Knowledge Logistics in E-Business Environment: KSNet-Approach and Advanced Technologies

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**Abstract**

Today an intensive knowledge exchange between participants of the global information environment is required. Along with a large number of distributed knowledge sources representing knowledge in various formats this leads to appearance of a new direction in knowledge management called knowledge logistics. The paper describes Knowledge Source Network configuration approach (KSNet-approach) to knowledge logistics through knowledge fusion. Main principles of the multiagent ontology-driven methodology are given. The most important ideas of the proposed KSNet-approach were implemented and verified via developed research software prototype of the system “KSNet”. Comparison of the system “KSNet” with some other known knowledge/information integration systems is also presented.

**Keywords**

Knowledge logistics, knowledge management, agent-based system, ontology.

1 Introduction

Current trends require using a global business information environment (e-business environment), including end-users and loosely coupled knowledge sources (experts, knowledge bases, repositories, documents, etc.) for decision making. E-business assumes cooperation and open standard-based information/knowledge exchange between all the participants of the e-business environment in a real-time. As a result, there arises a need for acquisition, integration, and transfer of the right knowledge from distributed sources in the right context to the right person in the right time for the right business purpose. These activities were referred to as Knowledge Logistics or KL [Smirnov, et al., 2001b], which is required for global awareness, dynamic planning and global information exchange in e-business environment.

The described here approach to KL through knowledge fusion (KF) called “Knowledge Source Network” (“KSNet”) implies synergistic use of knowledge from different sources in order to complement insufficient knowledge and obtain new knowledge [Smirnov, 2001a].

The developed architecture for the KF system called “KSNet” is based on the described here approach and utilizes such technologies as ontology management, intelligent agents, constraint satisfaction, soft computing, and groupware.

2 Existing Theories and Work

The main principles considered during development of the presented approach and a KF system based on this approach are originated from characteristics of modern e-business applications. These applications widely use ontologies as a common language for business
process / enterprise modelling (Goossenaerts and Pelletier, 2001; O’Leary, 2000; Smirnov, 2001b). Thus, the described approach is focused on utilizing reusable knowledge through ontological descriptions (Guarino and Welty, 2000), with object-oriented constraint network paradigm being considered as a common knowledge representation notation that correlates with semantic metadata representation concept of the Semantic Web project (Semantic Web, 2001).

Application of intelligent agents representing their knowledge via ontologies (Jennings, 2000, Weiss, 2000) was motivated by such requirements to KF systems as flexibility, scalability, and customizability. Multi-agent system architecture, based on FIPA Reference Model (FIPA, 1997–2000) was chosen as a technological basis for definition of agents’ properties and functions.

In order to define an ontology-driven agent-based architecture for the system “KSNet” a number of existing agent-based systems/projects for knowledge/information integration were analyzed (Aguirre, et al., 2001; Jacobs and Shea, 1996; Preece et al., 2000).

3 Research Approach

In the KSNet-approach ontologies are seen as dynamic, object-oriented structures. In accordance with the chosen object-oriented constraint network paradigm of knowledge representation it is defined by object classes, attributes, domains, constraints, and methods that are assumed to exist in some area of interest. The following types of ontologies and their use purposes for KL in the system “KSNet” were identified: top-level ontology (defines general notation of knowledge representation in the system), tasks & methods ontology (contains knowledge about problem solving methods), domain ontology (represents knowledge about a particular domain), application ontology (describes a particular real-world application domain), knowledge source ontology (describes correspondence between knowledge source terms and application ontology terms), and request ontology (describes correspondence between user request terms and application ontology terms). The ontologies are stored in the shared ontologies library. Detailed description of the developed ontology-driven methodology is given in (Smirnov, et al., 2001b).

The multi-agent architecture is described in (Smirnov, et al., 2001a). FIPA-based technological kernel agents used in the system are: wrapper, facilitator, mediator, and user agent. The designed problem-oriented agents and their main tasks are: translation agent (terms translation between different vocabularies), KF agent (operation performance for KF), configuration agent (efficient use of KSNet), ontology management agent (ontology operations performance), expert assistant agent (interaction with experts), and monitoring agent (knowledge sources verifications). Developed collaboration and negotiation scenarios are based on such cooperation protocols as contracts nets and constraint networks.

The most important ideas of the KSNet-approach were implemented and verified via development of the research software prototypes of the problem-oriented agents (figure 1). These include: ontologies library maintenance by ontology management agent (Internet-based system “Web-DESO” with a feature of DAML-based ontologies import/export), knowledge source ranking by monitoring agent (group decision support system “MultiExpert”), KSNet configuration by configuration agent (genetic algorithm implementation via MS Visual C++), and constraint network processing by KF agent (based on “ILOG Configurator” constraint satisfaction technology (ILOG, 2001)).
4 Findings

The comparison of the developed approach with some other knowledge/information integration approaches/projects is given in Table 1. The major advantages related to the presented here aspects of the KSNet-approach to KL and developed prototype of the system “KSNet” are presented below:

![Figure 1: Main tasks and technologies of problem-oriented agents](image-url)
Table 1: Comparison of the system “KSNet” with existing knowledge/ information integration systems

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>KRAFT</th>
<th>InfoSleuth</th>
<th>KSNet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Languages and formats used</td>
<td>KQML, P/FDM, CoLan, CIF</td>
<td>Initially KQML, KIF; currently OKBC. Initially ODBC; currently JDBC.</td>
<td>KQML, KIF, DAML+OIL, MS Visual C++, ILOG, MS Visual FoxPro, HTML, JavaScript</td>
</tr>
<tr>
<td></td>
<td></td>
<td>LISP, CLISP, LDL+, Java, C/C++, Netscape</td>
<td></td>
</tr>
<tr>
<td>Supported sources</td>
<td>Any available information sources for which appropriate processing mechanisms exist</td>
<td>Initially databases; currently any available sources for which appropriate processing mechanisms exist</td>
<td>Any available sources for which appropriate processing mechanisms exist</td>
</tr>
<tr>
<td>Relationships between ontologies</td>
<td>Hierarchy</td>
<td>Mapping of sources ontologies to the system ontology</td>
<td>Mapping of sources ontologies to application ontologies</td>
</tr>
<tr>
<td>Peculiarities</td>
<td>Data and constraints are processed</td>
<td>The network of interacting agents is developed; mechanisms of messages interchange in multi-agent systems are described</td>
<td>Object-oriented constraint network paradigm for knowledge representation; ontologies are stored in the common ontologies library</td>
</tr>
<tr>
<td>Multiagent architecture</td>
<td>FIPA-based with peer-to-peer interaction</td>
<td>FIPA-based with mediating interaction</td>
<td>FIPA-based with mixed peer-to-peer &amp; mediating interaction</td>
</tr>
<tr>
<td>Case study</td>
<td>Virtual enterprises</td>
<td>Environmental Data Exchange Network (EDEN) project</td>
<td>E-business, virtual enterprises</td>
</tr>
</tbody>
</table>

5 Conclusion

In the face of globalisation in the business and worldwide increasing competition the technology of KL is useful for enabling collaboration between global e-business environment members. The ontology-driven agent-based approach for KF processes is an innovative branch in KL. It enables utilizing heterogeneous knowledge sources (due to implementation of top-level ontology, wrapper, translation and ontology management agents), provides scalability (due to compatibility with common standards such as FIPA, DAML, etc.), and allows rapid knowledge search (due to knowledge mapping and reuse).
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References


