Towards Agent-based Architecture of Distributed Knowledge-driven Information Systems

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Abstract

A problem of knowledge management in information systems designed for open heterogeneous environments is considered in the paper. Agent approach is discussed as a design foundation and technological solution supporting the realization of such systems. A generic architecture of the system with *explicit knowledge* is proposed to aid the construction of decentralized decision-support systems. Selected implementation details of the realized platform for rule-based knowledge exchange conclude the work.

Keywords: multi-agent systems, knowledge management.

1 Introduction

Tremendous development of computer devices and software tools leads to newer and newer solutions for computer systems architecture oriented to various fields of application. Problems of knowledge acquisition and exchange (management of knowledge in general) create new directions of research and technology development, and seem to be *signum temporis*. In consequence, more and more resources are devoted to the design and implementation of systems that deal with these problems and provide adequate functionality. Effective operation of such systems requires great flexibility, in particular, ability to follow dynamic changes of demand for services. Application of artificial intelligence methods and new software techniques opens possibility to build dedicated mechanisms that consist in adaptation of a structure and organization of the system in order to widen (deepen) an offer and gain better quality of services.

In the paper some aspects related to the architecture of a system with a large variety of information resources are considered. The aspects deals with both their content as well as modes of their utilization. Such a system can be characterized briefly as an easily extensible (modified) platform that organizes co-operation of components implementing these information resources. It is assumed that the components may be built at different moments of time, under different conditions, and using computer technologies (tools) that did not keep exactly the same standards and, in consequence, are hardly integrated. In order to make the co-operation of the components possible as well as to facilitate use of the system by users of different profiles, providing possibly full knowledge about the components and platform in a symbolic and processable form is assumed. In this way a formal basis for the architecture becomes the idea of *systems with explicit knowledge* proposed in [4].

2 Knowledge management

The specific feature of decentralized information systems is the operation of information (data as well as knowledge), which not only comes from

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different sources but simultaneously may have different thematic fields and levels of details as well as be variously structured and interpreted. This feature inflicts essential problems in stages of both designing and utilisation of such systems. Therefore, a key role in the regular work of the systems plays the management of the resources understood here as the choice of suitable for the user's needs, sources of data and knowledge as well as modes of their utilisation.

Accepting, according to the status quo, that the creation or modification of the resources can be carried out autonomously, one needs to define metaknowledge describing these resources individually and creating a basis for management procedures. A solution acceptable here is to use the ontological description of the considered application area (domain) in the form of the simplified graph of notions. The nodes of it reflect notions representative for data or knowledge available and processed in the system. The edges point at relations between the notions, which in turn occur essential for the system functioning (see fig. 1).

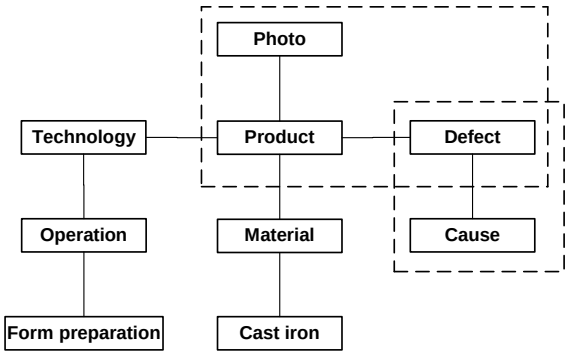

Figure 1: Graph of notions describing indicated sources of data or knowledge, related to the casting defects problem

The graph representation of metaknowledge acquires expressiveness when a concrete domain is considered. Therefore for the sake of illustration, the fragment of a graph is reproduced describing the knowledge resources of INFOCAST—the system dedicated to casting industry [2]. In particular, the areas of knowledge available through the data and knowledge resources relating to: recognizing a defect and the diagnosis of its cause respectively, are singled out with dashed rectangles.

3 Assumptions and design paradigm

The basic function of a system is to provide data and knowledge about the determined, relatively wide area of application. Terms, under which this function is created, can simultaneously be the design foundations of the system:

1. Providing knowledge is carried out in the form of the realization (mutually with the user) of various kinds of technical assessments in the area under consideration. In this matter the system resambles in its function advisory or decision support systems.

2. The assessment is usually based on several data and knowledge sources. At least some of them are accessible. Primary to the assessment performing is combining adequate and suitable—for the user—components of the system.

3. The components—with regard to the both magnitude of the domain and numbers of people engaged in creating them—represent the sources of diverse character and differing maybe somewhat in the sense of knowledge—applied terms and relations among them.

4. In general, the complexity of the assessment may require the arrangement of its course (in the sense of the components used) also in co-operation with the user. Moreover, the use of the component may occur ambiguous to the user or the steering out of the mode of its utilization may be neccessary (especially for a complex component).

5. Besides the integration of data and knowledge the necessity of the components integration arises in the aspect of applied technologies.

The basic decision which is undertaken in turn is the choice of a design paradigm. As it can be taken out easily from the above mentioned assumptions, the agent oriented paradigm [6, 7] fulfils them successfully. The most important features describing a multi-agent system—MAS (the central notion of the paradigm) are expressed in the following statements.

- A task delegated to the system is decomposed by the agents themselves neither by a designer nor a user. Moreover, the reorganization of the system is possible during its work. There is no central control—the system is decentralized.
- The agents can have also their individual (local) goals. Conflicts can arise in effect of contradiction in the local goals as well as with respect to the global goal (of the system).
- Each agent has incomplete knowledge or insufficient abilities to fulfill the task on his own. Data and knowledge are spread over the system. The agents acquire information about the possibilities and goals of other agents. Even complicated patterns of communication are needed for that purpose.
- The environment may change continuously, an agent ought to notice and remember such changes using some internal representation of it.
- The agents operate asynchronously. Each agent may enter the system or give up solving the problem at any moment—the system is open.

Treating components implemented independently, in different time, and with various technologies as legacy systems, allows to capture comparatively easily the technological aspect of integration. The modularization of the system based on agents makes possible also the encapsulation of the components and, therefore, keeping autonomy due to their creators or owners. The paradigm of web services would be competitive in the discussed aspect, insufficiently capacious, however, in the face of complicated and autonomous functions attributed to the components.

The arrangement of agents into the system (here assumed as open one) requires only the elaboration of suitable interactive (communication) protocols and implementing them using a chosen agent platform [1].

The next realization question dealing with the stressed above ability to the elastic self-adapting of the system to the requirements of an assessment needs yet another paradigm, which would generate desirable organization among the agents (including the user). A framework for the subject can be the idea of multi-agent systems with knowledge expressed explicitly [2] or, generally, knowledge-driven systems. Interaction protocols in such systems supervise the exchange of data and knowledge not only in the range directly required by an assessment, but also aiming at organization and adaptation of the system internally as well as to the user's requirements.

4 Flows of information and knowledge. Overall structure of the system

The structure of the system comprises three types of agents. They constitute three layers, that process gradually the idea of an assessment, maybe not strictly defined, in order to obtain the set of acting components (see fig. 2).

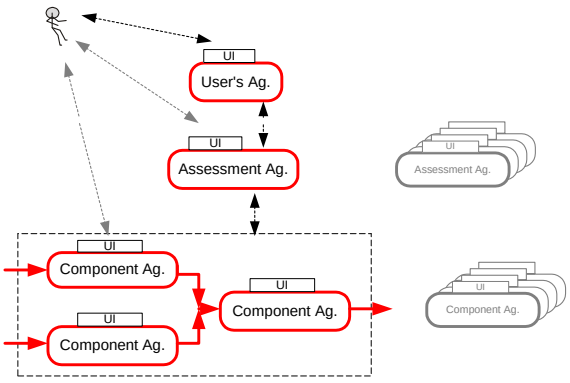

Figure 2: Flows of information and knowledge in the system

The user's agent operates in the first layer. As the result of a preliminary dialogue with the user the range of the assessment becomes agreed and access to the appropriate assessment agent is organized. If it is needed the dialogue is continued by the assessment agent, that aims to specify deeplier the range of assessment and relate its requirements with the possibilities of the system. At last the repertoire of components as well as connections among them indispensable for the assessment are established and the whole structure is set to operate. Depending on the current possibilities of the system—various assessments that can be done, several such agents occupy the second layer. Agents that encapsulate components occupy the third layer. It is obvious that in a