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Towards a Middle-out Approach for Building Legal Domain Reference Ontology

M. El Ghosh, H. Naja, H. Abdulrab, and M. Khalil

Abstract—This article presents a *middle-out* approach to build legal domain reference ontology for a Legal Knowledge Based System (LKBS). The proposed approach is a combination of *top-down* and *bottom-up* strategies. In particular, we propose to develop legal domain reference ontology, splitted into modules or fragments, based on merging two processes: **Conceptual Modeling Process**, by reusing foundational ontologies (*top-down* strategy) and **Ontology Learning Process** from textual resources (*bottom-up* strategy).

Index Terms—Conceptual modeling, domain reference ontology, legal ontology, modularization, ontology learning.

I. INTRODUCTION

The aim of this article is to present a *middle-out* approach for building legal domain reference ontology for a Legal Knowledge Based system (LKBS). The domain application of this work is the Lebanese penal system. The proposed approach is a combination of *top-down* and *bottom-up* strategies. In particular, we propose to develop legal domain reference ontology splitted into modules or fragments. For this purpose, the development process is based on merging two different processes: 1) *Conceptual Modeling Process* and 2) *Ontology Learning Process*. For the *Conceptual Modeling Process*, we apply the *top-down* strategy which is based on reusing foundational and core ontologies. Meanwhile, the *Ontology Learning Process* is based on the extraction of knowledge from legal textual resources such as the Lebanese Penal Code.

Generally, two types of domain ontologies can be developed: reference and operational [1]. Domain reference ontology is defined as conceptual model that describes clearly and precisely the domain entities. Meanwhile, an operational ontology is a machine readable implementation version of the ontology.

In this article, we focus on developing a domain reference ontology that will be formalized and implemented as an operational ontology in the future work.

The article is organized as follows: In Section II, we start by providing a state of the art about the existing approaches

for building legal ontologies. Section III discusses the related work in this domain. In Section IV, we present the architecture of our proposed *middle-out* approach. Finally, we conclude our work in Section V.

II. EXISTING APPROACHES FOR BUILDING LEGAL ONTOLOGIES

In this section, we study the existing approaches for building legal ontologies. The approaches are organized in two main categories: bottom-up and top-down approaches [2].

- 1) **Bottom-up**: start from the most specific concepts and build a structure by generalization [3]. In this approach, the building process of the ontology usually starts with linguistic study on existing data structures forms (documents, reports, etc.) in order to extract relevant concepts of the domain and relations among them with the semi-automatic support in document analysis (see Fig.1). This approach results in a very high level of detail which makes it difficult to spot commonality between related concepts and increases the risk of inconsistencies [4]. Moreover, the bottom-up approach is limited by developing domain-specific or application ontologies that are not reusable. Meanwhile, it can support the refining and expanding of existing ontologies by incorporating new knowledge emerging from texts [2]. Terminae is an example of bottom-up approach to develop ontologies from textual resources using Natural Language Processing (NLP) techniques [5].

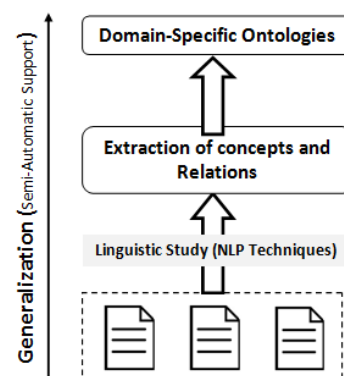


Fig. 1. Bottom-up approaches.

- 2) **Top-down**: start from the most generic concept and build a structure by specialization [3]. In this approach, the building process of the ontology starts by an analysis and study of relevant information sources about the given domain and then modeling the top level concepts which will be refined in next steps (see Fig. 2). This category of

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approaches typically carried out manually by domain experts and lead to reusable and shareable upper level ontologies [2]. Although, it results in better control of the level of detail. However, starting at the top can result in choosing arbitrary high-level categories which lead to a risk of less stability in the model [4]. The methodology of Uschold and Gruninger [4] is an example of *top-down* approach for building ontologies.

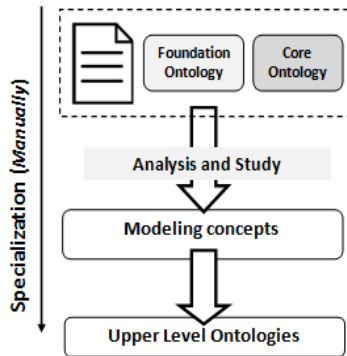


Fig. 2. Top-down approaches.

Therefore, and based on what found in the literature, we conclude that each category of approaches, *top-down* or *bottom-up*, have disadvantages and advantages. For better results in building comprehensive ontologies, there is a need to combine the two categories [2]. This claim is based on the complementary of the two categories which is a fact acknowledged in the literature, specifically in the work of [3], [4] and [6].

What is a Middle-Out Approach?

A *middle-out* approach is a combination of *top-down* and *bottom-up* strategies [4]. In other words, it is an integration of theoretical modeling and text analysis [2]. This approach strikes a balance in terms of the level detail. Detail arises only as necessary, by specializing the basic concepts [4].

Few attempts have been made to build legal ontologies, such as LKIF-Core [7], LOIS [8], OPJK [9], and DALOS [10], by following the *middle-out* approach.

III. RELATED WORK

Our proposed *middle-out* approach tends to combine *top-down* and *bottom-up* strategies in a hybrid *middle-out* approach in order to build legal domain reference ontology. Similar approaches, used to build ontologies in general, are found in the literature and used in the work of [2], [6] and [11].

- 1) **Francesconi and his colleagues 2008** [2]: proposed a methodology, for multilingual legal knowledge acquisition and modeling, which combines *top-down* and *bottom-up* strategies in the work of the DALOS KOS project.
 - *Top-down*: defines the conceptual language-independent structure of the legal domain under consideration on the basis of expert judgment. This structure is modeled as ontology.
 - *Bottom-up*: use of (semi-)automatic NLP techniques for the knowledge acquisition from texts.
- 2) **Saias and Quaresma** [6]: proposed a *middle-out*,

methodology to automatically create a legal ontology from a set of legal documents:

- *Top-down*: Choose an already existent top-level legal ontology.
 - *Bottom-up*: Identification of concepts and its properties using NLP techniques.
- 3) **Pellicer and his colleagues** [11]: proposed a hybrid approach, to build domain ontology in the hydrographical domain.
 - *Top-down*: use of the MENTHONTOLOGY methodology that emphasizes the reuse of existing domain and upper-level ontologies.
 - *Bottom-up*: application of FCA techniques to output a hierarchy of concepts from the feature instances contained in the repositories used as data sources.

IV. PROPOSED MIDDLE-OUT APPROACH

Our main objective is to define an approach that combines *top-down* and *bottom-up* strategies, in a hybrid *middle-out* approach, in order to develop **reusable modularized legal-penal domain reference** ontology.

As aforementioned, the current work is developing domain **reference** ontology for the penal system. Reference ontology, as defined by Falbo [1], is a conceptual model that describes clearly and precisely the domain entities. This kind of ontology is built with the goal of making the best possible description of the domain (legal penal domain in our case).

In the building process of the domain reference ontology, we tend to use the **modularization** activity in order to split the ontology into small fragments or sub-ontologies that are **reusable**.

The proposed approach is a combination of *top-down* and *bottom-up* strategies in a *middle-out* approach. In other words, we tend to combine two different processes: (1) the *Conceptual Modeling Process* and (2) the *Ontology Learning Process* from texts.

- *Top-down*: consists of the definition of the conceptual structure of the legal domain which is modeled as ontology modules (*upper*, *core* and *domain*). In this strategy, reusing other ontologies, that capture similar or complementary knowledge (foundational, upper-level or core-legal ontologies such as UFO [12], LKIF-Core [7]-[13]) can help in building well-founded ontology.
- *Bottom-up*: consists of 1) building the legal concepts and relations among them, by using Ontology Learning methodologies and (semi-)automatic NLP techniques to extract the legal knowledge from textual resources, then 2) modeling this knowledge as a *domain* and, or *domain-specific* ontologies (modules).

Consequently, the architecture of the legal domain reference ontology (Fig. 3) is modularized in four modules which are themselves ontologies (*upper*, *core*, *domain* and *domain specific* or *application*).

At the highest level, the *upper* module represents the most general concepts and relations that cover all the domains (Fig. 4). For instance Act is a common-sense concept for all the domains.

The *core* module provides a definition of structural knowledge in the legal domain. Legal-Act represents any

legal act in all the legal domains (penal, civil, etc.).

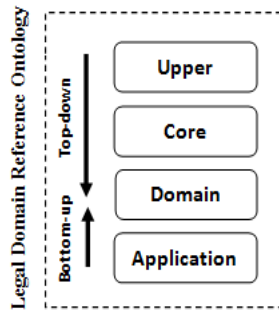


Fig. 3. Architecture of the legal domain reference ontology.

The *domain* module, in turn, describes the conceptualization of the penal domain. The concept *Infraction* represents a specific act for the penal system.

At the lowest level, the *domain-specific* module describes the knowledge of the application part of the penal domain. *Crime* is an instance of *Infraction* and is located in the *application* module of the ontology.

Therefore, and based on this architecture, the *upper* and *core* modules are developed using the *top-down* strategy. The *domain-specific* or *application* module is developed using the *bottom-up* strategy based on textual resources (see Fig.3).

However, the *domain* module can be developed using the two strategies at the same time. In other words, the concepts of the penal domain can be extracted from the textual resources, such as *Infraction*, and can be aligned with the concepts specialized from the top modules (*upper* and *core*).

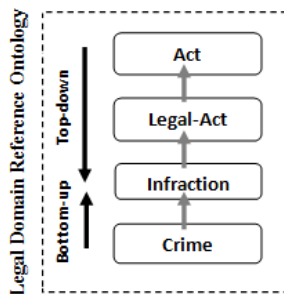


Fig. 4. Architecture of legal concepts.

Effectively, our approach is defined and specified by the following statements:

- 1) Modularize the ontology into small reusable modules or fragments (*upper*, *core*, *domain* and *domain-specific*) which are themselves ontologies.
- 2) **Use of foundational ontologies**, from the start of the ontology building process, to facilitate the ontology development by preventing to reinvent the wheel concerning basic categories and relations [14] and to improve overall quality and semantic interoperability of conceptual models [15].
- 3) **Use of legal-core ontologies**, such as LKIF-Core [7], in the development process of the ontology specifically for modeling the core module. Legal-core ontology is a complete and extensible ontology that expresses the basic concepts that are common across the domains of law and can provide the basis for specialization into domain and domain-specific concepts [16].

- 4) **Use of OntoUML** (UML class diagram profile that incorporates important foundational distinctions made by UFO the Unified Foundational Ontology) as an ontologically well-founded modeling language to support the conceptual modeling process of the ontology [12].

A. Bottom-up Strategy

In this section, we present the *bottom-up* part of the proposed *middle-out* approach which is based on the *Ontology Learning Process* from textual resources. This strategy tends to extract concepts and relations from texts using NLP techniques in order to build the *domain-specific* and *part of the domain* modules.

The context of this work is the Lebanese penal code which is used as the textual resource for term extraction and knowledge acquisition.

Texts resources, usually, contain unstructured data not meaningful for a computer system. Different Natural Processing techniques (such as TreeTagger, GATE, YaTeA, etc.) and (semi-)automatic textual analysis or ontology learning tools (such as OntoGen, ASIUM, Text-To-Onto, Text2Onto and TERMINAE) could be used to facilitate the knowledge acquisition and to support the building process of an ontology from natural language texts by reducing the development time and costs. This process referred to as *Ontology Learning* [17].

In the Literature, there is a diversity of methodologies for *Ontology Learning Process*. We quote the work of [2], [18], [19].

For this part of the *middle-out* approach, we propose the use of the methodology *Terminae* [18]. In *Terminae*, the knowledge modeling is based on the knowledge extraction or terminology extraction from textual resources. This methodology is widely used in projects for the legal domain such as *Legal ontology for a European community legislative text* [20] and a legislative project based on the creation of legal micro-ontologies [5].

In addition, *Terminae* is offered with a tool (TERMINAE) to help the designer to apply the methodology semi-automatically, to extract the legal knowledge from the corpus, and to build the domain or domain-specific modules of the ontology.

For the application of *Terminae*, we defined a legal corpus which is an excerpt of the Lebanese penal code (300 articles). After using NLP tools and linguistics techniques, such as YaTeA, to extract the legal terms and their frequency from the corpus, we obtained a list of 1200 terms (single and multi-word terms).

Although, using TERMINAE, the designer can evaluate the acquired terms with the help of legal expert and link them to the concepts they express (see Table I).

TABLE I: EXCERPT OF LEGAL TERMS EXTRACTED USING NLP TECHNIQUES

Term	Frequency	Concept
Infraction	60	Infraction
Crime	35	Crime
Offense	11	Offense
Violation	10	Violation

Some relationships hold between the concepts extracted

(see Fig. 5).

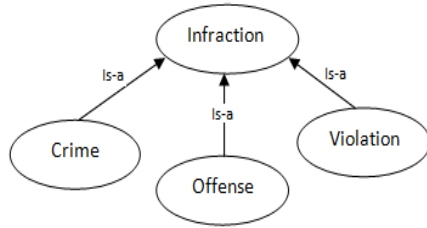


Fig. 5. Relations among extracted concepts.

In this context, we clarify the idea aforementioned in section IV and presented in Fig. 1 and Fig. 2, that part of the concepts of the domain module can be defined using the *bottom-up* strategy. The concepts **Crime**, **Offense** and **Violation** are located in the *domain-specific* module. Meanwhile, the concept **Infraction**, extracted from the corpus using the methodology *Terminae* and the tool TERMINAE, is located in the *domain* module.

Therefore, by applying the *bottom-up* part of the *middle-out* approach, the designer will obtain a list of legal domain-specific and domain concepts and relations among them. These concepts and relations tend to build the *domain-specific* and part of the *domain* modules.

B. Top-down Strategy

In this section, we present the *top-down* part of the *middle-out* approach. This strategy tends basically to build the *upper*, *core* and *domain* modules.

The strategy is based on the definition and (partial) reuse of existent ontologies.

Reuse is considered as a promising approach for Ontology Engineering, since it enables a speeding up of the ontology development process [21].

Typically, we distinguish four main sources for reuse: existing domain ontologies, core ontologies, foundational ontologies and ontology patterns [1]. In our work, we tend to reuse foundational and legal-core ontologies in combination.

Moreover, in the literature, different recent *top-down* approaches are cited, such as SABiO [1] and UPON [22] (see Table II).

TABLE II: SOME RECENT TOP-DOWN APPROCHES

Approach	Development Process
UPON (Unified Process for Ontology Building) (2009)	Requirements, Analysis, Design, Implementation, Test.
SABiO (Systematic Approach for Building Ontologies) (2014)	Requirements, Ontology Capture and Formalization, Design, Implementation, Test.

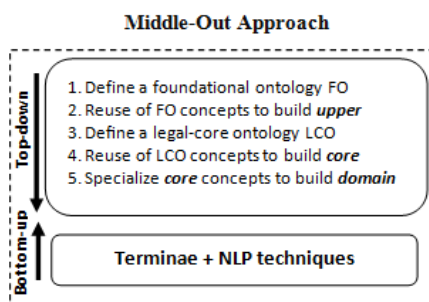


Fig. 6. Steps of the middle-out approach.

Fig. 6 shows our proposed *top-down* strategy which is

constructed in the light of the work of [1] and [6] and organized in five steps.

1) *Define a foundational ontology*. Actually it is a difficult task to choose the right foundational ontology to start the conceptual modeling of the legal reference ontology, because of the diversity of existing foundational ontologies in the domain of ontology engineering, such as DOLCE [23] and UFO [24]. Although, this step depends on different elements such as the purpose of building the domain ontology and the applicability domain.

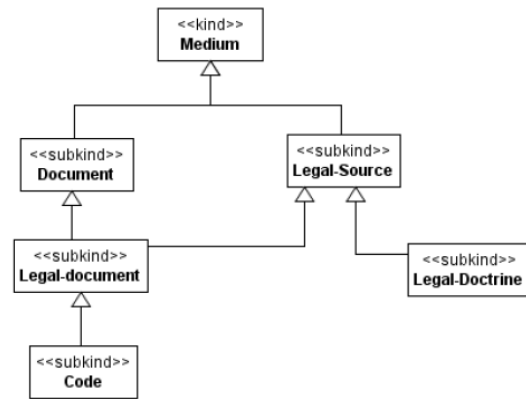


Fig. 7. Representing lkif-core concepts in ontouml.

At this point, we can clarify that our work is applied in the legal domain and more specifically in the penal system. In addition to this, the purpose of building the legal domain reference ontology is to make this reference ontology reusable as much as possible for LKBS and reasoning systems in the legal domain. Therefore, after studying the main concepts of some foundational ontologies, we found that UFO is the most convenient foundational ontology to use in our work. Specifically, we can cite some basic concepts in UFO that will be considered as foundations for the conceptual modeling of the legal penal domain reference ontology: **Agent**, **Intentional_Moment**, **Action**, **Event**, **Normative_Description**, **Goal**, and **Situation**.

- 2) *Reuse and extend the concepts and relations of the defined foundational ontology* in order to identify the main concepts and relations of the *upper* module. This step can be processed by analogy, specialization or analogical analysis [1].
- 3) *Define legal-core ontology*. Although it is a difficult task to choose the right legal-core ontology. We cite some legal-core ontologies found in the literature: LKIF-Core, LRI-Core, and FOLAW. Actually, LKIF-Core is the most recent legal-core ontology and contains essential legal concepts such as **Medium**, **Document**, **Legal_Source**, **Legal_Document**, and **Code**.
- 4) *Reuse and extend the concepts and relations of the defined legal-core ontology by specialization*, in order to define the concepts and relations of the *core* module.
- 5) *Specialize the concepts of the core module to define new concepts and relations for the domain module*.

Therefore, by applying these steps, the designer will obtain a list of concepts and relations organized in modules based on their level (general, legal or penal).

Since we decided to start the conceptual modeling process,

of the legal domain reference ontology, based on the foundational ontology UFO and using the modeling language ONTOUML, the representation and classification of the concepts and relations of all ontology modules (*upper*, *core*, *domain* and *domain-specific*) will be according to the types defined in ONTOUML such as *Kind* and *Subkind*. The Fig. 7 shows the classification of LKIF-Core concepts according to UFO concepts *kind* and *Subkind*.

Note that **Kind** represents a *rigid* concept, i.e., a class that applies necessarily to its instances. **Subkind** is a subtype of **kind** and is also *rigid*.

V. CONCLUSION

In this article, we have presented an overview on approaches for building legal ontologies and a proposed *middle-out* approach for the development of legal domain reference ontology, specifically for the penal system. The main purpose for building this legal domain reference ontology is to obtain a reusable ontology for LKBS and reasoning systems in the legal domain. For this reason, the main work was modularizing this ontology, and splitting it into small fragments or modules that are reusable. In addition to this, we focused on reusing foundational ontologies and legal-core ontologies in the conceptual modeling process of the reference ontology. Although, to make this ontology the most possible representative and reflective to the real penal domain, we used Ontology Learning Process techniques to extract the knowledge, concepts and relations, from textual resources, such as the penal code.

The proposed *middle-out* approach represents the merging process of the two different processes, the conceptual modeling (*top-down* strategy) and the Ontology Learning Process (*bottom-up* strategy).

This approach raises several perspectives such as:

- Define the alignment, or merging, process of the different modules (*upper*, *core*, *domain* and *domain-specific*).
- The possibility to use ontology patterns during the ontology conceptual modeling activity.

REFERENCES

[1] R. Falbo, "Systematic approach for building ontologies," presented at the 1st Joint Workshop ONTO.COM/ODISE on Ontologies in Conceptual Modeling and Information Systems Engineering co-located with 8th Conference in Formal Ontology in Information Systems, Rio de Janeiro, Brazil, September 21, 2014.

[2] E. Francesconi, S. Montemagni, W. Peters, and D. Tiscornia, "Integrating a bottom-up and top-down methodology for building semantic resources for the multilingual legal domain," in *Proc. Legal Texts. Where the Language of Law Meets the Law of Language*, LNAI 6036, Springer, Berlin, 2010, pp. 95-121.

[3] F. Gandon, "Distributed artificial intelligence and knowledge management: Ontologies and multi-agent systems for a corporate semantic web," Scientific Philosopher Doctorate Thesis in Informatics, INRIA and University of Nice Sophia Antipolis, Doctoral School of Sciences and Technologies of Information and Communication, 2002.

[4] M. Uschold and M. Gruninger, "Ontologies: Principles methods and applications," *The Knowledge Engineering Review*, vol. 11, pp. 93-136, 1996.

[5] S. Despres and S. Szulman, "Terminae method and integration process for legal ontology building," *Engineering and Other Applications of Applied Intelligent Systems*, pp. 1014-1023, 2006.

[6] J. Saias and P. Quaresma, "A methodology to create legal ontologies in a logic programming based web information retrieval system," in *Proc. Law and the Semantic Web Legal Ontologies, Methodologies, Legal Information Retrieval and Applications*, Springer, Berlin, 2004, pp. 185-200.

[7] R. Hoekstra, J. Breuker, M. D. Bello, and A. Boer, "The lkiif core ontology of basic legal concepts," in *Proc. the Workshop on Legal Ontologies and Artificial Intelligence Techniques, CEUR Workshop Proceedings*, 2007, vol. 321, pp. 43-63.

[8] W. Peters, M. T. Sagri, and D. Tiscornia, "The structuring of legal knowledge in LOIS," in *Proc. 10th International Conference of Artificial Intelligence and Law*, Bologna, Italy, 2005.

[9] N. Casellas, "Modelling legal knowledge through ontologies. OPJK: The ontology of professional judicial knowledge," Ph.D. thesis, Faculty of Law, Barcelona, 2008.

[10] T. Agnoloni, L. Bacci, E. Francesconi, W. Peters, S. Montemagni, and G. Venturi, "A two-level knowledge approach to support multilingual legislative drafting," *Law, Ontologies and the Semantic Web. Channelling the Legal Information Flood. Frontiers in Artificial Intelligence and Applications*, Amsterdam, pp. 177-198, vol. 188, 2009.

[11] F. J. Lopez-Pellicer, L. M. Vilches-Blazquez, J. Noguera-Iso, O. Corcho, M. A. Bernabe, and F. A. Rodriguez, "Using a hybrid approach for the development of an ontology in the hydrographical domain," in *Proc. 2nd Workshop Ontologies for Urban Development: Conceptual Models for Practitioner*, Italy, 2008, pp. 43-56.

[12] G. Guizzardi, "Ontological foundations for structural conceptual models," Ph.D. Thesis Series, No. 05-74, 2005.

[13] R. Hoekstra, "Ontology representation: design patterns and ontologies that make sense," Ph.D. thesis, 2009.

[14] M. Keet, "The use of foundational ontologies in ontology development: An empirical assessment," in *Proc. 8th Extended Semantic Web Conference*, Greece, 2011, vol. 6643, pp. 321-335.

[15] G. Guizzardi, "The role of foundational ontology for conceptual modeling and domain ontology representation," in *Proc. 7th International Baltic Conference on Databases and Information Systems*, 2006, pp. 17-25.

[16] M. Doerr, J. Hunter, and C. Lagoze, "Towards a core ontology for information integration," *Journal of Digital Information*, vol. 4, no. 1, February, 2006.

[17] J. Lehmann and J. Voelker, "An introduction to ontology learning," in *Perspectives on Ontology Learning*, J. Lehmann and J. Voelker, Ed., AKA / IOS Press, 2014.

[18] N. Aussenac-Gilles, B. Bibow, and S. Szulman, "Corpus analysis for conceptual modeling," presented at 12th International Conference on Workshop on Ontologies and Text, Knowledge Engineering and Knowledge Management: Methods, Models and Tools, 2000, France, Springer.

[19] B. Bachimont, A. Isaac, and R. Troncy, "Semantic commitment for designing ontologies: A proposal," in *Proc. 13th International Conference, EKAW*, 2002, vol. 2473, pp. 114-121.

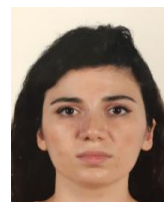
[20] S. Despres and S. Szulman, "Construction of a legal ontology from a European community legislative text," *Legal Knowledge and Information Systems*, pp.79-88, 2004.

[21] F. Ruy, C. C. Reginato, V. A. Santos, R. Falbo, and G. Guizzardi, "Ontology engineering by combining ontology patterns," in *Proc. 35th International Conference on Conceptual Modeling (ER 2015)*, Stockholm, 2015, vol. 9381, pp. 173-186.

[22] A. Nicola, M. Missikoff, and R. Navigli, "A software engineering approach to ontology building," *Information Systems*, vol. 34, pp. 258-275, April 2009.

[23] C. Masolo, S. Borgo, A. Gangemi, N. Guarino, and A. Oltramari, *Wonderweb Deliverable D18 (ver. 1.0)*, *Ontology Library*, 2003.

[24] G. Guizzardi and G. Wagner, "A unified foundational ontology and some applications of it in business modeling," *CAiSE Workshops*, vol. 3, pp. 129-143, 2004.



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