APPLICATION OF ONTOLOGY DESIGN PATTERNS IN THE DEVELOPMENT OF SUBJECT ONTOLOGIES FOR MULTIDISCIPLINARY REPRESENTATION OF CORPORATE KNOWLEDGE

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ABSTRACT

Article is devoted to the consideration of the issue of increasing the efficiency of the process of description of corporate knowledge by using the technology Ontology Design Patterns, as well as determining the most effective ways to implement this process. The paper considers the peculiarities of practical realization of ODP use to create an ontological description of corporate knowledge of a modern company. As a result of the analysis, the author concludes that the effective use of ontology patterns for the creation of extensive corporate ontologies is possible when ensuring the homogeneity and consistency of private results. To solve this problem, the article describes the process of automatic extraction of contextual information from text collections proposed by the author, based on the use of thematic modelling methods and allowing to increase the efficiency of ontological design.

KEYWORDS

Knowledge Engineering, Ontology Design, Ontology Pattern, Representation Homogeneity, Topic Modelling

1. INTRODUCTION

One of the foundations of the ongoing transition to highly automated technologies in Industry 4.0 is the reliance on knowledge engineering. Semantic modelling, which relies on ontological design procedures, is an effective method of representing knowledge in these processes.

Since creating domain-specific ontologies is a complex and time-consuming task, ways to simplify the creation of ontologies are being actively developed. One effective approach is to use ontological design patterns called Ontology Design Patterns (ODP) [1]. Using ODP allows you to create the resulting ontology by merging individual fragments created based on unified elements. This approach accelerates the processes of ontological design but requires solving the problem of integrating the components of the created ontology. This solution is related to the elimination of ambiguity in the representation of information about objects in ontological design. Such ambiguity can be both terminological and conceptual. This is since various experts form elements of a common ontological description based on their vision of the phenomenon. This strongly hinders the effective use of ODP technology [2]. Such ambiguity can lead to interpretative

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formalization errors, negatively affecting data integration and compatibility. This strongly hinders the effective use of ODP technology for building corporate ontologies.

Research highlights the need to create more rigorous techniques and tools to eliminate the problem of ambiguity in the description. However, many of the proposed solutions remain theoretical and difficult to implement in practice [3]. The lack of effective methods for managing ambiguity that occurs when creating an ODP seriously limits the use of patterns in the implementation of ontological design and reduces the overall effectiveness of systems for semantic description of multidisciplinary fields [4].

Purpose of this work is to develop approaches to overcome the semantic heterogeneity of ontology elements to ensure semantic interoperability in the multidisciplinary description of knowledge in information systems using Ontology Design Patterns (ODP).

2. METHODOLOGY AND DATA

ODPs are documented descriptions of proven solutions to ontological modelling problems.

A general approach to the application of ontological patterns is considered in [1], which describes the technology of ontological development, which is a set of well-established recommendations for the use of ODP. Their use enables specialists in a narrow subject area to correctly describe formalized corporate knowledge and create the necessary subject ontologies for their subsequent collective application, without having specialized expert knowledge in the field. Systematic observations conducted in the framework of specialized studies [5], have shown high efficiency and usefulness of ODP technology.

Lack of a unified standardized representation of patterns leads to the fact that using ODP technologies there are serious difficulties with automatic detection of specific patterns in already created ontologies. The difficulty of automatically detecting patterns seriously slows down the automation of their further use. The problems of unifying the use of productive technologies based on the use of ODP are explained by the fact that the creators themselves consider ODP technology not as a ready-made solution, but only as a methodological basis for companies to create their solutions. Therefore, companies that actively use the creation of interdisciplinary subject ontologies for knowledge management purposes need to independently conduct a large amount of preparatory work to build an internal system for unifying ontological patterns. The described research is devoted to the description and detailing of the directions of such work. At the same time, it is believed that when building basic ontologies of the corporate knowledge space as a methodological basis for creating a multidisciplinary subject ontology, it is most rational to use Information Artifact Ontology (IAO) approaches [6] and Basic Formal Ontology (BFO) [7]. The use of the IAO is aimed at describing the processes of obtaining information and describing information sources and participants in this process. BFO approaches are focused on describing the most common immutable objects and processes.

3. RESULTS

Workflow shown in Figure 1 describes the proposed sequence for creating an extendable corporate knowledge description system-from the initial transition to centralized knowledge representation to the full operational deployment of such a system.

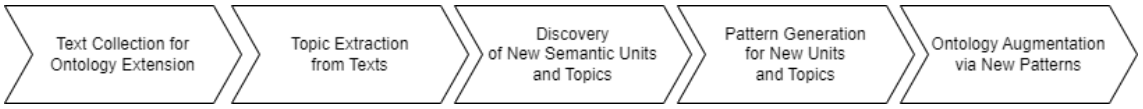

Figure. 1. Five-stage workflow for creating procedures for extendable corporate knowledge description using ODP technology

Generation of the base ontology for the corporate knowledge space involves creating a general description of a mutually consistent set of typical processes and fundamental facts. These are used to represent corporate technologies, describe a company's operations, and include the base domain knowledge ontology, base ontologies for typical corporate processes, typical task and method ontologies, and the ontology of corporate information resources.

Methodology for constructing this base ontology is grounded in BFO, which enables data standardization and facilitates high-level integration [7]. It also ensures a clear definition of concepts and their interrelations—critical for data compatibility within an organization.

Application of the Information Artifact Ontology (IAO) in creating domain specific ontologies ensures structured representation and allows formalization of various aspects of informational artifacts (e.g., content, context, purpose) [8]. This simplifies further integration of created ontologies into corporate knowledge management systems [9].

In planning the first three workflow stages (see Fig. 1), it is essential that the specialists possess advanced competencies in ontology engineering and knowledge management. The following stages involve significant detailing of the corporate knowledge ontology.

Developing rules for generating customized patterns using ODP technology is driven by the need to reduce semantic heterogeneity during the design phase. Methodological recommendations should be prepared for modelling techniques and terminology definitions using previously developed Content Design Pattern guidelines [1,10]. This standardization helps domain experts extend corporate ontologies with uniform templates and reduces the risk of inconsistencies.
At the content pattern creation stage, a large number of domain experts are engaged, using agile ontology engineering techniques that do not require deep knowledge of ontology modelling.

Expanding the corporate ontology involves even broader participation by experts, particularly for integrating multidisciplinary descriptions and validating results. A key challenge is ensuring effective knowledge transfer through visualization tools that support ontology sensemaking [11]. Many such tools exist today [12, 13].

These tools are based on general visual information structuring principles, helping users of varying ontology expertise understand the knowledge model consistently.

4. ANALYSIS OF RESULTS

Proposed approach formalizes the process of creating a multidisciplinary corporate ontology using specialized unified building blocks.

A major advantage of ODP in this scheme is the ability to involve many domain experts-who may not specialize in ontology design-by simplifying the ontology extension and refinement process.

This expansion is only effective if supported by well-developed protocols and methodological guidelines to ensure consistent representation, which is crucial for reliable information system performance [14].

Semantic alignment becomes more complex with ontology expansion, necessitating procedures for aligning new elements with the existing structure. To address this, the workflow in Figure 2 presents a semantic comparison-based approach using automated contextual information extraction.

Source of information about concepts that describe actions, relationships, or phenomena is the document, which in ontological terms contains interconnected semantic units that collectively describe the subject.

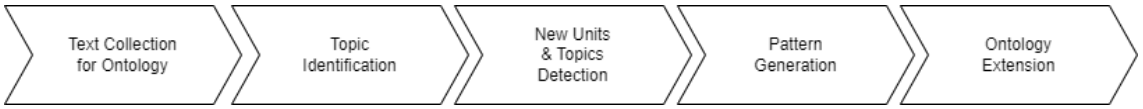

Figure. 2. Five-stage workflow for generating new patterns through automated contextual information extraction

Text collection phase involves gathering documents that describe the phenomenon to be represented in the ontology.

Theme identification phase involves semantic analysis to identify recurring word groups that best describe the document content.

Semantic unit identification phase uses domain-specific semantic dictionaries to detect unique terms or term groups in the texts.

Pattern generation phase creates universal semantic structures based on these units and latent themes.

Ontology enrichment phase incorporates new elements into the corporate pattern library for future use in updating the ontology.

This approach not only enhances semantic consistency but also speeds up the identification of ontology segments needing updates.

5. CONCLUSIONS

The findings of this research support the following conclusions for advancing practical ontology design approaches in corporate knowledge structuring:

- The highest effectiveness of ODP-based ontology design is achieved by involving numerous domain experts working with standardized templates and tools.
- Effective use of ODP for multidisciplinary ontology creation is possible only with consistency and uniformity in partial results, which can be achieved through unified corporate design methodologies.
- The overall consistency and efficiency of ODP-based ontology design can be improved by incorporating contextual information extraction using topic modelling techniques.

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