INFORMATION AGENT REACTION ANALYSIS METHOD UNDER THE INFLUENCE OF INFORMATION AND COMMUNICATION ENVIRONMENT

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Abstract. A perspective direction of development of information infrastructures is allocated. The main feature of the complex approach to the intellectualization of information infrastructures is presented. The key tasks of the model-analytical intelligence of information agents are described. The expediency of developing a method for analyzing reactive actions of an agent under the influence of an infocommunication environment is substantiated. The class of query models of intelligent information agents is selected. The characteristics of extended object-oriented query models are considered. A new method has been developed for the formation of the model-analytical intelligence of information agents under the influence of the infocommunication environment. The sequence and content of the basic operations of the new method are revealed. The advantages of the proposed method are determined.

Keywords: *intellectualization, a complex approach, intellectual agent, infocommunication environment, quality of functioning, model-analytical intelligence, extended object-oriented models, method of analysis*

One of the prospective directions for the information infrastructures development is based on their intelligence implementation. Complex approach for intelligence implementation is provided by means of smart agent-oriented technologies introduction for engineering support of information infrastructures [1].

In information infrastructures, smart agents are successfully used either for system problems or applied problems solving. Herewith, applied problems are referred to different types of activity. These types include professional, recreational and social activity.

Each time when agent technologies are introduced into information infrastructure, the layer of information agents is formed. The highest level of their intelligence implementation is provided through planning of agents actions focused on achievement of the given objectives.

The most advanced smart information agents generate their objectives independently. Objectives are generated based on the results acquired in the course of analysis of environmental condition and effects of the completed activities. Intelligence level of information agents can be increased by including a new component into their architecture – model-based analytical intelligence [2].

This new component is formed in the course of the quality analysis of smart information agents functioning. The model-based analytical intelligence implements the following tasks:

- advanced preliminary quality evaluation of agent functioning according to the predetermined plan,
- check of conformance to the given quality level requirements,
- in case of non-conformance to the quality level requirements for agent functioning, an agent must generate a new activity plan.

Any specification of a smart information agent must unconditionally use queries addressed to data resources. When an active information infrastructure is used, it can be necessary to receive a confirmation from a smart agent.

In this case, environment of a smart information agent is classified as reactive. Here it is reasonable to use modelling methodology **M**, which is focused on forming the model-based analytical intelligence of information agents for reactive environments $\mathbf{M}_{MAI}$ [3].

The components of the modelling methodology **M** are given in [4, 5, 6]. The methodology includes the method $\mathbf{M}_O$ for analysis of information agent reaction under the influence of information and communication environment. The method that considers information and communication environment influence is proposed in [6].It envisages the equivalent model, which uses a finite Markov chain with accepting state in matrix form.

According to the general concept of model-based analytical intelligence of an information agent, for agent verification an alternative of the method $\mathbf{M}_O$ is required. Consequently, an alternative principle of information and communication environment influence consideration is proposed. The alternative method $\mathbf{M}_{OA}$ is focused on the analysis of an extended object-oriented model of the query execution process with probable return to the initial action. The object-oriented model of a smart agent is implemented in activity diagrams class. The following parameters are input in the query model:

- $u_i(k_i), k_i = 1,2,...,K_i$ –density of probability distribution of discrete time k_i for action number i execution, K_i – upper limit of discrete time for action number i execution, I – quantity of actions in a query activity. For each density value, the following condition is met:

$$\sum_{k_i}^{K_i} u_i(k_i) = 1, i = 0,1,2,...,I.$$

– $p_{j,l}$, $j = 1,2,...,J; l = 1,2,...,L_j$, probabilities of choice of alternative activities in the course of the query execution:

$$\sum_{l=1}^{L_j} p_{j,l} = 1, \; j = 1,2,...,J.$$

where j – number of decision node; L_j – number of alternativesfor behaviour after decision-making j, J – quantity of decision nodes;

– incidence matrix **A** for disconnection and connection nodes with size $(n \times n)$ where n – total quantity of disconnection and connection nodes;

$a_{i,j} = 0$, if nodes are not connected through action nodes; $a_{i,j} = 1$, if a node number j is preceded with action nodes, which are included into sequence of nodes after the node number i; $a_{i,j} = -1$, if action nodes, which precede the node number $i$follows the node number j;

– specifications of all connection nodes, which ensure exchange of data on actions in the course of activity;

– q, probability of return to the initial action.

At the first stage of the new method $\mathbf{M}_{OA}$, each sequence is replaced by a new node of more complex action. For a complex action, the equivalent characteristics is determined as $u(k_{0,1,...,m})$, density of probability for time of this action execution:

$$u(k_{0,1,...,m}) = \sum_{\min k_{0.1,...,(m-1)}}^{\max k_{0,1,...,(m-1)}} u(k_{0,1,...,(m-1)}) u_m(k_{0,1,...,m} - k_{0,1,...,(m-1)}).$$

$$k_{0,1,...,m} = \min(k_0 + k_1 + ... + k_m),...,\max(k_0 + k_1 + ... + k_m).$$

$$m = 0,1,...,M_j.$$

$$u(k_0) = u_0(k_0),$$

where $k_{0,1,...,m}$ – discrete time of *m*-actions sequence execution; $u(k_{0,1,...,m})$ – density of probability for time of (*m*+1)-actions sequence execution.

At the second stage of the new method $\mathbf{M}_{OA}$, each determined group of nodes of alternative actions is replaced by a new node of more complex actions. Then density of probability for its execution time is determined:

$$u(k_{1,2,...,l,...,L_j}) = \sum_{l=1}^{L_j} p_{j,l} u_l(k_l),$$

$$k_{1,2,...,l,...,L_j} = \min_l k_l, ..., \max_l k_l;\ l = 1,2,...,L_j,$$

where $u(k_{1,2,...,l,...,L_j})$ – density of probability $k_{1,2,...,l,...,L_j}$ for alternative actions L_j execution time.

At the third stage of the method $\mathbf{M}_{OA}$, a sequence of nodes for new and more complex actions is determined. Then the equivalent characteristics as density of their execution probability is determined. At the forth stage of the method $\mathbf{M}_{OA}$, groups of nodes for parallel activities are determined in the group. Each group is replaced by a new node of consolidated action with the equivalent characteristics determination:

$$u_{\wedge}(k_{1,2,...,n,...,N}) =$$

$$\prod_{n=1}^{N}\Big(\sum_{k_n=1}^{k_{1,2,...,n,...,N}} u_n(k_n)\Big) - \prod_{n=1}^{N}\Big(\sum_{k_n=1}^{k_{1,2,...,n,...,N}-1} u_n(k_n)\Big),$$

$$k_{1,2,...,n,...,N} = \max_n(\min k_1, \min k_2, ..., \min k_n, ..., \min k_N), ...,$$

$$..., \max_n(\max k_1, \max k_2, ..., \max k_n, ..., \max k_N),$$

$$u_{\vee}(k_{1,2,...,n,...,N}) =$$

$$\prod_{n=1}^{N}\Big(1 - \sum_{k_n=1}^{k_{1,2,...,n,...,N}-1} u_n(k_n)\Big) - \prod_{n=1}^{N}\Big(1 - \sum_{k_n=1}^{k_{1,2,...,n,...,N}} u_n(k_n)\Big),$$

$$k_{1,2,...,n,...,N} = \min_n(\min k_1, \min k_2, ..., \min k_n, ..., \min k_N), ...,$$

$$..., \min_n(\max k_1, \max k_2, ..., \max k_n, ..., \max k_N).$$

At the fifth stage of the method $\mathbf{M}_{OA}$, sequence of nodes of consolidated actions is formed and $u(k_{0,1,...,i,...,I})$ density of probability for $k_{0,1,...,i,...,I} = 1,2,...,K_{0,1,...,i,...,I}$ their execution time is determined.

At the sixth stage of the method $\mathbf{M}_{OA}$, expected value $E[k_{0,1,...,i,...,I}]$ for discrete time for query execution until confirmation is determined.

$$E[k_{0,1,...,i,...,I}] = \sum_{\min k_{0,1,...,i...,I}}^{\max k_{0,1,...,i...,I}} k_{0,1,...,i,...,I}\, u(k_{0,1,...,i,...,I}).$$

At the seventh stage of the method $\mathbf{M}_{OA}$, expected value $E[k_{0,1,...,i,...,I,(I+1)}]$ for discrete time of iterative query execution with confirmation is determined.

$$E[k_{0,1,...,i,...,I,(I+1)}] = (E[k_{0,1,...,i,...,I}])/(1-q).$$

If to compare the implemented method $\mathbf{M}_{OA}$ with the method $\mathbf{M}_{O}$, new method has more simplified process of calculation because operations with matrices are not required. However, the method $\mathbf{M}_{OA}$ can be used to determine only expected value for the discrete time of iterative execution of an information agent query with confirmation in reactive information and communication environments.

The values $E[k_{0,1,...,i,...,I,(I+1)}]$ calculated using the method $\mathbf{M}_{OA}$ are intended for check, if the expected value for the discrete time of query execution from an information agent according to the method $\mathbf{M}_{O}$ is correct. Combination of the methods $\mathbf{M}_{O}$ and $\mathbf{M}_{OA}$ ensures verification of the resulting model-based analytical intelligence $\mathbf{M}_{MAI}$ for an agent in active information and communication environment. The advanced method $\mathbf{M}_{OA}$ extends the methodology for the model-based analytical intelligence implementation of information agents for reactive environments $\mathbf{M}_{MAI}$.

This extension makes it possible to monitor the model-based analytical intelligence of information agents.

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