Operational Management of Distributed Active Systems Based on the Cloud Approach

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Abstract *The paper deals with decision making in operational management of distributed active systems. The problem is associated with the necessity to consider a sequence of poorly formalized decision making problems, arising on the level of distributed system local modules. A possibility of the problem solution based on cloud technology and distributed innovation knowledge is investigated.*

Keywords**:** decision making problem, distributed system, cloud technology, subject collection, independent estimation, proposal for improvement

1. INTRODUCTION

Decision making in distributed active systems (DAS) is the important problem of socio-economic systems or modern large-scale enterprises operational management. The problem urgency is caused by the fact that on the one hand it significantly affects on effective functioning and competitive advantage of the enterprises. And on the other hand the problem solution is far from the completion by virtue of a variety of features such as:

- undefined and poorly predictable environment;
- dynamic, multi-component and hierarchical nature of distributed systems;
- presence of local authorized agents, participating in the decision;
- a great number of control objects and their active behavior;
- fragmentarity, diversity and weak-structuredness data, used for decision;
- a variable number (and semantics) of numeric and linguistic diagnostic features;
- short time for making adequate management solutions.

As a result, arising decision making problems (DMPs) are characterized by poor formalization and uncertainty. These DMPs require the use of methods of solution based on fuzzy formalization. Key importance in such methods has effective use of the expertise. This problem can be considered as the decision making intellectualization, based on innovation knowledge. In this paper the possibility of the decision making intellectualization in distributed active systems, based on approach, suggested in [1], is investigated.

2. PROBLEM STATEMENT

Let W be DAS functioning in the environment S and consisting of the center *Center* and n geographically distributed control objects (nodes) $P^1,\ldots, P^n$. Objects have their own behavior and are related by partial ordering which is determined by the set of relations such as «$P \succ G$», signifier that object G are under control of object P. It's evident, that $Center \succ P^i,\ \forall i = 1,...,n$.

$$W = (Center, P^1,P^2,...,P^n, O),\ n \neq cons. \quad (1)$$

The general scheme of management in DAS W can be represented as a tree (Fig.1) [2].

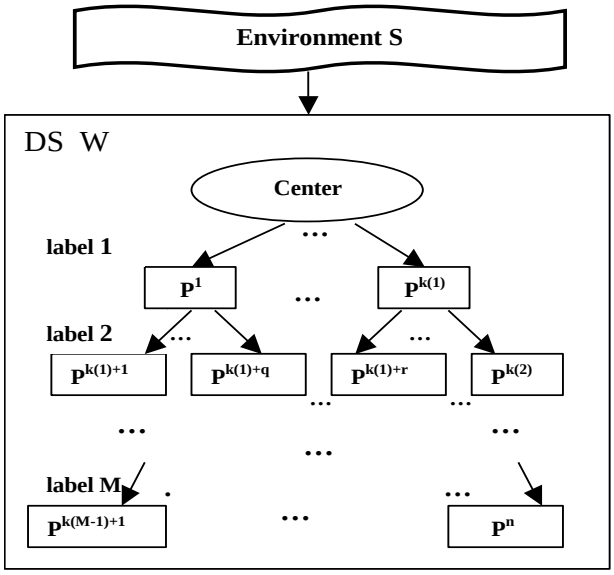

Fig. 1 Tree-like structure of DAS management

The effectiveness of functioning DAS W is determined by criterion

$$F = (<c_1> \in \Delta_1^*) \wedge \ldots \wedge (<c_k> \in \Delta_k^*), \quad (2)$$

where $c_1,\ldots,c_k$ be set of effectiveness indices for *Center*, $<c_1>,\ldots,<c_k>$ be their values and $C^* = \{\Delta_1^*,...,\Delta_k^*\}$ be sets of their required values. Both numeric and linguistic indices are allowed.

The problem U of operational management is to develop management technology ensuring compliance of criterion (1) throughout the process of DAS W functioning in the condition of possible changes in the external environment S, the structure of W (objects $P^1,\ldots, P^n$, their number, position and the relation of partial order), indices $c_1,\ldots c_k$ and their required values.

The time interval $\tau(u)$, necessary for decision making u, should satisfy the condition:

$$\tau(u) \leq \tau^*, \quad (3)$$

where τ^* is a threshold, which can also be changed during the DAS lifetime.

The activity of objects $P^1,\ldots,P^n$ implies their own decisions. So for them the effectiveness criteria $F^1,\ldots,F^n$ and operational management problems $U^1,\ldots, U^n$, similar F and U correspondingly, are also determined. If

$P^i \succ P^j$, then the results of the solution of problem U^j are taking into consideration when choosing a control action for problem U^i. In particular, the solution of U is based on the results of the solution of problems $U^1,\ldots, U^n$.

Operational management of DAS W is based on the situation management ideas. Its general scheme is as follows.

1) Monitoring of criteria F and $F^1,\ldots,F^n$ fulfillment is carried out at the levels of *Center* and objects $P^1,\ldots, P^n$.

2) The current state of W or P^i is estimated in the case of criteria F or F^i, $1 \le i \le n$ unfulfillment.

3) According to the results of the assessment:

- control action, eliminating of the arising malfunction state, is selected or
- a decision maker determines, that the malfunction is caused by troubles on underlying nodes and produces the objective, readdressing the problem to the level of child modules;
- at child modules above actions are repeated, that generates a movement from top to bottom along the corresponding branches of the control tree (fig.1). The movement from top to bottom continues until the malfunction source will be revealed and corresponding control action will be selected. After that at child modules above actions are repeated. It generates a movement from top to bottom along the corresponding branches of the control tree (fig.1). After that the feedback movement from bottom to top is initiated, accompanied by selection of the hierarchical control actions set.

As a result, a management of DAS is connected with the necessity to solve the set of hierarchical DMPs on the basis of using the set of different decision algorithms. This intensifies the effective algorism selection problem, because in consequence of using non-effective algorism the danger of errors and distortions accumulation is appeared and time and material costs are excessively increased. Besides it is necessary to provide timely actualization of used algorithms – they must be changed or corrected according to the dynamics of external environment and DAS W itself and also with account of innovation knowledge appearance.

3. DECISION MAKING ON BASED OF CLOUD APPROACH

To provide the efficiency of algorithms, used in nodes of DAS W can be applied approach to making decision intellectualization based on so-called subject collections as a new category of cloud service KaaS (Knowledge as a Service) [1,2].

A subject collections acts as the form of diverse expert knowledge presentation and is described by the tuple

$$(nZ, Z, Z^n_1, B^n_1, C^n_1, D^n_1,\ldots,t, ind),\ n\to\infty \ , \quad (4)$$

where nZ - problem identifier, Z - problem description, Z^n_1 - subproblems, B^n_1, C^n_1, $D^n_1,\ldots$ - diverse expert knowledge of solving subproblems ,t – generation time, *ind* - independent estimations (utility measure) of the subject collection. Knowledge B^n_1, C^n_1, D^n_1 are presented by algorithms, technologies and expertise.

The efficiency of decision algorithms, selected on the base of this approach is provided by following means:

- formation of subject collections;
- formation of open interactive environment for communications of distributed actors (experts, users, cloud service agents);
- a mechanism of filling and updating subject collections by distributed rating experts that provide innovative and permanent improvement of content;
- a feedback mechanism between users and subject collections on the basis of external independent estimations and proposals for improving knowledge content;
- decision making on the basis of subject collections in accordance with users requirements and environment state.

For each particular DAS W a result of applying approach can be:

- utilization of some existing subject collection, if at the Internet portal “Subject Collections” (available in cloud resource “Byelex”) there is a corresponding subject collections, covering all types of DAS W permissible DMPs or
- formation of the complex subject collection, combined several collections covering all types of DAS W permissible DMPs.

General features of applying the approach in distributed active environments are:

- the necessity to solve a set of polytypic DMPs that requires to provide mapping between a type of DMP and available cloud resources at all nodes of DAS;
- the participation in decision-making process a number of actors (decision makers) with own authorities, hierarchy of DMPs (utilization of the decisions taken at the lower levels, when taking decisions at higher levels) that requires coordinated actions of decision makers during their interaction with the cloud service;
-the necessity for multiple addresses to the cloud service in the process of malfunction situation eliminating that complicates the implementation of restrictions on the time of adopting adequate control solutions.

To ensure consistency between the type of solved DMPs and used program and information cloud resources it is required:

- to make a list of permissible DMPs, arising on each individual workstations at the levels of *Center* and objects $P^1,\ldots,P^n$. For each workstation are determined: brief descriptions of each type of DMPs, requirements to the existing horizontal communication links with other workstations which participate in solving each type of DMPs;
- for each identified type of DMP to determine a set of corresponding cloud-based DMPs in subject collections and a set of permissible subject collections. Forming a set of permissible subject collections it is necessary to take into account the requirements for decisions made in DAS;
- to implement DMP parametric setting on each workstation, for which it is necessary to determine the correspondence between the type characteristics in permissible subject collections and observed diagnostic features of DMPs and to determine how on observed values of diagnostic features to assess values of type characteristics of the subject collections.

Above steps are repeated again after any change of DAS or its environment that may affect the set of solved DMPs, their statements, requirements to made decisions

and the diagnostic features.

An important means of ensuring the effectiveness and actualization of cloud resources is the mechanism of forming users independent estimations and proposals for improvement. In view of the hierarchy of DMPs estimations and proposals are formed by not only decision makers involved in the decision directly, but also those using the selected decisions. Their activities are coordinated in accordance with horizontal and vertical communication links that are involved in decision-making process.

In addition to the integral independent estimation of the subject collection for each of its subproblems are formed their own independent estimations.

If the DMP is localized within a single workstation and there is one decision maker, then maker form its independent estimation and proposals for improvement

If the DMP is distributed among several workstations located at some of horizontal control level (Center, label 1, …, label M in Fig. 1), and there are several decision makers, involved in the decision making process and operating in accordance with their authorities and available resources, independent estimation and proposals for improvement are formed as follows:

- each decision maker forms its independent estimation and proposals for improvement;
- the integral estimation and proposals for improvement are formed on the basis of the set of decision makers estimations and proposals.

For the integral estimation and proposals formation can be used methods of the collective decision-making theory, allowing to take into account decision maker qualification and the degree of responsibility for the adopted decision.

If the result of the solution of the DMP is reported to a higher parent node by back vertical communication links, the independent estimation and proposals for improvement are formed as follows:

- estimations, proposals and reports formed by decision makers, which are directly participated in the decision making, are transmitted to the parent node;
- the decision maker at the parent node analyzes the supplied data and concludes on the effectiveness of the decisions adopted at the child node. According to the results of this analysis the decision maker can correct and specify the provided independent estimation and proposals. If the decision maker of the parent node is not satisfied with the decisions or doubts the reliability of the information provided, he/she requires to reduce the independent estimation or provide reliable results;
- to resist to accumulating inaccuracies and distortions in the process of malfunction situation eliminating, the decision maker, initiating this process, implements the final analysis of the process efficiency by quality indicators and time indicators. Based on the results of this analysis, the decision maker can decide on the need to correct earlier formed independent estimations and proposals for subject collections that were used in malfunction situation eliminating.

4. CONCLUSION

The report covered only a small part of problems encountered under the operational management of distributed systems based on cloud technologies. In particular, the problem of information security is not touched. It requires special consideration and involves the use of such means as:

- transmitted and stored data encryption;
- authentication and authorization for users and administrators;
- security auditing;
- removing of the residual information;
- data backup and others.

Besides a number of organizational security measures should be taken on the provider side.

5. REFERENCES

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