Knowledge Representation, Modelling and Processing in Modern Semantic Systems

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Abstract: Modern intelligent applications based on semantic technologies constitute an interesting class of Knowledge-Based Systems. The paper gives an overview of the methods and tools used in semantic systems and presents the research concerning adaptation of well-founded solutions for Rule-Based Systems to the semantic systems conditions. Theoretical solutions as well as practical implementations are briefly discussed. Outline of future directions and research problems is given.

Keywords: semantic technologies, knowledge modelling, representation and reasoning, rule-based systems, ontology-driven systems, intelligent systems

Semantic technologies have gained a steadily increasing popularity in the field of intelligent systems over the last decade. Knowledge representation and reasoning based on explicit metadata and ontologies expressed in a standarized way opens up possibilities of processing knowledge in distributed environment. Modern Knowledge-Based Systems (KBS) explore "new ways and methods of acquiring, organizing and spreading knowledge" in the environment of increasing capacity [1]. While exploring new possibilities of the Semantic Web and semantic systems, it is worthwhile to consider how well established and grounded solutions can be adapted or integrated.

1. Semantic Technologies

Semantic technologies [2] work on different levels of abstraction. At the lowest level, existing encoding and serialization methods are used, to provide unified representation of resources. Using the unified representation, basic semantic layer is introduced. Main method of this layer is ascribing semantic metadata that describe relations among resources (documents, people, object, places etc.). Such a representation, which forms a sort of a semantic graph, is universal and flexible. To organize the metadata into structures and express more information (classification of objects, relations between whole classes of objects etc.), ontologies of different kinds are used. These divide into upper-level ontologies, domain and task ontologies, and most specific – application ontologies. Even more expressive knowledge representation can be achieved with the use of rules. They are able to express complex relations among classes of objects, as well as introduce some sort of dynamics to the Knowledge-Based System. Integrating ontologies with selected sort of rules is an active research area in the Semantic Web community.

2. Modern Semantic Systems – Examples

There are several examples of application of the Semantic Web concepts and technologies. An interesting direction is the development of ontology-driven systems, where an ontology is the core of the system, determining its knowledge and performance. Such systems can be used in various domains. An example is a system for citizen safety in urban environment developed within the EU FP7 project INDECT (`http://indect-project.eu`). The system described in [3] is a knowledge-based application combining database technologies with ontological representation and reasoning. While fundamental (declarative) knowledge is stored in an ontology that can be reused across application boundaries, operational facts describing changing traffic conditions are stored in a database.

Another important application of the semantic technologies are Semantic Wikis (see `http://semanticweb.org/wiki/Semantic_wiki`). They combine the accessible and user-friendly environment characteristic of regular wiki systems with improved possibilities of knowledge representation. Knowledge representation and reasoning methods vary between different implementations of the semantic wikis. Basic semantic annotations allow users to assign categories to wiki pages, define attributes of the described objects and relations between them. Navigation and querying enriched in this way allow semantic wikis to serve as semantic encyclopedias in various domains. A proposal of a semantic wiki for dieticians has been formulated in [4].

More advanced KR methods may be introduced to this class of systems. A semantic knowledge-based wiki Loki [5] provides diverse knowledge acquisition methods, while using a unified underlying representation based on logic. This enable to integrate the system with other tools and solutions. Loki is a platform for knowledge engineering [6] and a potential platform for knowledge verification [7].

3. Integrating Rule-Based Solutions with Semantic Technologies

3.1. Rule-Based Systems and Technologies

Reasoning beyond classification tasks and queries is possible thanks to knowledge representation based on rules. Well established solutions for Rule-Based Systems (RBS) include formalization of the representation [8] as well as the whole process of knowledge engineering [9], advanced algorithms for modularized rule bases [10] and verification of RBS [11]. It is worthwhile to investigate how the semantic systems could benefit from the achievements of the

RBS methodologies. The complete design and verification framework for hybrid intelligent systems HaDEs [12] has been used to implement prototype solutions.

3.2. Research Directions and Results

Research on integration of the RBS solutions and semantic technologies have been conducted on several levels. First of all, possibility of integration of the logical foundations of a class of RBS and ontologies have been investigated. The most widely used formalism for ontologies are Description Logics (DL) [13]. For a formalized description of RBS, the ALSV(FD) Attribute Logic [14] has been used. An integration proposal for a hybrid formalism, supported by a dedicated language DAAL (Description and Attribute Logics), has been described in [15].

Based on this proposal, a prototype implementation of a system combining ontology and rule reasoning called Pellet-HeaRT has been proposed in [16]. Pellet is a widely used tool for reasoning in DL-based ontologies, while HeaRT [17] is a dedicated rule engine able to operate in various inference modes on modularized rule bases.

Another research direction is enhancing semantic knowledge-based wikis with rule reasoning. To this end, the HeaRT engine has been embedded in the Loki system [18]. The resulted system combines the flexibility of the semantic representation with strong rule-based knowledge representation and reasoning. Knowledge engineering possibilities in such a hybrid system has been recently described in [19].

4. Summary and Outlook

New context of the systems equipped with semantic technologies has been explored in order to investigate possibilities of adapting solutions originally developed for rule-based systems. Integration proposal of Attribute Logic and Description Logics has been formulated. A prototype implementation of a hybrid system combining ontology-based representation with rule-based reasoning has been developed. A semantic wiki with unified rule-based representation has been proposed and tested in the field of knowledge engineering.

For future work, issues and challenges of Business Processes and Business Rules [20] are planned to be investigated. Support for Business Process Model and Notation (BPMN) in wiki followed by a possibility of collaborative development of business processess and rules will be analyzed.

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Reprezentacja, modelowanie i przetwarzanie wiedzy w nowoczesnych systemach semantycznych

Streszczenie: Nowoczesne systemy inteligentne, wykorzystujące technologie i języki semantyczne, stanowią interesują klasę systemów opartych na wiedzy. W tym nowym kontekście warto rozważyć wykorzystanie rozwiązań wypracowanych w klasycznych sztucznej inteligencji, w szczególności systemach regułowych. W artykule nakreślono obszar badawczy obejmujący integrację istniejących metod i narzędzi z tego obszaru z rozwiązaniami Sieci Semantycznej. Poruszono zarówno problem integracji wybranych formalizmów stanowiących podstawy logiczne reprezentacji wiedzy w obydwu dziedzinach, jak i praktyczne implementacje systemów.

Słowa kluczowe: technologie semantyczne, modelowanie i reprezentacja wiedzy, wnioskowanie, systemy regułowe, systemy ontologiczne, systemy inteligentne

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