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IMPLEMENTATION GUIDELINES FOR A TEMPORAL INTELLIGENT SYSTEM SUPPORTING ORGANIZATIONAL CREATIVITY*

METODYKA WDRAŻANIA TEMPORALNEGO SYSTEMU INTELIGENTNEGO WSPOMAGAJĄCEGO TWÓRCZOŚĆ ORGANIZACYJNĄ

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Summary: The main aim of the paper is to present and discuss the implementation guidelines of a temporal intelligent system, intended to support organizational creativity. The discussion is based on the author's proposal concerning such guidelines, on literature research, and on the author's research concerning temporal intelligent systems. Thus, motivation for implementing a temporal intelligent system is presented, temporal aspects of organizational creativity are pointed out, related work on implementation methodologies is included, and finally a proposal of implementation guidelines is presented and discussed in detail.

Keywords: organizational creativity, temporal intelligent system, implementation guidelines, KADS, CAKE.

Streszczenie: Głównym celem artykułu jest prezentacja i omówienie metodyki wdrażania temporalnego systemu inteligentnego, mającego wspomagać twórczość organizacyjną. Dyskusja opiera się na autorskiej propozycji metodyki, na badaniach literaturowych oraz badaniach autorki w zakresie systemów temporalnych. Zaprezentowano motywację dla implementacji temporalnego systemu inteligentnego, wskazano temporalne aspekty twórczości organizacyjnej, odniesiono się też do istniejących metodyk, a także zaproponowano własną metodykę wdrażania.

Słowa kluczowe: twórczość organizacyjna, temporalny system inteligentny, metodyka wdrażania, KADS, CAKE.

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1. Introduction

Organizational creativity is nowadays a hot concept in management practice, gaining more and more attention as a new way of obtaining competitive advantage.

Many authors have already defined this notion, see e.g. [Unsworth 2001; Andriopoulos, Dawson 2014]. Although the definitions differ, there are some common features of this activity. These are:
- involving teams, not individuals,
- dependence on changes both in the environments and inside the organization,
- being composed of processes.

What seems most important while discussing organizational creativity is its dynamics. This arises from the fact that processes are dynamic, and above all changes have temporal characteristics. Therefore, if an IT tool is to be used as a support for organizational creativity it has to be able to encompass the temporal dimension of reality. This is the reason why we propose to use a temporal intelligent system, which has been defined by [Mach 2007] as "an artificial intelligence system, which explicitly performs temporal reasoning. Such a system contains not only fact base, rule base, and inference engine, but also directly addresses the question of time. For an intelligent system to be temporal, it should contain explicit time representations in its knowledge base – formalized by the means of temporal logics – and at least in the representation and reasoning layers."

The main aim of the paper is to present and discuss the implementation guidelines of a temporal intelligent system intended to support organizational creativity. The discussion is based on the author's proposal concerning such guidelines, on literature research, and on the author's research concerning temporal intelligent systems.

2. Motivation for implementing a temporal intelligent system

As was already said in the introduction, the tool for supporting organizational creativity should be a temporal one. Let us now justify this choice by pointing out the temporal aspects of organizational creativity.
- Woodman et al. [1993] and Shalley et al. [2000] stress the fact that organizational creativity is composed of ideas and processes. Above all processes are of temporal characteristics. The effect of this activity – mainly new ideas – is called by us "creative knowledge". This knowledge also changes in time, as ideas change. Thus the creative knowledge base should be a temporal one. Similar characteristics of organizational creativity are given by [Martins, Terblanche 2003; Alvarado 2006; Hirst et al. 2009; Baer 2012; Basadur et al. 2012].
- Unsworth [2001] claims that the creative knowledge should respond to the changing situation of the organization (p. 289). As the situation changes in time, so should the creative knowledge.

- Mumford et al. [2011; 2012] write about the badly structured nature of creative problems. This in our opinion justifies the use of temporal formalisms in an intelligent system's creative knowledge base, because these formalisms are able to formalize unstructured problems.

Organizational creativity and the creative knowledge resulting from it are of a temporal nature, so a classical knowledge base system is not enough to support them. It has to be a temporal knowledge base one, due to the following reasons:

- The changing creative knowledge has to be fully captured (including its temporal context) and then disseminated – this can be done by a temporal knowledge base system;
- Organizational environment, which influences organizational creativity, is constantly changing [Mach 2007, pp. 13-15; Czaja 2011, pp. 150, 176].

There is a constant flow of new information coming both from inside and outside the organization which makes the creative knowledge change [van Benthem 1995].

The changing organizational knowledge makes it possible for organizations to adapt to changes [Sirmon et al. 2011]. And finally, creative knowledge may be treated as a valuable organizational asset, which also changes in time [Krupski (ed.) 2011].

Some researchers from different areas have been already attempting to capture organizational assets' dynamics, e.g. [Jakubczyc 1996] – in the field of dynamic econometrics, or [Adda, Cooper 2003] – in the field of dynamic economics. Unfortunately, their efforts encompass only quantitative assets, while knowledge, including the creative one, is qualitative, and needs different apparatus. In this paper we propose to use temporal logics, built-in the temporal knowledge base system, because they directly capture time. More information on various temporal logics may be found e.g. in [van Benthem 1995; Klimek 1999; Fisher et al. 2005].

3. Related work

In the literature there are many methodologies concerning expert systems, among others [Michalik 2014, p. 136]:

- Blackboard architecture,
- KADS and CommonKADS,
- HyM for hybrid systems,
- Protégé,
- CAKE.

It must however be noted that the above mentioned methodologies have been created for expert systems, while the proposed intelligent system is not a typical ES (expert system). In the context of its architecture, it is worth considering the blackboard architecture, which is by some authors understood as a knowledge engineering methodology [Kendal, Creen 2007]. This enables to explicitly represent knowledge and its structure in a rule-based system (and the proposed temporal intelligent system is a rule-based one). It may be acknowledged that a postulated division of a system's knowledge base into several sub-bases means implementing the blackboard architecture and achieving its assumptions. The advantages of such an approach are as follows[1]:

- possibility of using the creative knowledge from many participants of the creative process,
- groupworking, and brainstorming support,
- easy implementation of creative knowledge chunks in a formalized manner,
- possibility of differentiating knowledge representation forms, and ways of reasoning (i.e. the possibility of using more than one temporal formalism),
- facilitation of processing the creative knowledge coming from heterogeneous sources – that is knowledge created in various ways, by different means, and during different stages of the organizational creativity process.

The second interesting methodology is CAKE (Computer Aided Knowledge Engineering), elaborated by Michalik. A detailed description of CAKE may be found in [Michalik et al. 2013; Michalik 2014]. Its advantages are similar to those of the blackboard methodology:

- use of the blackboard methodology (with all its advantages),
- easy management of heterogeneous knowledge sources,
- support of groupworking,
- automatic control of formalized creative knowledge code,
- knowledge base editor,
- a package of wizards facilitating the coding process of the acquired knowledge.

It has to be pointed out, however, that the knowledge coding formalism embedded in the CAKE system, has no temporal references.

We have discussed in more detail only two methodologies, namely the blackboard and the CAKE, because of two reasons. First, they would be the most appropriate – in our opinion – for implementing an intelligent system supporting organizational creativity if the system would not contain any temporal component. Second, they are – again in our opinion – the most interesting ones. Obviously the choice is purely subjective.

It is also important that the aforementioned methodologies relate mainly to building expert systems, while the guidelines needed for a temporal intelligent system has also to take into account the processes of implementing the system in a creative organization. Therefore it is not possible to directly use any of the aforementioned methodologies[2], and a new one has to be developed, suited to the task of supporting organizational creativity by a temporal intelligent system. Two very important questions thus arise.

[1] Based on [Michalik 2014, p. 139].

[2] Speaking of "intelligent systems" as a whole, there are so many various kinds of them that probably there is no universal methodology to build such a solution, maybe only a very general waterfall model would apply.

First, the proposed system is an intelligent one, containing at least one temporal knowledge base, therefore the implementation guidelines has to make use of (but not copying directly) existing methodologies for implementing such systems, as such as expert ones.

Second, the main aim of the system is to support organizational creativity, therefore the most important system elements are user interface and knowledge base. The first enables both adding creative knowledge to the system, and querying this kind of knowledge, the second is needed in the representation and reasoning layers. The proposed guidelines should accommodate also these elements.

The implementation guidelines for a temporal intelligent system has to be conformable to a temporal intelligent system's lifecycle. We propose the following lifecycle for the system (adapted from [Infernetica 2012]):

1. Problem identification, and definition of users' needs.
2. System's formal specification, encompassing dialogues with users.
3. Definition of knowledge sub-bases, and general knowledge base structure and scope, choice of knowledge representation technique(s), creation of reasoning algorithm.
4. Creative knowledge acquisition.
5. Prototype creation and verification.
6. System coding and testing.
7. System maintaining and development – principally the creative knowledge bases and user interface.

The implementation guidelines for the temporal intelligent system cover points 1, 2, 4-6, and 7 of the proposed system's lifecycle. As we will show in the next section of the paper, the proposed implementation guidelines are not a simple copy of the system lifecycle because they are adapted to the nature of the creative processes in an organization. For example, stage no. 3 seems to be omitted in our guidelines, in fact it is present in a tacit way in such steps as knowledge analysis and modeling, knowledge implementation, and finally knowledge verification and validation.

The guidelines should be focused primarily on the creative knowledge (its continuous acquisition and representation), and on user interface. Therefore its main elements are creative knowledge engineering, and system engineering, with the emphasis put on interface design and prototyping. The general structure of the proposed guidelines is presented in Figure 1.

4. Implementation guidelines details

The proposed guidelines have been inspired by other knowledge engineering methodologies for the process of knowledge management – particularly by the work [Yazdanpanah, Sadri 2010] – and by classical, fundamental methodologies for implementing expert systems: [Waterman 1986, pp. 135-139; Hayes-Roth et al. 1983, p. 139]. Obviously it was not possible to directly merge the existing models, the proposal concerning knowledge engineering had to be remodeled in the context of organizational creativity process, while the methodologies for implementing expert systems had to be adapted to the temporal intelligent system, and its main task.

The guidelines for implementing a temporal intelligent system, presented in Figure 1, start with the group of activities concerning the capturing and modeling of creative knowledge. At this stage it is essential to discover the creative processes running within the team of employees involved in organizational creativity. This will enable identifying the needs concerning the creative knowledge and its usage by an organization (or team). Having this information, the next step of the guidelines is to choose and/or design tacit creative knowledge acquisition methods, as well as to acquire explicit creative knowledge. This is so because we assume that the creative knowledge, as any other kind of knowledge, may be divided into tacit and explicit. Next, it is necessary to identify (with the aid of previously gathered information) tacit knowledge, and sources of explicit knowledge, and to acquire both types of creative knowledge. Only then it is possible to model and analyze the creative knowledge which is to be incorporated in the temporal intelligent system.

During each stage of the proposed guidelines, especially during the creative knowledge engineering stage, it is indispensable to closely cooperate with system users, that is the employees involved in the process of organizational creativity. Without them it is impossible to identify and to acquire tacit knowledge. Moreover the system will be useful only if people want to use it.

The employees' willingness to work with the system can be investigated before implementing it, using for example the modified version of willingness test, proposed by Ear Hadden – originally for the methodology of implementing data warehouses. The test is presented in [Januszewski 2012, pp. 96-97]. Its version modified for the needs of the hereby proposed guidelines could incorporate the following sample factors:

- accessibility of good quality explicit knowledge sources (e.g. schemas describing the brainstorming process);
- understanding and acceptance by potential system users of the aim of building the system supporting organizational creativity;
- possibility of identifying queries concerning creative and situational knowledge which is to be gathered by the system;
- existence of organizational culture promoting organizational creativity;
- good mastery of the proposed computer technology by the computer team;
- endorsement of the proposed system by the strategic management members, and their willingness to participate in its development and implementation.

We agree with [Stokalski 1998], that if in the majority of the above listed points the answer is negative, it is necessary to rethink the organization's readiness to build the system (in this case a temporal intelligent system), before undertaking any concrete activities.

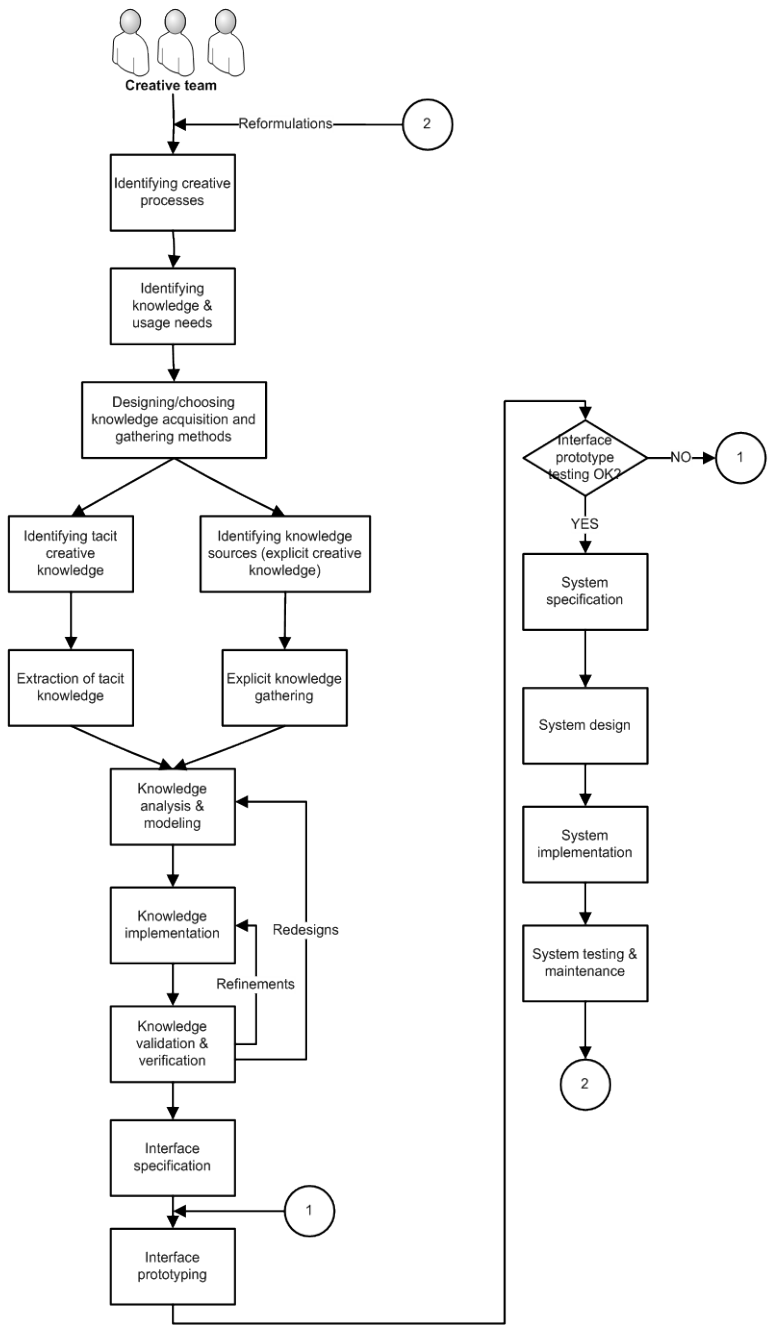

Figure 1. Schema of temporal intelligent system implementation guidelines

Source: own elaboration.

Activities concerning creative knowledge modeling, implementation, and verification are absolutely crucial, therefore in the proposed guidelines there is a possibility to return to the previous stages in order to refine knowledge representation and implementation, or even to completely change the design of the knowledge model.

The next crucial element of the proposed guidelines is the development of the user interface. The interface is fundamental because through the GUI (graphical user interface) users will load creative and situational knowledge into the system, and will also get information on the gathered knowledge, its changes, evolution, or possible development directions. This is why it is so important to properly establish the users' needs, and to take the time to interface specification, prototyping and testing. Only if the tests are passed, it is possible to move to other activities, concerning system's engineering. In our guidelines we propose the classical process of system's engineering, consisting of the system's specification, design, implementation, testing, and maintenance. Obviously, during the maintenance process a continuous system development is assumed because of organizational creativity dynamics, therefore the proposed guidelines allows for reformulations concerning the users' needs for creative knowledge and/or system's tasks.

It also has to be explained why activities concerning the system's specification, design, and implementation are placed at the end of the guidelines, which differs from the classical implementation methodologies for intelligent systems. As has been already said, the main task for the temporal intelligent system is to support organizational creativity, so its most essential elements are temporal creative knowledge base(s) and GUI. Thus the guidelines is focused on these elements. Activities concerning the system's engineering are also important, but are of an ancillary nature regarding temporal KB (knowledge base), creative knowledge management and GUI design.

5. Concluding remarks

In the paper the guidelines for implementing a temporal intelligent system supporting organizational creativity has been presented and discussed. The new guidelines are needed because due to the dynamic characteristics of organizational creativity and to the architecture of the system (mainly its temporal elements as the reasoning engine and temporal representation layer), the most outstanding classical methodologies cannot be directly used and have to be re-created. Thus, the proposed guidelines originates in some of the existing methodologies, but at the same time it is a completely new approach to the system's implementation.

The next research steps will consist of formalizing some examples of dynamic creative knowledge, and of attempts to build a prototype of the temporal intelligent system.

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