Novel Approach to Intellectualization of Decision Making Based on Subject Collections

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Abstract: *Actual problems of decision making intellectualization are considered. The proposed solution is based on subject collections and cloud computing.*

Keywords: Decision making, subject collections, distributed knowledge, cloud computing

1. INTRODUCTION

The problem of decision making intellectualization is an important element in state policy of developed countries. It is reflected in the corresponding government documents and programs, including "Computational Science: Ensuring America's competitiveness" (USA) [1]. "Intellectualization" is the involvement of innovative knowledge, which should ensure competitive advantages for government agencies, private companies and certain sectors of the population. The main sources of such knowledge are experts, dispersed in leading scientific and technological centers of the world. The primary means of intellectualization are computer Decision Support Systems (DSS), which accumulate the innovations.

Theoretical and technological aspects of decision making intellectualization are investigated in works of well-known scientists: P.Drucker, S.Kniazev, D.Lessard, R.Miller, H.Priemus, Y. Zhuravlev, etc.

In spite of the obtained success there are many unsolved actual problems. In particular, insufficiently studied are mechanisms for representing diverse innovative knowledge in a manner that ensures its rapid development and versatile use. Traditional models (production, semantic, etc.) do not solve the problems under consideration, because the models are narrow-focused, complex and difficult for decomposing into components. Furthermore, there are neither environment models ensuring synchronization of activities between sources and consumers of innovations nor mechanisms for timely accumulation of such knowledge and making the corresponding decisions, the relevance of which is confirmed by the competence of experts and compliance with the environment requirements [2, 3, 4, 5].

The paper attempts to comprehensively investigate and solve the stated problems on the basis of the synthesis of the decision-making theory, organization theory, artificial intelligence and possibilities of modern software technologies.

2. PROBLEM STATEMENT

In general, a Decision Making Problem (DMP) is reduced to a choice of one or more alternatives from a variety of preset options. It is described by the tuple:

$$DM = Alg\ (S, G, E, V, Kr, V) \qquad (1)$$

where: S signifies problem situation; G stands for the goal; V signifies possible alternate solutions; Kr is a selection criterion; Alg is an algorithm; V stands for the solution result.

A typical scene is described by the tuple:

$$Scene = (C, E, P, DM, mod, com, sys, t, m) \qquad (2)$$

where: *C* is a decision initiator (the center); *E* stands for information sources; *P* signifies users of the decision; *mod* is a knowledge representation model; *com* denotes means for information exchange between *C, E, P*; *sys* is a Decision Support System (DSS); *t* and *m* are time and money expenses.

Traditionally, the synthesis of the solution on the basis of DSS is carried out for long-lived tasks within local scenes on the basis of permanent sources of knowledge and rigid schemes of communication. Expert knowledge or the results of the statistical analysis of time series, formalized within logical, production or other models, are used to form constituents of DM. The number of users of the decision is limited, as a rule, by the center (C). Knowledge base of DM is difficult for decomposing into components as well as for implementation, which is the cause of narrow-focused use and rapid knowledge aging. Synthesis of the solution **V** is generally characterized by large investment of time and money, which limits the number of DSS users including government agencies and large companies.

As a solution to the problems, properties of the new environment and peculiarities of decision making are determined on the basis of the analysis of the existing studies.

It is shown that as a result of globalization, properties of DM (1) and the scene of its solution (2) are significantly changed, in particular:

– knowledge has acquired the status of the primary means to obtain competitive advantages. This substantially increases the role of technology-oriented innovative knowledge represented in various models and formats, allowing fragmentation, export, and versatile use. As a result, there is a problem of compatibility (interoperability) of homogeneous models (logical, production, etc.) and diverse cognitive structures;

– globalization of the environment has changed the scene of the solution (2), there is a need for remote communication of distributed actors to create, update and use of innovative knowledge bases;

– expansion of users has led to the need for the development of inexpensive and easy to use DSS, providing the remote formation of DM constituents, the access to innovations and the choice of effective solutions.

It is shown, that traditional methods and technologies can not overcome the emerged contradictions, therefore, a number of scientific schools are trying to solve them within the so-called "problem of intellectualization". This term refers to a wide range of problems for developing protective mechanisms to support the homeostasis of natural and artificial systems on the basis of competent knowledge and objective assessments.

A new approach to the intellectualization of decision making is proposed. The approach is based on subject collections as a form of representing diverse knowledge, the relevance of which is confirmed by the competence of sources and external estimates.

3. SUBJECT COLLECTION MODEL

The problems concern representation of innovative knowledge in the form convenient for multiple applications, printing and export; construction of mechanisms for acquiring and updating of knowledge.

The existing models of frames (M.Minsky), patterns (U.Grenander) and design patterns (E.Gamma, R.Helm, R.Johnson, J.Vlissides) are homogeneous in nature and technologically are not compatible with the heterogeneous nature of innovative knowledge.

The concept of a subject collection (SC) is proposed as a solution to the problem of interoperability. The subject collection is an abstract structure that integrates homogeneous models of knowledge as components of the general solution. The ontology of SC is represented by the tuple:

$$SC = (nZ, Z, Z_1^n, B_1^n, C_1^n, D_1^n), n \to \infty. \quad (3)$$

where: *nZ* is a problem identifier; *Z* stands for the task description and requirements to its solution; Z_1^n are subtasks of *Z*; B_1^n, C_1^n, D_1^n signify heterogeneous models of subtasks that are implemented in different formats.

A distinctive feature of the concept of SC is an inextricable connection between the notion of knowledge and mechanisms of its synthesis and application, thus ensuring objective assessment of the level of utility over time.

Fig. 1 shows a variant of the model (3), oriented for use in the global environment to solve practical IT problems and ensuring assessment of the usefulness of a subject collection by independent users.

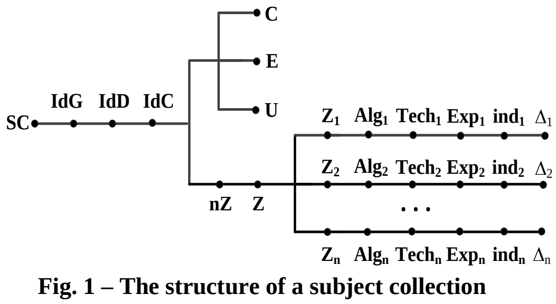

Fig. 1 – The structure of a subject collection

The vertices of the graph identify the SC in the global (IdG), subject (IgD) and corporate (IdC) environment and determine actors, i.e. the initiator (C) of the SC formation, sources of knowledge (E) and users (P). The solution of task Z is represented by a set of algorithms (Alg), technologies (Tech) and experience (Exp), the usefulness of which are confirmed by external evaluations. Independent suggestions for improving knowledge content are represented in $\Delta^1..\Delta^n$.

Three actors (i.e. the center, experts and users) are involved in the life cycle of a subject collection. On the basis of the socio-psychological model a universal, technologically-oriented model of actors is developed:

Actor = (eActor, nActor, fRol, Rol, dRol, dbOther, know, mc, X),

where: *eActor* is an address; *nActor* is an identifier; *fRol* stands for the function forming a role; *Rol* is a role; *dRol* signifies a dialogue corresponding to the role; *db* is information about other actors of the scene; *know* denotes cognitive preferences; *m* are expenses involved in the scene; *X* is information about the actor.

For practical use of the graph model an object-oriented version is developed, which includes a class, an object and the standard for storing the SC:

```
class SubjCol
{
  Init (IdG, IdD, IdC, C, E, U); // SC initialization
  Build (SC);     // building
  Dm (SC);        //  decision making
  Util (SC);       // utility estimate
  Upd (SC);        // content updating
}
SubjCol  Ortho = new (SubjCol (C, E, U, SC));
```

The structure ensures implementation of heterogeneous models in different programming languages within a single class. This solves the problem of semantic interoperability of knowledge models.

A universal structure in XML is proposed as the standard for SC storage.

```
<?xml version="1.0"?>
<SubjectCollections>
 <SC isbn="873650001">
 <content>
<IdG,IdD,IdC>
<C,E,U>
<nZ>
<Z>
<Alg.rar>
<Tech.rar>
<Exp.rar>
<ind>
<Δ>
 </content>
</SubjectCollection>
```

The option enables fragmentation and export of SC to external systems. This largely solves problems of software interoperability and multipurpose use of innovative knowledge.

4. OPEN INTERACTIVE ENVIRONMENT

Next, the problem of modeling the information exchange between actors C, E, P is considered. An Open Interactive Environment (OIE) is proposed as a solution of the problem (Fig. 2).

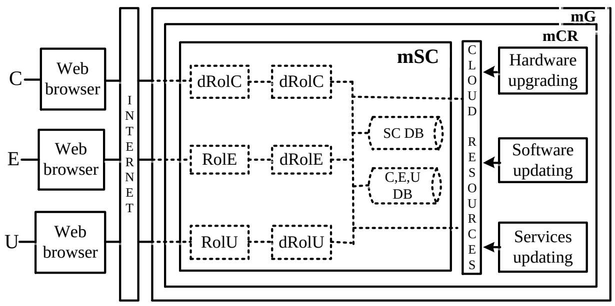

Fig. 2 – The open interactive environment

The structure of the open interactive environment is a set of nested environments (corporate (mSC), cloud (mCR), global (mG)), and the developed and implemented standards for the roles (RolC, RolE, RolP) and dialogues (dRolC, dRolE, dRolP).

The environment of mSC includes C, E, P components, interacting through interfaces. Thus, it can be considered as an open system with the properties of interoperability, mobility and scalability.

The interoperability ensures the integration of the mSC into mCR cloud resources, provided by Microsoft Azure, IBM SmartCloud, Apple iCloud, Amazon EC2.

The mobility of mSC creates a possibility, if necessary, to promptly change the mCR cloud environment to any other one within the mG global environment. The scalability ensures the arbitrarily change of the number of actors.

Thus, the subject collection (SC) can be considered as a new category of the cloud service, i.e. Knowledge as a Service (KaaS), complementing the traditional SaaS (Software as a Service), PaaS (Platform as a Service), IaaS (Infrastructure as a Service). As a result, the number of SC users is increased and there is a possibility to construct efficient architectures, delegating the support of software and hardware life cycles to the cloud provider.

After modeling the environment interaction, the problem of knowledge acquisition for constructing and implementing SC content is considered. It is shown that the existing algorithms can not solve the stated problem. The existing algorithms form knowledge bases, which are difficult for decomposing into components, hard to change and costly. They lack mechanisms for independent content assessment and considerations of its improvement.

5. SUBJECT COLLECTION FORMATION

The proposed approach for solving the problem is based on "Lego" principle. A set of fragments, in total, form an entire view. The general idea of the algorithm is as follows. First, center C, through the dialogue dRolC, forms SC as a template, which includes the classification features and the description of the problem(Fig.3).

Then, expert E forms a set of SC fragments (within the dialogue dRolE), implements them into SC and places them into the template. Users P put SC into practice (dialogue dRolP), assess the level of content usefulness (ind), and make suggestions for the content improvement (Δ). The expert periodically considers the suggestions and updates the corresponding fragments, if necessary.

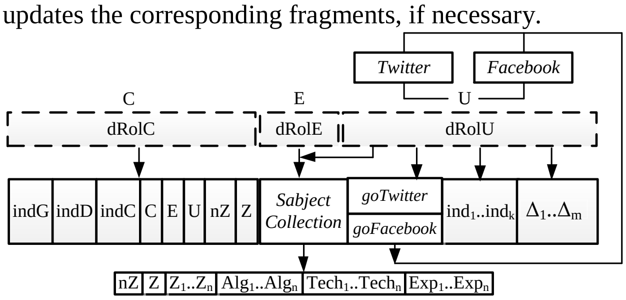

Fig. 3 – Scheme for SC pattern formation

The built SC content is a set of heterogeneous fragments. The estimates of knowledge usefulness and suggestions for the improvement allow the expert timely update fragments of content, thus solving the problem of knowledge "aging" and decomposition into components. The possibility to form SC alternatives ensures the competition of experts, thus reducing the time from the appearance of an innovation to its implementation.

6. CONCLUSION

The following main results are obtained.

Subject collections as a form for representing diverse knowledge and the corresponding object model, ensuring the solution to the problem of structural, semantic and linguistic interoperability of heterogeneous models of knowledge represented in different formats, are proposed. The use of the object-oriented approach makes it possible to represent rigid heterogeneous models as one class of methods, consistent performance of which solves the general problem. As a consequence, there is a possibility to share previously developed and new methods, inherit the results, to export meta-model elements and update any method without changing other ones.

The model of the environment that unites the activities of distributed actors and focuses on the cloud deployment of software and computing resources is developed. As a result, expenses for building, updating and application of subject collections of distributed actors are lowered.

7. REFERENCES

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