



Semantic Model for the Legal Maintenance: the Case of Semantic Annotation of France Legislative and Regulatory Texts

Julien Breton, Mokhtar Boumedyen Billami, Max Chevalier, Cassia Trojahn

► To cite this version:

Julien Breton, Mokhtar Boumedyen Billami, Max Chevalier, Cassia Trojahn. Semantic Model for the Legal Maintenance: the Case of Semantic Annotation of France Legislative and Regulatory Texts. Workshop on Methodologies for Translating Legal Norms into Formal Representations (LN2FR 2022) in conjunction with JURIX 2022, Dec 2022, Saarbrücken, Germany. hal-04212544

HAL Id: hal-04212544

<https://ut3-toulouseinp.hal.science/hal-04212544>

Submitted on 20 Sep 2023

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.



Distributed under a Creative Commons Attribution 4.0 International License

Semantic Model for the Legal Maintenance: the Case of Semantic Annotation of France Legislative and Regulatory Texts

Julien Breton^{1,2}, Mokhtar Boumedyen Billami²[0000–0003–4428–4298], Max Chevalier¹[0000–0001–5402–6255], and Cassia Trojahn¹[0000–0003–2840–005X]

¹ IRIT, Toulouse, France

`firstname.lastname@irit.fr`

² Berger-Levrault, Labège, France

`firstname.lastname@berger-levrault.com`

Abstract. In different domains, compliance with legal documents about industrial maintenance is crucial. Legal industrial maintenance is the legal commitment of a company to control, maintain and repair its equipments. With the evolution of legal texts, companies are increasingly adopting automatic processing of legal texts in order to extract their key elements and to support the task of analysis and compliance. To perform such a task of knowledge extraction, a number of state-of-the-art proposal relies on a semantic model. Based on existing models from both legislative and industrial maintenance domains, we propose a new semantic model for the legal industrial maintenance: SEMLEG (SEmantic Model for the LEGal maintenance). This model results from an analysis of documents extracted from the Légifrance French governmental website.

Keywords: Semantic model · legal maintenance · industrial maintenance.

1 Introduction

In December 2021, the CNIL (French National Commission for Computing and Liberties)³ has applied a record penalty against Google of 150 million euros for non-compliance with the law. This example shows that companies are obliged to respect the law and risks, otherwise, severe sanctions can be applied. In order to carry out a legal monitoring, companies usually rely on human expertise to manually analyse legal documents. As highlighted in [17], in France, there are “more than 10,500 laws, 120,000 decrees, 7,400 treaties, 17,000 community’s texts, tens of thousands of pages in 62 different codes. Some are constantly being modified: 6 modifications per working day for the 2006 Tax Code”. Therefore, a first problem is the quantity of legislative documents and their constant updates. Secondly, the domain-specific vocabulary can make it difficult to understand the

³ <https://www.cnil.fr/>

legislation. Third, the abundance of cross-references in legal documents makes reading them tedious.

In order to address these issues, companies and the scientific community consider the automated processing of legislative documents. With the advantage of helping to process massive information, the processing of such documents aims to extract and to represent legislative rules. In this paper, we focus on structuring the legal maintenance information through a semantic model: SEMLEG (SEmantic Model for the LEGal maintenance). These extraction and structuring objectives have concrete applications. As an example, elevator maintenance technicians can be assisted by automated tools that analyse legal documents and propose to them a synthetic view of the elevator maintenance plan.

The rest of this paper is organized as follows. Section 2 presents a motivating example to illustrate our goals. Section 3 introduces the main related works on knowledge extraction from textual documents, with a focus on legislative semantic models and on semantic models of industrial maintenance. Section 4 presents SEMLEG model, which aims to cover the domain of legal industrial maintenance. Finally, the paper is concluded in Section 5.

2 Motivating example

Figure 1 shows an example of document from the French governmental website Légifrance. This document has been translated with Google Translate. It describes the legal regulation for companies working on lifting devices, and more specially on their checks. As in Figure 1, several cross-references are illustrated in Section 1; the text mentions different articles (*R4323-23 to R4323-27, R4535-7, [...]*) and refers the reader to the labour code. Section 2 of the document is dedicated to define what is a lifting device and a lifting accessory. It is worthwhile, with an automated process, to extract and synthesize the relevant elements from the document. In our case, we can expect knowledge extraction about the definitions in Section 2 and the rules in Section 3. First, the definitions allow systems or human to categorize the equipments into a group bound with a set of rules. In this way, when the technician uses a Computerized Maintenance Management System (CMMS) to operate on a lift, it knows the lift as an asset category and can suggest retrieving the manufacturer’s instructions from the head of the establishment according to the order of March 1, 2004, Section 3.a.

The information extraction task can be broken down into multiple subtasks. The first one is the extraction of information from legal documents. The second one is the structuring of this information. The next sections are dedicated to answer these questions. Later in this paper, we will illustrate our proposition with the legal document, as in Figure 1.

3 Related work

This section presents a state of the art of the different proposals in information extraction from textual documents. The use of semantic models will be studied



Order of March 1, 2004 relating to verifications of lifting devices and accessories

🕒 Last update of the data of this text: January 09, 2011
NOR: SOCT0410464A

Version in force on July 01, 2022

The Minister for Social Affairs, Labor and Solidarity and the Minister for Agriculture, Food, Fisheries and Rural Affairs,

Having regard to Directive 98/34/EC of the European Parliament and of the Council of 22 June 1998 providing for an information procedure in the field of technical standards and regulations and rules relating to information society services, and in particular the notification no. 2003/0262/F;

Considering the labor code, and in particular its articles L. 620-6, R. 233-11, R. 233-11-1, R. 233-11-2;

Considering the decree of December 22, 2000 relating to the conditions and methods of approval of organizations for the verification of the state of conformity of work equipment;

Having regard to the opinion of the Higher Council for the Prevention of Occupational Risks, specialized commission no. 3;

Having regard to the opinion of the National Commission for Occupational Hygiene and Safety in Agriculture,

Section 1. (Articles 1 to 3)

Section 1

Modified by Decree n°2008-244 of March 7, 2008 - art. 9 (V)

This Order determines the work equipment used for lifting loads, elevating workstations or elevating people to which the general periodic checks apply, checks during commissioning and checks during the return to service after any dismantling and reassembly operation or modification likely to jeopardize their safety, provided for by articles R4323-23 to R4323-27, R4535-7, R4721-11, R4323-22 and R4323-28 of the labor code, at the expense of the head of the establishment in which this work equipment is put into service or used.

This order defines, for each of these verifications, their content, the conditions for their execution and, where applicable, their periodicity.

Section 2

The work equipment listed below must undergo the checks defined in Article 1:

a) The lifting devices defined below and their supports:

machines, including those moved by directly employed human power, and their equipment, driven by one or more operators who act on the movements by means of service devices over which they retain control, at least one of whose functions is to move a load made up of goods or equipment and, where applicable, of one or more people, with a significant change in the level of this load during its movement, the load not being permanently linked to the device. A change in level corresponding to what is just necessary to move the load by lifting it off the ground is not considered significant and is not likely to create risks in the event of failure of the load support.

In this decree, the term lifting devices also refers to lifting installations meeting the definition given above and specified in the appendix to this decree;

b) Lifting accessories meeting the following definition:

equipment not incorporated into a machine, a tractor or other equipment and placed between the machine, the tractor or any other equipment and the load, such as slings, lifting beams, self-tightening clamps, magnets, suction cups, lifting keys.

Section 3

Amended by Ordinance no. 2007-329 of March 12, 2007 - art. 12 (V)

a) The head of the establishment must make the lifting devices and accessories concerned and clearly identified available to the qualified persons in charge of the checks for the time necessary, taking into account the foreseeable duration of the examinations, tests and tests to be carried out.

b) The head of the establishment must make available to the qualified persons in charge of the examinations, tests and tests to be carried out the necessary documents, such as the manufacturer's instructions, the declaration or the certificate of conformity, the reports of the checks previous records and the aircraft maintenance log.

Fig. 1. Example of an 'Order' from Légifrance translated in English.

in Section 3.2 with a particular attention on models related to the law (Section 3.2.1) and models related to the industrial maintenance (Section 3.2.2).

3.1 Information extraction

Information extraction is a broad domain with multiple proposals in the scientific community. Nowadays, a wave of works has notably adopted neural networks in labelling or classification tasks in order to extract relevant elements. We can cite, for example, the work of David B. et al. [3] who developed a system allowing to anonymize German financial documents. The system makes it possible by finding entities such as first and last names, postal and e-mail addresses, locations, etc. The study was conducted on different architectures such as RNN (Recurrent Neural Networks), LSTM (Long and Short Term Memory) [18] or CRF (Conditional Random Fields) [12]. The Transformers' technology has been introduced [21] and has surpassed many existing models. It has been demonstrated that this architecture can be successfully used to extract named entities [24] and to structure texts into knowledge graphs [5].

A significant part of the works proposes an information extraction based on resources containing, in a structured way, the concepts of a domain as well as the relations between them. These resources are semantic models like, for example, ontologies or knowledge graphs. The creation and the use of a semantic model has been the subject of different proposals in the literature. Munira A. et al. [1] proposed an Ontology-Based Information Extraction (OBIE) system with the objective of extracting, from textual documents, the land suitability for residential use. In the domain of industrial maintenance, [6] developed a system that relies on a semantic model and that allows managing the maintenance assets in industry. In the following section, we introduce the semantic models in the domain of the legal maintenance. We will, at least, present the two main domains related to the legal maintenance: the law and the industrial maintenance.

3.2 Semantic models

Semantic models related to the law. One of the early works in semantic modelling related to the law [11] created the "Frame" model, which aims to structure legal rules. Many of its concepts will be found in the further works. Van E. et al. [20] detail two of these models dedicated to the representation of legislation: FOLaw and LRI-Core. LRI-Core has been used as a high-level ontology for the modelling of German administrative laws. LKIF [8] is an open source ontology alternative to LRI-Core which can be applied on multi-domain representation of the law in order to facilitate its reuse. This ontology contains for example the notion of "Right" which characterizes the permission, obligation or prohibition to perform an act according to the law. LegalRuleML [2], an XML standard for the legal domain, has been inspired by LKIF to represent the legal knowledge and legal reasoning.

The LKIF ontology has been constructed via a supervised approach in order to manually build a semantic model [9]. While most works have considered the

construction of the models in a manual manner, several alternative approaches have considered the construction using automatic approaches on large corpus [16].

Beyond structuring knowledge semantically, other works focus on mathematical formalizations using, e.g., deontic logic rules. Propagated in the scientific community by [23], this formalization of philosophical concepts relies on symbolic reasoning with notions of modality (prohibition, permission, obligation).

Semantic models for industrial maintenance. Semantic models dedicated to legal maintenance have also been addressed in scientific research. In 2004, Rasovska I. et al. [15] proposed a system composed of a conceptual model allowing to make decisions related to the industrial maintenance. Few years later, the IMAMO (Industrial MAintenance Management Ontology) [6] has been published. IMAMO is an ontological model with the objective of standardizing information exchanges related to maintenance. It aims at ensuring semantic interoperability while generating data to be used as a decision-making support. Many other works reflect this structure life cycle for industrial equipment [7, 19, 14, 13, 10]. We find in these models essential concepts for industrial maintenance. For example, the notion of ‘actions’ that group different acts specific to maintenance such as assembly, energization, scrapping, etc. We can mention a last open source model produced by the IOF group (Industrial Ontologies Foundry) which tries to *"create a set of reference and open ontologies covering the whole industry domain"*⁴.

3.3 Positioning

From all semantic representations listed above, none of them is sufficient on its own to represent legal industrial maintenance. On one hand, we have models specially designed to model legal rules, but we can’t find key elements of maintenance such as material entities. On the other hand, industrial maintenance models have been proposed by the scientific community, but do not structure the legal notions. The limit of the state of the art arises here with the inability to fully model the domain of legal industrial maintenance.

The reuse of existing ontologies is in fact a practice in ontology construction. In particular for information retrieval and knowledge engineering, in [22], the authors mention two main constraints for the implementation: the first one is the adequacy of ontologies with the information retrieval task. The second constraint is to find ontologies that represent, jointly and accurately, the domain. However, it appears that the domain of legal industrial maintenance, being very specialized, do not comply with the second constraint. The existing models, not covering the specificities of the domain we are dealing with, we decided to create SEMLEG, reusing as much as possible existing ontologies. This model allows linking the Computerized Maintenance Management System (CMMS) with the legal obligations present in the legal texts.

⁴ <https://www.industrialontologies.org/our-mission/>

4 Semantic model for legal maintenance: SEMLEG

In this section, we detail the different concepts of SEMLEG. A second part is devoted to illustrate the SEMLEG model on an example taken from Légifrance⁵.

4.1 Reusing existing vocabularies

As introduced in the previous section, there are two main approaches for building an ontology: automatically with a large corpus or manually by experts. In this paper, we have chosen the construction via experts, supported by the reuse of existing semantic models (as further detailed in the following). This choice is motivated by a desire for interpretability between the models, as well as the reuse of existing concepts rather than trying to recreate them [4]. In SEMLEG we use two existing ontologies: LKIF-CORE is dedicated to the legal elements and IOF to the maintenance elements. In this section, we will describe in more detail the motivation for choosing these ontologies. Both of LKIF-CORE⁶ and IOF⁷ are hosted on GitHub and can be easily accessed.

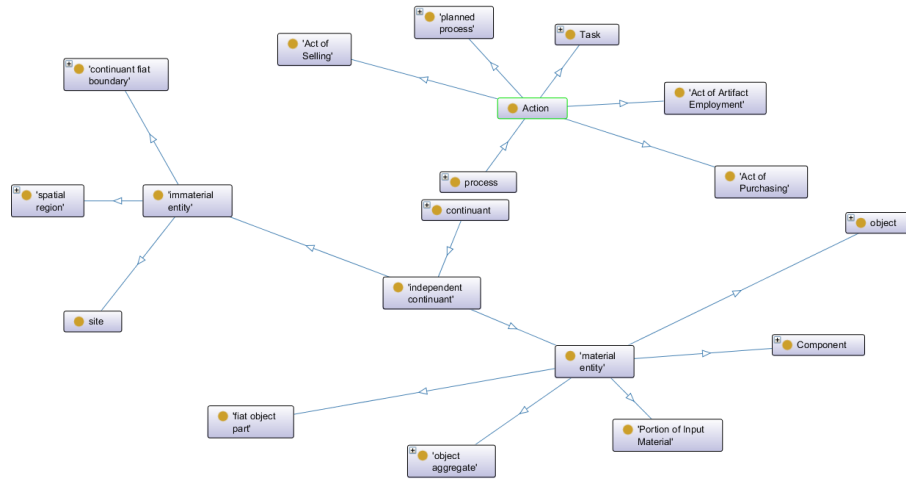


Fig. 2. Fragment of the IOF ontology.

Figures 2 and 3 illustrate the fragments of IOF and LKIF of interest for SEMLEG: *Norm* for LKIF-CORE and *independent contingent*, *action* for IOF. We have the class **lkif-core:Norm** and, with this concept, we can represent the notion of obligation and prohibition as presented before. On the IOF side, we

⁵ <https://www.legifrance.gouv.fr/>

⁶ <https://github.com/RinkeHoekstra/lkif-core>

⁷ https://github.com/welschmichel/IOF_Maintenance_Working_Group_Public

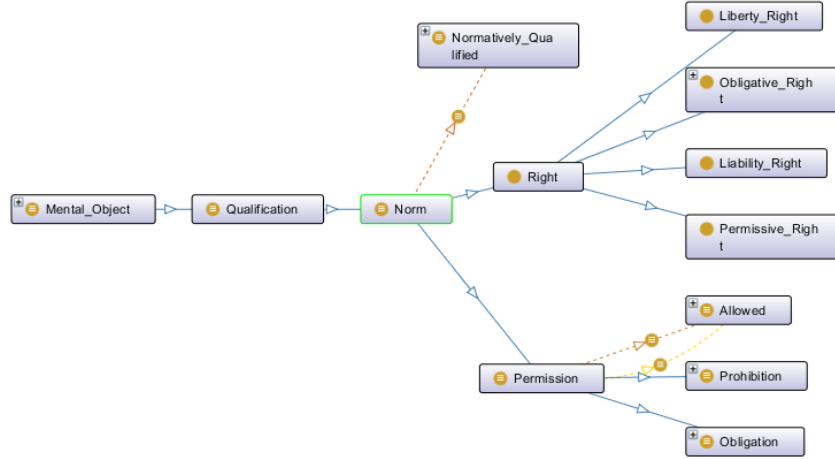


Fig. 3. Fragment of the LKIF-CORE ontology.

have the class **lkif-core:independent continuant** which allows representing material and immaterial entities. We will find, for example, on the immaterial side: geographical areas. On the material side, we will find: the owner, a buyer, a seller, etc. We will also find more inert elements like: mechanical systems, tools, machines. We also chose to include **iof:Action** which allows representing, for example, maintenance tasks, the action of buying, selling, etc.

4.2 Construction and explanation of SEMLEG

The process of constructing SEMLEG has been divided in two main steps: (1) the extraction from Légifrance of three representative industrial maintenance decrees in various domains: pressured equipments⁸, lifting machines⁹, and buried tanks¹⁰; (2) the identification of the recurrent parts of the rules that compose the orders and the construction of the semantic model by 4 experts, each one coming from a different field of expertise: (a) industrial legal maintenance, (b) ontological knowledge modelling, (c) generalized information systems and (d) automatic natural language processing. This work allowed us to obtain the model illustrated in Figure 4. Its implementation in OWL from the software Protégé¹¹ is available as open source on GitLab¹².

⁸ <https://www.legifrance.gouv.fr/loda/id/JORFTEXT000036128632/2022-06-01/>

⁹ <https://www.legifrance.gouv.fr/loda/id/JORFTEXT000000439029/2022-07-01/>

¹⁰ <https://www.legifrance.gouv.fr/loda/id/JORFTEXT000018820571/2022-06-01/>

¹¹ <https://protege.stanford.edu/>

¹² <https://gitlab.irit.fr/semleg/semleg>

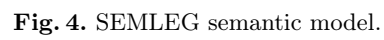


Fig. 4. SEMLEG semantic model.

Table 1. SEMLEG concepts and definitions

Concept	Definition	Example
Source	Allows, like Russian dolls, to encapsulate a set of rules, definitions or other sources.	Article L. 512-5
Link	Links two sources together. This link can be a repeal, a mention or a modification.	Modified by ORDER of May 11, 2015
Definition	Stores the definition of an act or resource.	A functional test of a lifting device is the test which consists in moving in the most unfavorable positions
Rule	Describe the rules and allows aggregating the necessary entities.	The periodic general verification of lifting devices must be done every twelve months.
Act	Is the act of the rule.	Verification
iof:Action	Represents actions in the field of industrial maintenance.	Verification
Resource	Represents the material or immaterial resources of a rule.	Lifting devices
Undefined	Represents undefined resources.	
iof:independent continuant	Brings together tangible and intangible entities.	Lifting devices
Modality	Represents the modality of a rule, which can be an obligation, a prohibition or a permission.	Must (obligation)
lkif-core:Norm	Reflects the legal or moral right to do or not to do something or to obtain or not obtain an action, thing or consideration in civil society.	Must (obligation)
Operand	Represents the elements on which a logical operation will operate.	
Operator	Represents the logical operation operator.	
SuccessiveConjunction	Represents performing one action after another.	I do A and after B
ParallelConjunction	Represents the performance of an action at the same time as another.	I do A and at the same time B
SimpleDisjunction	Represents the completion of one action or another.	I do A or B
Condition	Conditions acts, resources and operators.	Lifting devices used for the transport of persons
TemporalCondition	Conditions via a temporal aspect.	Every twelve months
SpatialCondition	Conditions via a spatial aspect.	In the factory area
NumericalCondition	Condition via a numeric value.	After 5 cm

Table 1 presents the list of SEMLEG concepts and the definition attached to each concept. In the rest of this section, we will see in particular how SEMLEG allows us to structure the legislative tree, the rules, the operators between the rules as well as the conditions.

The legislative tree is modeled by a successive imbrication of groups, allowing to structure the legal information. For example, we will find a chapter dedicated to an idea which is itself in a section. Chapters, sections, articles, etc. are modeled via the concept **semleg:Source** and their nesting via the relation **semleg:hasSubSource**. To link sources together, we have introduced the concept **semleg:Link**. It allows a source to abrogate, mention or modify another source. At the leaves of this tree, which is the legislative document, there are two types of elements: definitions and rules. Definitions are a legal explanation of what is meant by the use of a term. They aim to characterize objects, acts, actors, etc. Rules, on the other hand, are responsible for carrying the main legislative information.

The rule is characterized, in SEMLEG, by: a subject (**semleg:hasSubject**), an act (**semleg:Act**), a modality (**semleg:Modality**) and an object (**semleg:hasObject**).

For the construction of SEMLEG, we have reused existing concepts; this is why we can see on the diagram equivalence relations between SEMLEG classes and IOF or LKIF-CORE classes. So we have equivalence between the classes: **lkif-core:Norm** and **semleg:Modality**, **lkif-core:independent continuant** and **semleg:Resource**, **iof:Action** and **semleg:Act**.

Note that a resource can sometimes be undefined (**semleg:Undefined**). For example, in the sentence: “A draft of the report must be sent at the end of the audit”, we do not find any mention of the subject (who must hand in the report). As a result, the rule will therefore be modelled with an undefined subject.

Sequence of rules. Like the mathematical operations, we have introduced operators (**semleg:Operator**) and operands (**semleg:Operand**) which are concepts that allow us to reason about the sequence between rules. We have so far identified 3 different operators: simple disjunction, the parallel conjunction and the successive conjunction. The simple disjunction can be translated as: “I do A or B”. The parallel conjunction can be translated as: “I do A and at the same time B”. The successive conjunction can be translated as: “I do A and then only B”. The operators thus make it possible to structure the chains of rules (the operands) in the legislative texts.

Conditions are concepts that can be used by acts, resources and operators. For example, conditions can add a notion of time to the performance of an act: “When the installation is shut down [...]”. Within the framework of our

study, we met mainly three sub-types of conditions: temporal conditions (**semleg:TemporalCondition**), spatial conditions (**semleg:SpatialCondition**) and numerical conditions (**semleg:NumericalCondition**). This list is not exhaustive, and the more particular conditions can be structured via the parent class : **semleg:Condition**.

4.3 Extract from Légifrance structured via SEMLEG

In this section, we illustrate the use of SEMLEG with an example (Figure 5) extracted from Légifrance. Consider the following example: “*When the installation is permanently shut down, the tanks and pipes are degassed.*”¹³.

Order of 18 April 2008 relating to buried tanks of flammable or combustible liquids and their ancillary equipment operated within a classified installation subject to authorisation, registration or declaration under one or more of headings Nos. 1436, 4330, 4331, 4722, 4734, 4742, 4743, 4744, 4746, 4747 or 4748, or for crude oil under one or more of headings Nos 4510 or 4511 of the nomenclature of classified installations for the protection of environment

TITLE A: PROVISIONS COMMON TO NEW AND EXISTING INSTALLATIONS (Articles 1 to 8)

TITLE B: PROVISIONS APPLICABLE TO NEW FACILITIES (Articles 9 to 15)

TITLE C: PROVISIONS APPLICABLE TO EXISTING INSTALLATIONS (Articles 16 to 20)

TITLE D: TERMS OF APPLICATION (Articles 21 to 24)

Appendices (Articles Appendix I to Appendix III)

Navigate in the summary

Section 5

Version in force since September 24, 2017
Modified by Order of August 9, 2017 - art. 2

When the installation is permanently shut down, the tanks and pipes are degassed.

The tanks are then removed or, failing that, neutralized by an inert physical solid.

The solid used for the neutralization covers the entire surface of the inner shell of the tank and has sufficient and durable resistance to prevent the subsidence of the soil on the surface.

Fig. 5. Order of 18 April 2008 from Légifrance.

As we can see in Figure 5, the example is depicted in a sequence of nested blocks. In our case, the rule is in Section 5, itself in Title A, itself in the Order of 18 April 2008. This nesting introduces the first concept: **semleg:Source**. This separation allows two sources to be linked together via **semleg:Link**. In our example, “Section 5” is a source connected to “Order of August 9, 2017 - art. 2” by a modification link. It is through this process that we are able to model the evolution over time.

The following sentence available in Section 2 illustrates the concept of definition: “*A tank is said to be buried when it is completely or partially below the level*

¹³ https://www.legifrance-gouv-fr.translate.google.com/loda/article_lc/LEGIARTI000035650389/2022-06-01?_x_tr_sl=fr&_x_tr_tl=en&_x_tr_hl=fr&_x_tr_pto=wapp

of the surrounding ground, whether it is directly in the ground or in a pit. Tanks installed in premises are not considered buried, even when the premises are located below the surrounding ground.”¹⁴. This sentence is an essential element in understanding and defining what a buried tank is.

In Figure 6, we have labelled our example sentence using the concepts we define in SEMLEG (we do not detail the links with other ontologies). We thus find the following concepts: modality, resources, act and conditions.

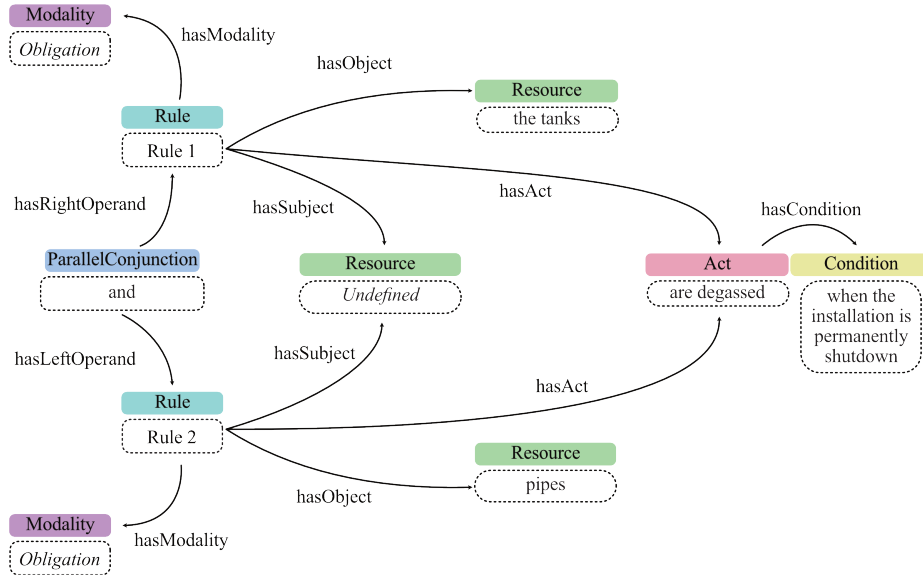


Fig. 6. Example of a Légifrance sentence structured with SEMLEG

In our example, the modality is an obligation in implicit form. Indeed, unlike explicit modalities which can have verbs like “must” and “can”, implicit modalities do not have these verbs. The second element is the act which is in our sentence: “are degassed”. This action is performed by a subject not mentioned in this sentence. Finally, the subject will perform an action on another resource considered as the object of the rule: the tanks and the pipes. This second resource can find a more precise characterization in IOF via the concept: **iof:Maintainable Item**.

Then, the operator is in our case a simple disjunction thanks to the word “or” which allows choosing between ‘a competent person’ and ‘an organization’. The operator acts here as a junction between the rule proposing ‘a competent person’ and the second one proposing ‘an organization’.

¹⁴ https://www.legifrance-gouv-fr.translate.google/loda/article_lc/LEGIARTI000030706280/2022-06-01?_x_tr_sl=auto&_x_tr_tl=en&_x_tr_hl=fr&_x_tr_pto=wapp

Finally, we have the conditions. In our example, “when the installation is permanently shutdown” is a condition that qualifies the act.

5 Conclusions and future work

In this paper, we have presented a semantic model called SEMLEG which allows structuring textual documents of legal industrial maintenance. This model results from a manual analysis of documents from Légifrance involving domain experts. It combines existing ontologies from legal and industrial maintenance domains. While we have illustrated the use of SEMLEG with a subset of representative documents, the next step of this work will be to extend the evaluation of the adequacy of the proposed model with a larger set of documents within a task of information extraction. This can lead to the evolution of the model. We plan also to assess the benefits of SEMLEG in the extraction task, by comparing the task performance without SEMLEG and with SEMLEG.

References

1. Al-Ageili, M., Mouhoub, M.: An ontology-based information extraction system for residential land use suitability analysis. *ArXiv* (2022)
2. Athan, T., Boley, H., Governatori, G., Palmirani, M., Paschke, A., Wyner, A.: Oasis legalruleml. In: proceedings of the fourteenth international conference on artificial intelligence and law. pp. 3–12 (2013)
3. Biesner, D., Ramamurthy, R., Stenzel, R., Lübbering, M., Hillebrand, L.P., Ladi, A., Pielka, M., Loitz, R., Bauckhage, C., Sifa, R.: Anonymization of german financial documents using neural network-based language models with contextual word representations. *International Journal of Data Science and Analytics* pp. 151–161 (2022)
4. Carriero, V.A., Daquino, M., Gangemi, A., Nuzzolese, A.G., Peroni, S., Presutti, V., Tomasi, F.: The landscape of ontology reuse approaches. In: Applications and Practices in Ontology Design, Extraction, and Reasoning (2020)
5. Friedman, S.E., Magnusson, I.H., Sarathy, V.: From unstructured text to causal knowledge graphs: A transformer-based approach. *ArXiv* (2022)
6. Hedi Karray, M., Chebel-Morello, B., Zerhouni, N.: A Formal Ontology for Industrial Maintenance. In: Terminology & Ontology : Theories and applications, TOTH Conference 2011. pp. 1–20 (May 2011), <https://hal.archives-ouvertes.fr/hal-00602182>
7. Hodkiewicz, M., Klüwer, J.W., Woods, C., Smoker, T., Low, E.: An ontology for reasoning over engineering textual data stored in FMEA spreadsheet tables. *Computers in Industry* (Oct 2021). <https://doi.org/10.1016/j.compind.2021.103496>, <https://linkinghub.elsevier.com/retrieve/pii/S0166361521001032>
8. Hoekstra, R., Breuker, J., Di Bello, M., Boer, A., et al.: The lkif core ontology of basic legal concepts. *LOAIT* pp. 43–63 (2007)
9. Kingston, J., Schafer, B., Vandenberghe, W.: Towards a Financial Fraud Ontology: A Legal Modelling Approach. *Artificial Intelligence and Law* (4), 419–446 (Dec 2004). <https://doi.org/10.1007/s10506-005-4163-0>, <http://link.springer.com/10.1007/s10506-005-4163-0>

10. Koukias, A., Nadoveza, D., Kiritsis, D.: Semantic Data Model for Operation and Maintenance of the Engineering Asset. In: *Advances in Production Management Systems. Competitive Manufacturing for Innovative Products and Services*, pp. 49–55. Berlin, Heidelberg (2013)
11. Kralingen, R.v.: A Conceptual Frame-based Ontology for the Law. In: *Proceedings of the First International Workshop on Legal Ontologies*. pp. 6–17 (1997)
12. Lafferty, J., McCallum, A., Pereira, F.C.: Conditional random fields: Probabilistic models for segmenting and labeling sequence data (2001)
13. Matsokis, A., Kiritsis, D.: An ontology-based approach for Product Lifecycle Management. *Computers in industry* pp. 787–797 (2010)
14. Otte, J.N., Kiritsi, D., Ali, M.M., Yang, R., Zhang, B., Rudnicki, R., Rai, R., Smith, B.: An ontological approach to representing the product life cycle. *Applied Ontology* pp. 179–197 (Apr 2019). <https://doi.org/10.3233/AO-190210>, <https://www.medra.org/servlet/aliasResolver?alias=iospress&doi=10.3233/AO-190210>
15. Rasovska, I., Chebel-Morello, B., Zerhouni, N.: A conceptual model of maintenance process in unified modeling language. *IFAC Proceedings* pp. 497–502 (2004)
16. Saravanan, M., Ravindran, B., Raman, S.: Improving legal information retrieval using an ontological framework. *Artificial Intelligence and Law* pp. 101–124 (Jun 2009). <https://doi.org/10.1007/s10506-009-9075-y>, <http://link.springer.com/10.1007/s10506-009-9075-y>
17. Sassier, P., Lansoy, D.: *Ubu loi*. Arthème Fayard, France (2008)
18. Sherstinsky, A.: Fundamentals of recurrent neural network (rnn) and long short-term memory (lstm) network. *ArXiv* (2018)
19. Smith, B., Ameri, F., Cheong, H., Kiritsis, D., Sormaz, D.N., Will, C., Otte, J.N.: A first-order logic formalization of the industrial ontologies foundry signature using basic formal ontology. In: *JOWO : Joint Ontology Workshops* (2019)
20. Van Engers, T., Boer, A., Breuker, J., Valente, A., Winkels, R.: *Ontologies in the Legal Domain*, pp. 233–261. Boston, MA (2008). https://doi.org/10.1007/978-0-387-71611-4_13
21. Vaswani, A., Shazeer, N.M., Parmar, N., Uszkoreit, J., Jones, L., Gomez, A.N., Kaiser, L., Polosukhin, I.: Attention is all you need. In: *NIPS* (2017)
22. Wimalasuriya, D.C., Dou, D.: Using multiple ontologies in information extraction. In: *Proceedings of the 18th ACM conference on Information and knowledge management*. pp. 235–244 (2009)
23. von Wright, G.H.: Deontic Logic. *Mind* pp. 1–15 (1951), <https://www.jstor.org/stable/2251395>
24. Yan, H., Deng, B., Li, X., Qiu, X.: Tener: Adapting transformer encoder for named entity recognition. *ArXiv* (2019)