. This concept is introduced for almost all objects of activity, be it a product or an information object. Currently, many definitions of a life cycle are known, and some of them have ambiguous interpretation [5].

In a general sense, a life cycle reflects a sequence of time intervals. At each interval, the object manifests itself differently. In accordance with GOST R 56862-2016, a life cycle is a set of phenomena and processes that repeat with a frequency determined by the lifetime of a typical product design from its conception to disposal or a specific product instance from the moment of completion of its production to disposal. Considering the "informational"nature of the object of study, the given definition does not seem entirely correct. Consequently, we consider it appropriate to dwell on the system engineering definition of a life cycle as a set of interconnected processes (stages) of creation and successive change of the state of the system (object) from the formation of initial requirements (concept) to the end of operation and disposal [6, 7]. It should be noted that the stages of the life cycle of any object include certain stages, distinguished by the characteristics of control moments. During these moments, the conformity of the object characteristics is verified [8]. In this case, a lifecycle model is called a formal description reflecting the composition, content and interrelations of the stages (stages) of the object of study (management) [8].

According to GOST R 59853-2021, an information resource of an automated information support system is a classified set of scientific information materials in a form that ensures their automated search, selection and provision to the user of the system [9]. It should be noted that at the moment when the automated information support system begins to function, the information resource can be in two qualitatively different states: it can already be formed and meet the information needs of users or it can be in the process of being formed. The first case is possible in the case of transferring an information resource from a third-party, specialized system or its preliminary preparation outside the automated information support system. Since the first state is a special case of the second, in the future we will consider the processes of forming an information resource directly during the functioning of the automated information support system.

The processes of an information resource creation must be considered as inseparable from the processes of automated information support system functioning. In this regard, the information resource of the automated information support system can rightly be classified as objects with a dependent life cycle [10, 11]. Then, in order to identify the life cycle of an information resource, it is first necessary to consider the life cycle of an automated information support system.

As a rule, the life cycle of an automated information support system is identical to the life cycle of any automated system and consists of the following stages: requirements formation (concept), design, implementation, introduction, operation, and termination of operation (utilization) [8].

Taking into account the stages (phases) of the evolution of an automated information support system, the life cycle of an information resource can be represented by the following stages: goal setting (analysis of information needs and determination of the subject coverage in accordance with the selected information rubricator); formation using internal sources; formation using external (third-party) sources; application and replenishment; archiving (withdrawal from circulation) [3, 12]. The interrelationship of the life cycle of an information resource and an automated information support system is shown in Figure 1.

At the stage of goal setting, the immediate appearance of the resource to be created and its subject matter (reference, educational, cultural, recreational, etc.) are determined, which is directly related to the purpose of the system to be developed. From the moment the automated information support system starts working, the formation of an information resource is initiated by loading relevant information materials from available internal sources (local information resources of structural divisions of the organization). In this case, the filling of the information resource is retrospective. After exhaustion of internal sources of scientific and informational materials, as well as after reaching a certain completeness, the information resource moves to the next stage of its life cycle, which is characterized by the use of third-party sources of specialized information (for example, specialized

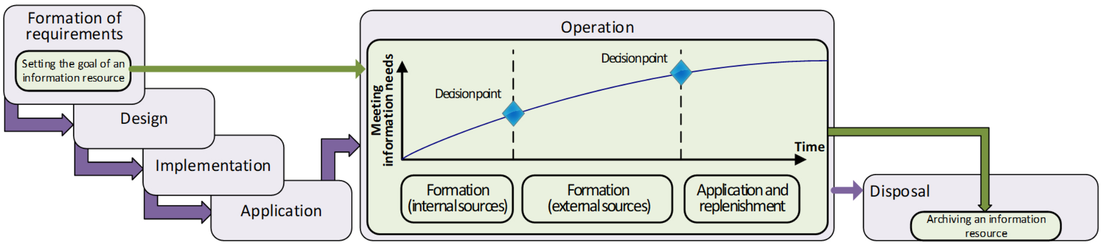

Fig. 1. Codependency of life cycles of an automated information support system and an information resource

information resources of third-party organizations, including on a contractual basis).

Upon reaching the specified (required) completeness, the information resource moves to the stage of direct application and continuous replenishment with newly emerging scientific and information materials. In the event that an information resource loses its pragmatic value, its owner may decide to archive it or delete it, which is the terminal stage of the life cycle of an information resource. As can be seen from Figure 1, the stages of the information resource life cycle are divided by "decision points"or moments of state control, indicating the achievement of a certain level of quality (the degree of compliance with the information needs of users). Considering that the quality of an information resource cannot be unambiguously characterized by completeness alone, it is necessary to consider the set of basic properties of the quality of an information resource of an automated information support system that determine its suitability for use for its intended purpose with the obligatory description of them quantitatively using specific indicators. Thus, the task arises to develop a clear system of private indicators, criteria and approval procedures for transition from stage to stage of life cycle of an information resource of an automated information support system, which at the initial stage requires direct determination of characteristic properties, which are the bearers of its quality.

2. Characteristic Properties of the Information Resource of the Automated Information Support System

The information resource of an automated information support system, unlike material resources, cannot be assessed using generally accepted measurement systems [2, 13]. The quality of the information resource at each stage of the life cycle is characterized by subsets of properties. Currently, researchers distinguish more than 20 characteristics of a modern information resource based on one or another feature [1-3]. At the same time, taking into account the intended purpose of the information resource of an automated information support system, it is rational to distinguish the following characteristic properties of the life cycle stages: completeness, reliability, originality, relevance and value. It should be noted that there are no requirements for the quality of the information resource for the initial and final stages.

The completeness of an information resource (X_1) is correctly understood as the representation of scientific and information materials of the corresponding headings of the hierarchical classification system (information heading) underlying the knowledge system of the information resource at the stage of its goal-setting. It should be noted that when analyzing the property of completeness, it is also necessary to take into account the aspect of the novelty of the materials. Scientific and information material may correspond to the heading, but at the same time it may be hopelessly outdated and have no practical value.

The information resource of any automated information support system should, first of all, be a source of reliable materials (X_2):scientific and informational materials that make up the resource should objectively reflect existing regulations and be based on a comprehensive analysis of previously completed scientific research work on the subject of research and the use of proven scientific and methodological tools [2, 14, 15]. It should be noted that in the conditions of the "information explosion"characterized by a stable trend towards an increase in the total number of newly generated scientific and information materials and their availability, materials reproducing old, previously published knowledge have become increasingly common. In this regard, the problem of the originality of information (X_3) contained in the information resource of the automated information support system comes to the fore. In the conditions under consideration, the property of relevance of the information resource (X_4) is also important. In modern conditions, one of the characteristic properties of the information resource of the automated information support system is its pragmatic value (X_5). In this case, value is understood as the contribution of information support of processes to the overall effectiveness of research work. The paper [2] presents a set-theoretic model of the quality of an information resource with partial indicators and corresponding methods for calculating them. However, in the context of the object under consideration, it is advisable to supplement the specified model with the property of completeness (X_1) and value (X_5), while excluding the property of availability of the information resource. Then, taking into account the justified properties, the quality of the information resource of the automated information support system can be represented by the following basic set:

$$G = \langle X_1, X_2, X_3, X_4, X_5 \rangle,$$

where $X_i = \{x_1^i, x_2^i, \ldots, x_m^i\}$ is the i-th property, characterized by a finite set of particular indicators ($i = \overline{1,5}; m = \overline{1,N}$).

As indicated earlier, to analyze the properties of reliability (X_2), originality (X_3) and relevance (X_4), it is advisable to use the analytical constructs previously developed in [2].

The completeness of the information resource of the automated information support system (X_1) can be characterized by the level of information coverage of the rubricator of scientific and information materials, embedded in the ideology of the information resource, with mandatory compliance with the parameter of novelty. In general, the classification system of knowledge of the resource can be specified as follows:

$$\Theta = \{Y_1, Y_2, \ldots, Y_n\},$$

where Y_n is a set of scientific information materials of the n-th heading of the first level ($n = \overline{1,N}$).

Depending on the depth of the rubrication, the set defining the first-level rubric may include subsets of second-level rubrics, as well as materials directly corresponding to the n-th first-level rubric:

$$Y_n = \{\langle Z_1^n, Z_2^n, \ldots, Z_g^n \rangle, y_1^n, \ldots, y_h^n\},$$

where Z_g^n is a subset of scientific information materials of the second level of the n-th heading; y_h^n is the h-th scientific information material of the n-th heading of the first level.

It should be noted that depending on the depth of the rubricator used, further constructions of the hierarchy of levels are performed recurrently. Let us consider the situation of information coverage of the second level:

$$|Z_g^n| \neq 0 | t_h^g > t_g^z; \quad \begin{cases} |R_1^g| \neq 0 | t_1^j > t_1^z \\ \dots \\ |R_q^g| \neq 0 | t_q^l > t_q^z \end{cases},$$

where R_q^g is a set of materials of the third level, where $R_q^g \subseteq Z_g^n$; t_h^g is the time of creation of the h-th scientific information material of the n-th section of the first level; t_q^l is the time of creation of the l-th material of the q-th section of the third level. Then the informationally complete information resource can be characterized as follows:

$$|\Theta| \neq 0 | \begin{cases} |Y_1| \neq 0 | t_1 > t_1^z \\ \dots \\ |Y_n| \neq 0 | t_n > t_n^z \end{cases}.$$

The most difficult property to formalize is the value of an information resource. The value of an information resource should be understood as its pragmatic relevance, which determines the level of efficiency (effectiveness) of achieving the goal by users of an automated information support system. In accordance with [12], the value of an information resource can be expressed by a value coefficient:

$$X_5 = \frac{P^* - P}{1 - P},$$

where P is the probability of achieving the goal without using the information resource; P^* is the probability of achieving the goal with the help of the information resource.

Thus, the quality of the information resource of the automated information support system, depending on the stage of the life cycle, can be characterized by various properties and their indicators. At the same time, specific requirements for indicators can be set by expert methods or correspond to "ideal" values. Taking into account the above, to develop a model of the life cycle of the information resource of the automated information support system, it remains to formulate and formalize specific approval procedures for the transition between stages.

3. Model of the Life Cycle of the Information Resource of the Automated Information Support System

By the approval procedure we understand one or another system of indicators and criteria, the fulfillment of which indicates the achievement of the quality level necessary for the transition to the next stage of the life cycle of the information resource. In this case both evolutionary and involutionary transitions of the information resource are possible.

In order to formalize and describe the logic of the evolution of the life cycle of the information resource, presented in Figure 1, taking into account the given quality indicators and criteria for their evaluation, it is advisable to use the mathematical apparatus of extended Petri nets, Figure 2.

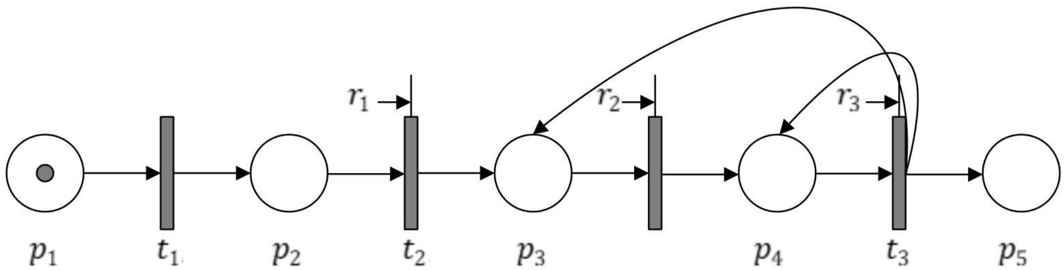

Fig. 2. Information resource life cycle model

The presented model can be analytically defined as follows:

$$C = \{P, T, I, O, R, \mu\},$$

where $P = \{p_2, \ldots, p_5\}$ are the life cycle stages; $T = \{t_1, t_2, t_3\}$ are the moments of transitions of the information resource; $I(t_n)$ is the input incidence function; $O(t_n)$ is the output incidence function; $R = \{r_1, r_2, r_3\}$ is the set of decision procedures; μ is the initial marking depending on the initial state of the information resource. In this case, the decision procedures will have the following form:

$$r_1 : x_2 > v \left| \begin{cases} x_1 \geq x_1^t \\ x_3 \geq x_3^t \end{cases} \right. ,$$

$$r_2 : x_2 > w \left| \begin{cases} x_1 \geq x_1^t \\ x_3 \geq x_3^t \end{cases} \right. ,$$

$$r_3 : x_1 \geq x_1^t \vee x_2 < v \vee x_3 < x_3^t \vee x_4 < x_4^t \vee x_5 < x_5^t,$$

where v and w are the corresponding levels of information coverage; x_k^t are the required values of the particular quality indicators of the information resource.

Conclusion

The developed life cycle model of the information resource of the automated information support system allows us to unambiguously determine the current stage of development of the resource, which guarantees the justified development of control actions in order to ensure the appropriate quality levels. The presented model acquires special practical significance in the context of the application of modern technologies of artificial intelligence. At present, generative technologies are becoming increasingly popular, especially in information systems for supporting scientific research, while their effectiveness is directly related to the quality of the initial data – the information resource.

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Mikhail A. Prokhorov, PhD (Tech), Senior Researcher, St. Petersburg Federal Research Center of the Russian Academy of Sciences (Saint Petersburg, Russian Federation), mihan78@mail.ru

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МОДЕЛЬ ЖИЗНЕННОГО ЦИКЛА И СВОЙСТВА ИНФОРМАЦИОННОГО РЕСУРСА АВТОМАТИЗИРОВАННОЙ СИСТЕМЫ

М. А. Прохоров, Санкт-Петербургский Федеральный исследовательский центр Российской академии наук, Санкт-Петербург, Российская Федерация

В статье представлена оригинальная модель жизненного цикла информационного ресурса автоматизированной системы информационного обеспечения научных исследований, в основу которой положена система частных показателей, критериев и разрешающих процедур эволюции жизненного цикла. Определены характерные свойства качества информационного ресурса и предложена формализация модели с применением математического аппарата расширенных сетей Петри.

Ключевые слова: информационный ресурс; жизненный цикл информационного ресурса; качество информационного ресурса; автоматизированная система.

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Прохоров Михаил Александрович, кандидат технических наук, старший научный сотрудник, Санкт-Петербургский Федеральный исследовательский центр Российской академии наук (г. Санкт-Петербург, Российская Федерация), mihan78@mail.ru

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