Universitat Oberta de Catalunya

Comparative Analysis of Legal Ontologies, a Literature Review (TFR)

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FITXA DEL TREBALL FINAL

Títol del treball:	*Comparative Analysis of Legal Ontologies, a Literature Review*
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Paraules clau	Legal ontology Legal knowledge modelling Legal semantic web

Resum del Treball (màxim 250 paraules): *Amb la finalitat, context d'aplicació, metodologia, resultats i conclusions del treball*

La finalidad de este trabajo es proporcionar un artículo científico tipo review de referencia para personas interesadas en el diseño y creación de ontologías en el ámbito del derecho.

Se pone al lector dentro de contexto en ontologías en general y las ontologías legales en particular, se repasan estándares y metodologías. Después se entra en materia enumerando los estándares más importantes para las ontologías legales, los diferentes sistemas legales que existen, las ontologías fundacionales más importantes, y se analizan las ontologías de dominio más recientes creadas en diversos sistemas jurídicos repartidos por el mundo.

Finalmente se llega a la conclusión de que la evolución histórica ha tendido a dividir un mismo dominio en varias ontologías, que no hay una sola metodología correcta, que se puede utilizar alguna, o crear una nueva, o tomar varias ideas de diversas metodologías. Y finalmente, la importancia de la metodología de Hoekstra y su ontología legal LKIF y la separación entre norma y situación.

Abstract (in English, 250 words or less):

The purpose of this research work is to provide a reference review for people interested in the design and creation of ontologies in the field of law.

The reader is put in context within ontologies in general, and legal ontologies in particular, standards

and methodologies are reviewed. Then, the subject is listed, listing the most important standards for legal ontologies, different legal systems that exist, most important foundational ontologies, and analyzing the most recent domain ontologies created in various legal systems throughout the world.

Finally, we come to the conclusion that historical evolution has tended to divide the same domain into several ontologies, that there is no single correct methodology, that one can be used, or create a new one, or take several ideas from various methodologies. And finally, the importance of the methodology of Hoekstra and its legal ontology LKIF and the separation between norm and situation.

"Work in Artificial Intelligence, whether aimed at modelling human minds or designing smart machines, necessarily includes a study of knowledge"

Aaron Sloman, 1979

Abstract

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Keywords

Legal ontology, legal knowledge modelling, legal semantic web.

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1. Introduction

In this final research work, the study of legal ontologies has been addressed in a generalist way. It has been wanted to give a very didactic approach so that any reader with some basic knowledge can put themselves in the situation and be able to follow the reading comfortably. The need for this work arises because there is a considerable amount of research in the field of legal ontologies, and we want to make a compendium of what is most important in this domain, not only from the technical point of view, but from the legal point of view, since the different existing legal systems have been exposed, and it has been wanted to analyze a series of systems and ontologies spread all over the world.

The first (1) point of this work is simply introductory and exposes the management of this work from a project management point of view. The second section (2) relates the phase of information search related to the treated domain. In point 2.2 The library that was created for this project is listed.

Section 3 (3) deals with ontologies in a generalist way, listing their classification and types, methodologies and standards of representation more important. Section 4 (4) deals with in-depth legal ontologies, reviews the legal systems scattered around the world, the specific standards for representing legal information, the specific characteristics of this type of information, etc.

Section 4.4. it is of special importance, since the most important core ontologies are listed, and from which other ontologies have subsequently extracted ideas, or have used them directly. Section 5 (5) deals with the analysis of the chosen legal ontologies: Eurovoc, Eunomos, the legal activity of Ukraine, an ontology for the civil court of Japan, and finally a system of legal provisions in China.

Finally, in point 6 (6) are the conclusions of this work.
In point 7 (7), a brief summary of the project's performance is made.
And in section 8 (8) possible future jobs are reported.
In point 9 (9) an analysis of the work done and self-evaluation is done too.

1.1. Description

1.1.1. Selected theme

I have chosen legal ontologies topic because I am interested in joining in a project, on the one hand, my knowledge in artificial intelligence and “knowledge representation” acquired in Computer Sciences Degree, and on the other hand with legal knowledge acquired in the Business Law Minor and part of the Degree in Law.

I believe that semantic web will play a very important role in the next few years in the artificial intelligence field and will have a great impact on the development of this branch of computer sciences since an artificial intelligence system basis is a valid, well-structured and correctly related knowledge base.

By extension, legal and social sciences could take advantage of, and they are taking advantage of artificial intelligence great potential, but it is necessary to have a legal knowledge structure as a basis in these systems, living knowledge that is very complex to model, where continuous changes occur.

1.1.2. The problem to solve

Knowledge representation study field, and within this, ontologies and semantic web, is a field that is still not very mature, in which, relatively little research has been done, and much remains to be explored, a situation that worsens in the representation of legal knowledge, which is the basis of any artificial intelligence system applied to laws.

This final research work will extract and combine the knowledge contained in the literature and papers referring to legal ontologies published in recent years, and draw its own conclusions, in order to group the very scattered documents that exist and offer this knowledge and conclusions to the scientific community for future use as a base of artificial intelligence systems with legal issues.

1.2. General Objective

Creation of a review that compiles, analyses and compares different literature published from 2010 to nowadays. The subject of the analyzed literature is ontologies applied to the legal domain, in particular, aims to analyze these aspects:

- Creation methodology followed.
- Architecture.
- The legal system under which it has been conceived.

1.2.1. Main Objectives

Part I: Finding resources

- Establish an effective search strategy for resources, using all the tools available to researchers such as the university library, databases or references, and bibliography managers.
- Collect, classify and filter information on legal ontologies, methodologies, and systems that use these ontologies.

Part II: Analysis and conclusions

- Analysis of existing legal ontologies: methodologies, architecture, and legal System.
- Draw conclusions based on all the information that generates new knowledge and new possibilities in web ontologies.

1.3. Methodology and Work Process

This final work is different from the typical final degree work, it is intended to research in a very specific topic, so the final product will be a writing of a scientific review.

The final work has been divided into three well-differentiated phases:

- **The first phase** that includes **planning** and the **search for resources**, which covers the delivery of the PAC2.
- **The second phase** of **analysis of resources** and **conclusions**, which would be the period between PAC2 and 3.
- Finally, the **final phase** includes the writing of the **review** type article, the **presentation** of slides, and the defense **video**, so it includes three different deliverables.

All the resources that the UOC library offers for research will be used, and profitable and advanced use of the library will be made.

The support tools used are:

- **Mendeley**: It is a manager of bibliographic references, it allows classifying and save the files of all the references, as well as to provide a great amount of metadata of each reference.

- **JabRef**: It is another manager of bibliographic references, but open source, in this case, it is used because it facilitates the export to csv format of the references, very useful for the writing of the memory.

- **Google Academics** Extension: It is a Chrome extension for searching for scientific articles.

- **Mendeley Extension**: Facilitates the export to Mendeley of any item seen on the web.

- **Kopernio Extension**: Search scientific articles, and greatly facilitates the download of these articles.

- **Scopus Extension**: It facilitates the download of the Scopus database articles.

- Planning

1.3.1. Phase 1: Searching for resources

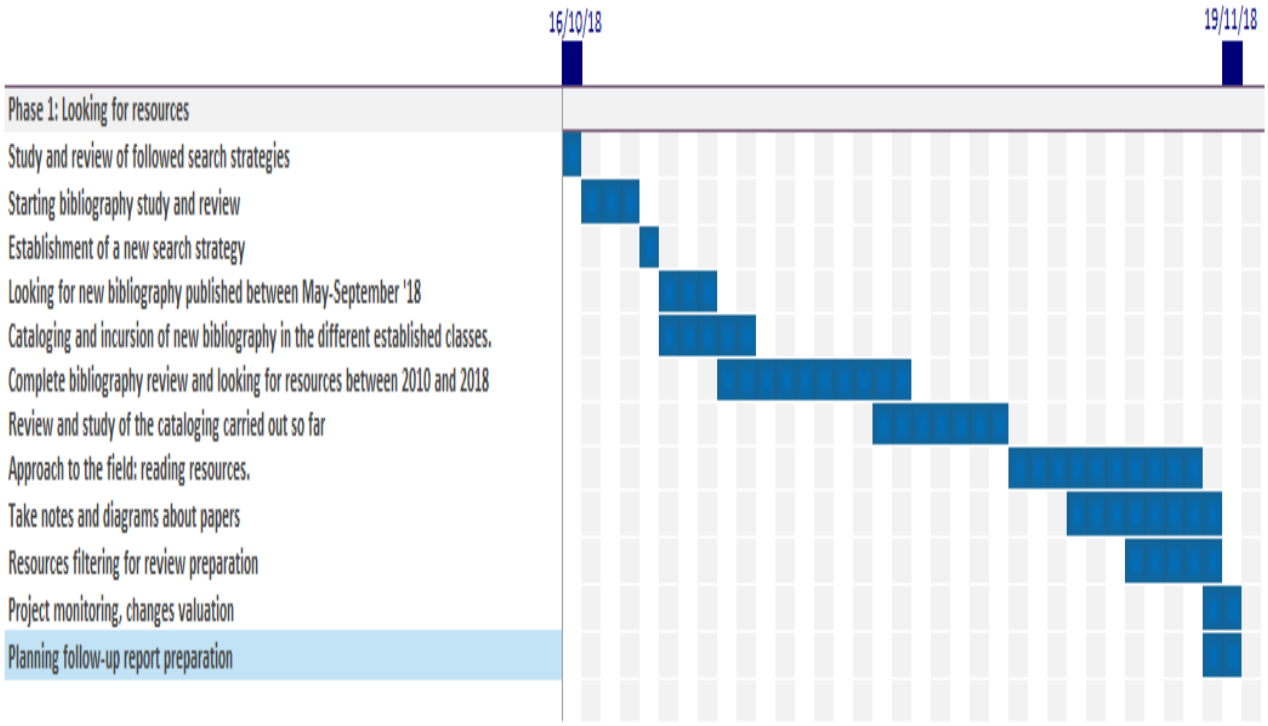


Illustration 1: Phase 1 planning

1.3.2. Phase 2: Analysis and Conclusions

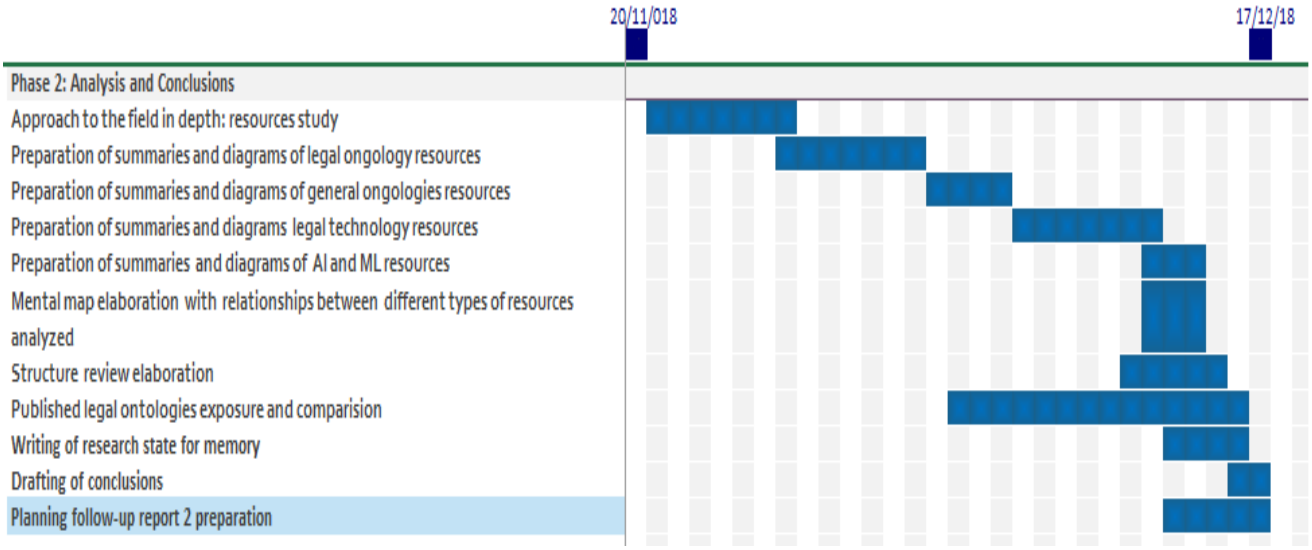


Illustration 2: Phase 2 planning

1.3.3. Final phase: Report and review writing

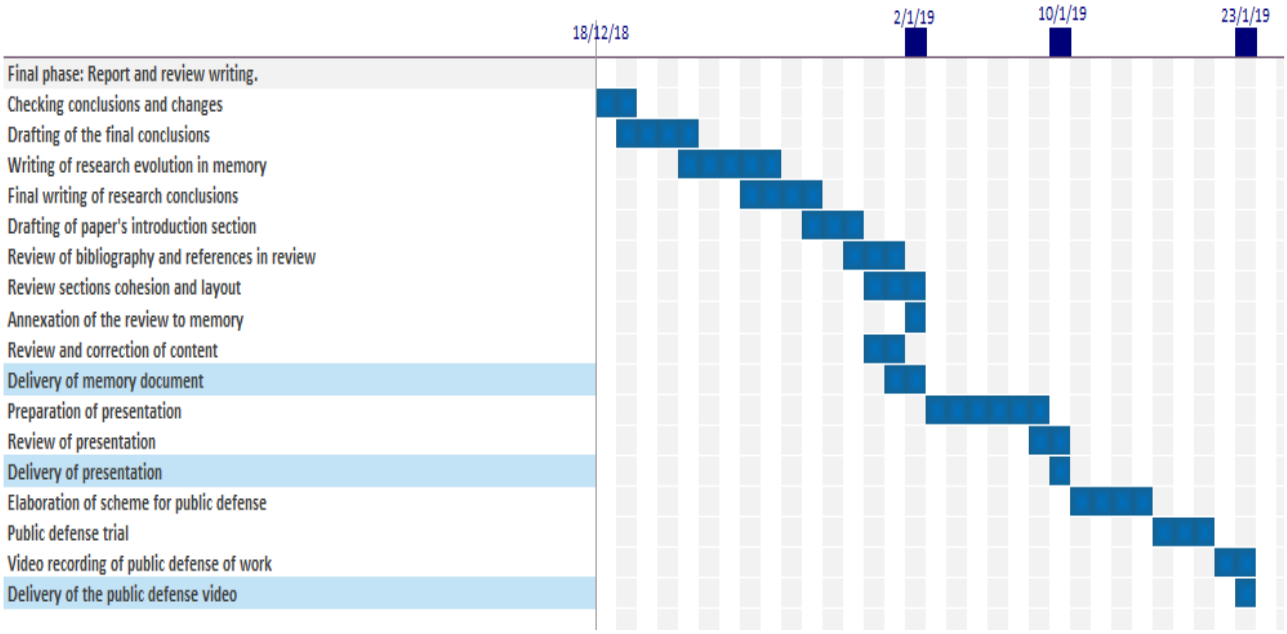


Illustration 3: Final phase planning

1.3.4. Risk Evaluation

Cod	Name	Cause	Description	Consequence	Probability	Impact	Level
R01	Lack of research experience	Student's first research work	-	Delays	High	Medium	Med
R02	Copyright	Selected bibliography with copyright license	You cannot use copyrighted material without work owner permission	Decrease in sources	Medium	Low	Low
R03	PAC 3 delivery and Memory delivery.	There are many activities concentrated	There is a very short time between two deliverables, and many activities are concentrated in that period of time	Delays	High	Medium	Med
R04	Requested material	Library does not have requested material	-	Delays / Decrease in sources	Medium	Low	Low
R05	Material delivery	Delay in material delivery	-	Delays	Medium	Low	Low

Table 1: Risk Evaluation

1.3.5. Contingency Plan

Cod.	Action	Type	Residual risk	Deadline
A1R01	Consult tutor	Mitigating	Med	23/04/2018
A2R01	Search methodology and writing materials in research	Mitigating	Med	10/04/2018
A1R02	Dispense with this material and search free material that deals with the same subject	Corrector	Low	01/05/2018
A1R03	Assess project status and restructure activities	Mitigating	High	21/05/2018
A1R04	Continue working on the available material	Corrector	Low	22/04/2018
A2R04	Request material for the concerted loan service (PUC)	Mitigating	Medium	22/04/2018
A1R05	Continue working on the available material	Mitigating	Low	22/04/2018

Table 2: Contingency plan

1.3.6. PACs and Final Deliver Content

Deliverable	Date	Content
PAC 2	19 Nov 2018	It will contain the development of phase 2 of the work, the methodology followed, if there has been any difficulty, and the list of sources consulted and collected
PAC 3	17 Dec 2018	It will contain the development of phase 3 of the work, if there have been difficulties, an analysis and comparison of the legal ontologies consulted
PAC 4	2 Jan 2019	It will contain the main part of the final phase: the writing of the report, with the writing of conclusions, and as an annex a scientific review type paper
PAC 5A	10 Jan 2019	Will contain the work presentation
PAC 5B	23 Jan 2019	It will contain a video with the public defense

1.4. Memory Report Structure

- Development and research methodology
- Library classification and organization
- First approach to the field: representation of knowledge
- Ontologies
    - Ontologies Classification
    - Design and creation
    - Data representation standards
- Legal Ontologies
    - Characteristics of the different legal systems
        - Civil Systems
        - Systems based on Common Law
    - Legal domain standards
    - Features of legal information and design challenges
- Analysis and description of selected ontologies
- Conclusions
- Article type review
- Work evolution/ Analysis
- Future research lines
- Analysis and self-evaluation
- Bibliography

2. Searching Resources Phase

2.1. Information search strategy

The search strategy of information that I have decided to follow, I have called it a search by layers.
The first layer consists of directly searching sources in scientific databases, with the most obvious keywords that can be deduced from the subject in question. To do this, the full potential offered by the search engines will be used, that is: the use of logical operators and filters by date, topic or access.

The second layer consists of analyzing the keywords of the results obtained in the first layer, and repeating the search process using these keywords, also using logical operators and filters.

Finally, the third layer consists of including interesting and relevant articles that appear in all the resources that have been collected, and that had not yet been collected in the previous layers.

2.1.1. First Layer

The first search that has been done was search for "legal ontologies" and "law ontologies", for this, I have searched introducing this string*: (legal OR law) AND ontolog**; This will include articles that contain words with the root ontolog' and words legal or law.
The filters used have been:

- Date: from 2010 to 2018.
- Topic: Computer Science, Artificial Intelligence
- Access: Open Access

These have been the results for the most important databases:

Data Base	Results	Open Access Results	Computer Sciences Results
FECYT - WOS	1052	210	30
SCOPUS	2943	227	41
Springerlink	3963	--	918
Elsevier sciencedirect	36	6	2
Association for Computing Machinery (ACM)	70	--	70
IEEE Xplore	59	3	3
Taylor & Francis	17412	--	13

Table 3: Results for (legal OR law) ontolog*

The second search has been: *(legal OR law) AND artificial intelligence*

The filters used have been:

- Date: from 2010 to 2018.
- Topic: Computer Science, Artificial Intelligence
- Access: Open access

These have been the results for the most important databases:

Data Base	Results	Open Access Results	Computer Sciences Results
FECYT - WOS	2847	349	349
SCOPUS	1086	136	5
Springerlink	1463	--	79
Elsevier sciencedirect	12	3	1
Association for Computing Machinery (ACM)	26	--	6
IEEE Xplore	22	2	0
Taylor & Francis	6434	0	0

Table 4: Results for (legal OR law) AND artificial intelligence

2.1.2. Second Layer

In this phase of the search, I first analyze which have been the most used keywords:

In this phase of the search, I first analyze which keywords have been the most used, for this I have helped by exporting the results of these searches to BibTex format, from here I was able to easily manipulate the keywords with a spreadsheet program, to discover which ones have been repeated the most, then a list with the ten most repeated keywords is shown:

1. Legal Ontology
2. Semantics
3. Ontology engineering
4. Knowledge representation
5. Semantic web
6. Legal documents
7. e-democracy
8. Natural Language Processing Systems
9. Computational linguistics
10. Legal engineering

The first keyword of the list has been repeated much more than the rest, approximately twice as many appearances, except for "semantics", which has also been repeated more than the rest of the list.

Search results are included below for: *(legal OR law) semantic **

The filters used have been:

- Date: from 2010 to 2018.
- Topic: Computer Science, Artificial Intelligence
- Access: Open access

These have been the results for the most important databases:

Data Base	Results	Open Access Results	Computer Sciences Results
FECYT - WOS	2572	505	222
SCOPUS	1203	94	5
Springerlink	1620	--	124
Elsevier sciencedirect	14	2	0
Association for Computing Machinery (ACM)	28	--	9
IEEE Xplore	24	1	1
Taylor & Francis	7121	--	0

Table 5: Search results for (legal OR law) semantic*

Finally, I append the search results*: (legal OR law) AND knowledge:*

The filters used have been:

- Date: from 2010 to 2018.
- Topic: Computer Science, Artificial Intelligence
- Access: Open access

These have been the results for the most important databases:

Data Base	Results	Open Access Results	Computer Sciences Results
FECYT - WOS	28999	6875	1026
SCOPUS	106	6	1
SPRINGER LINK	143	--	26
ELSEVIER	1	0	0
ACM	2	--	2
IEEE	2	0	0
Taylor & Francis	631	--	0

Table 6: Results for (legal OR law) AND knowledge

2.1.3. Third Layer

In the last phase of the search, the bibliography in general of all the results collected so far has been reviewed, and it has been checked whether each reference already existed in the bibliographic database that I created.

This phase has led me to consult some sources of data that I did not know, such as:
The Foundation for Legal Knowledge Based Systems (JURIX)

- Doiserbia
- mEDRA
- AICIT
- Sciendo
- IOS Press

2.2. Classification and organization of the library

2.2.1. Journal Articles, Papers, Reviews

Theme: Legal Ontologies

Author	Title	Journal	Year
McDaniel, Marguerite; Sloan, Emma; Day, Siobahn; Mayes, James; Esterline, Albert; Roy, Kaushik; Nick, William	Situation-based ontologies for a computational framework for identity focusing on crime scenes	2017 IEEE Conference on Cognitive and Computational Aspects of Situation Management, CogSIMA 2017	2017
Mezghanni, Imen Bouaziz; Gargouri, Faiez	CrimAr: A Criminal Arabic Ontology for a Benchmark Based Evaluation	Procedia Computer Science	2017
Osathitporn, Pongpanut; Soonthornphisaj, Nuanwan; Vatanawood, Wiwat	A scheme of criminal law knowledge acquisition using ontology	2017 18th IEEE/ACIS International Conference on Software Engineering, Artificial Intelligence, Networking and Parallel/Distributed Computing (SNPD)	2017
Reyes Olmedo, Patricia	Technical-legal management standards for digital legislative information services	REVISTA CHILENA DE DERECHO Y TECNOLOGIA	2017

Zhang, Ni; Pu, Yi Fei; Yang, Sui Quan; Zhou, Ji Liu; Gao, Jin Kang	An Ontological Chinese Legal Consultation System	IEEE Access	2017
Boella, Guido; Caro, Luigi Di; Humphreys, Llio; Robaldo, Livio; Rossi, Piercarlo; vana der Torre, Leendert	Eunomos, a legal document and knowledge management system for the Web to provide relevant, reliable and up-to-date information on the law	Artificial Intelligence and Law	2016
Casanovas, Pompeu; Palmirani, Monica; Peroni, Silvio; Van Engers, Tom; Vitali, Fabio	Semantic Web for the Legal Domain: The next step	Semantic Web	2016
Ceci, Marcello; Gangemi, Aldo	An OWL ontology library representing judicial interpretations	Semantic Web	2016
Kunkel, Rebecca	Using skos to create a legal subject ontology for defense agency regulations	Legal Reference Services Quarterly	2015
Getman, Anatoly P.; Karasiuk, Volodymyr V.	A crowdsourcing approach to building a legal ontology from text	Artificial Intelligence and Law	2014
Barabucci, Gioele; Di Iorio, Angelo; Poggi, Francesco; Vitali, Fabio	Integration of legal datasets: from meta-model to implementation	Proceedings of International Conference on Information Integration and Web-based Applications {\&} Services - IIWAS '13	2013
Boer, Alexander; Van Engers, Tom	LEGAL KNOWLEDGE AND AGILITY IN PUBLIC ADMINISTRATION	Intelligent Systems in Accounting, Finance and Management	2013
Cornoiu, S.; Valean, H.	New development for legal information retrieval using the Eurovoc Thesaurus and legal ontology	2013 17th International Conference on System Theory, Control and Computing, ICSTCC 2013; Joint Conference of SINTES 2013, SACCS 2013, SIMSIS 2013 - Proceedings	2013
Dhouiba, Karima; Gargouria, Faiez"	A textual jurisprudence decision structuring methodology based on extraction patterns and arabic legal ontology	Journal of Decision Systems	2013

Gostoji??, Stevan; Milosavljevi??, Branko; Konjovi??, Zora	Ontological model of legal norms for creating and using legislation	Computer Science and Information Systems	2013
Jinhyung; , Myunggwon Hwang; , Hanmin Jung; , WonKyung Sung	iLaw: Semantic Web Technology based Intelligent Legislation Supporting System	International Journal of Information Processing and Management	2012
Lu, Wenhuan; Xiong, Naixue; Park, Doo-Soon	An ontological approach to support legal information modeling	The Journal of Supercomputing	2012
Tang, Qi; Wang, Ying-lin; Zhang, Ming-lu	Ontology-based approach for legal provision retrieval	Journal of Shanghai Jiaotong University (Science)	2012
Wyner, Adam; Hoekstra, Rinke	A legal case OWL ontology with an instantiation of Popov v. Hayashi	Artificial Intelligence and Law	2012
Zhang, X. M.; Liu, Q.; Wang, H. Q.	Ontologies for intellectual property rights protection	Expert Systems with Applications	2012
Zurek, T.	Conflicts in legal knowledge base	Foundations of Computing and Decision Sciences	2012
Casanovas, Pompeu; Sartor, Giovanni; Biasiotti, Maria Angela; Fernandez-barrera, Meritxell	Approaches to Legal Ontologies		2011
Casellas, Nuria; Vallbe, Joan-Josep; Bruce, Thomas Robert	From Legal Information to Open Legal Data: A Case Study in U.S. Federal Legal Information	SSRN Electronic Journal	2011
Kiryu, Yuya; Ito, Atsushi; Kasahara, Takehiko	A Study of Ontology for Civil Trial		2011

Table 7: Legal ontologies articles

Theme: Legal systems/ Legal technology

Author	Title	Journal	Year
Boella, Guido; Caro, Luigi Di; Humphreys, Llio; Robaldo, Livio; Rossi, Piercarlo; vana der Torre, Leendert	Eunomos, a legal document and knowledge management system for the Web to provide relevant, reliable and up-to-date information on the law	Artificial Intelligence and Law	2016
Paliwala, Abdul	Rediscovering artificial intelligence and law: an inadequate jurisprudence?	International Review of Law, Computers and Technology	2016
Cardellino, Cristian; Villata, Serena; Alemany, Laura Alonso; Cabrio, Elena	Information Extraction with Active Learning: A Case Study in Legal Text		2015

Antonini, Alessio; Boella, Guido; Hulstijn, Joris; Humphreys, Llio	Requirements of legal knowledge management systems to aid normative reasoning in specialist domains	Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)	2014
Bach, Ngo Xuan; Minh, Nguyen Le; Oanh, Tran Thi; Shimazu, Akira	A Two-Phase Framework for Learning Logical Structures of Paragraphs in Legal Articles	ACM Transactions on Asian Language Information Processing	2013
Maxwell, Jeremy C.; Anton, Annie I.; Swire, Peter; Riaz, Maria; McCraw, Christopher M.	A legal cross-references taxonomy for reasoning about compliance requirements	Requirements Engineering	2012
Bench-Capon, Trevor; Prakken, Henry	Using argument schemes for hypothetical reasoning in law	Artificial Intelligence and Law	2010

Table 8: Legal systems and legal technology articles

Theme: Ontologies in general/ Semantic web

Author	Title	Journal	Year
Bennett, Mike	The financial industry business ontology: Best practice for big data	Journal of Banking Regulation	2013

Table 9: Ontologies in general articles

2.2.2. Books

Theme: Legal Ontologies

Author	Title	Pages	Year
Casanovas, Pompeu; Pagallo, Ugo; Palmirani, Monica; Sartor, Giovanni	Law, Social Intelligence, nMAS and the Semantic Web: An Overview	1--10	2014
Ceci, Marcello	Representing Judicial Argumentation in the Semantic Web	172--187	2014
Dhouib, Karima; Gargouri, Faiez"	A Legal Knowledge Management System Based on Core Ontology	183--214	2014
Nakamura, Makoto; Ogawa, Yasuhiro; Toyama, Katsuhiko	Extraction of Legal Definitions and Their Explanations with Accessible Citations	157--171	2014
Breuker, Joost; Hoekstra, Rinke	A Cognitive Science Perspective on Legal Ontologies	69--81	2011
Khadraoui, Abdelaziz; Opprecht, Wanda; Leonard, Michel; Aidonidis	Law-based ontology for e-government services construction - Case study: The specification of services in relationship with the venture creation in Switzerland	149--166	2011
Casanovas, Pompeu; Sartor, Giovanni; Biasiotti, Maria Angela; Fernandez-Barrera, Meritxell; Biasiotti, Mariangela Angela	Approaches to Legal Ontologies		2011
Casellas, Nuria	Legal Ontologies	109--170	2011
Francesconi, Enrico	A Learning Approach for Knowledge Acquisition in the Legal Domain	219--233	2011
Mazzega, Pierre; Bourcier, Daniele; Bourgine, Paul; Nadah, Nadia; Boulet, Romain; Casanovas, Pompeu; Sartor, Giovanni	A Complex-System Approach: Legal Knowledge, Ontology, Information and Networks	117--132	2011
Schweighofer, Erich	Indexing as an Ontological Support for Legal Reasoning	213--236	2011
Agnoloni, Tommaso; Tiscornia, Daniela	Semantic web standards and ontologies for legislative drafting support	184--196	2010
Boonchom, Vi Sit; Soonthornphisaj, Nuanwan	Legal ontology construction using ATOB algorithm	268--279	2010
Hondros, Constantine	Standardizing legal content with OWL and RDF	221--240	2010
Mommers, Laurens	Ontologies in the legal domain	265--276	2010
Schweighofer, Erich	Semantic Indexing of Legal Documents	157--169	2010
Breuker, Joost; Valente, Andre; Winkels, Radboud	Use and reuse of legal ontologies in knowledge engineering and information management	36--64	2005

Corcho, Oscar; Fernandez-Lopez, Mariano; Gomez-Perez, Asuncion; Lopez-Cima, Angel	Building legal ontologies with METHONTOLOGY and WebODE	142--157	2005
Gangemi, Aldo; Sagri, Maria Teresa; Tiscornia, Daniela	A constructive framework for legal ontologies	97--124	2005

Table 10: Legal Ontologies books

Theme: Legal systems / Legal technology

Author	Title	Pages	Year
El Ghosh, Mirna; Naja, Hala; Abdulrab, Habib; Khalil, Mohamad	Towards a Legal Rule-Based System Grounded on the Integration of Criminal Domain Ontology and Rules	632--642	2017
Wyner, Adam; Casini, Giovanni	Legal Knowledge and Information Systems-JURIX 2017: The Thirtieth Annual Conference	212	2017
Cyras, Vytautas; Lachmayer, Friedrich; Schweighofer, Erich	Views to legal information systems and legal sublevels	18--29	2016
Freitas, Pedro Miguel; Andrade, Francisco; Novais, Paulo	Criminal Liability of Autonomous Agents: From the Unthinkable to the Plausible	145--156	2014
Ossowski, Sascha	Agreement technologies	1--645	2013
Tang, Yong; Yang, Shihan; Chai, Jiwen; Liu, Shanmei	Extracting semantic information from chinese language patent claims	547--556	2013
Verheij, Bart.; Intelligence, A. C. M. Special Interest Group on Artificial.; ACM Digital Library.	Proceedings of the Fourteenth International Conference on Artificial Intelligence and Law		2013
Ota, Shozo; Satoh, Ken; Nakamura, Makoto	The Fifth International Workshop on Juris-Informatics (JURISIN 2011)	110--111	2012
Palmirani, Monica.; World Congress on Philosophy of Law; Social Philosophy (25th : 2011 : Frankfurt am Main, Germany)	AI Approaches to the Complexity of Legal Systems. Models and Ethical Challenges for Legal Systems, Legal Language and Legal Ontologies, Argumentation and Software Agents		2012
Chopra, Amit K.; Oren, Nir; Modgil, Sanjay; Desai, Nirmit; Miles, Simon; Luck, Michael; Singh, Munindar P.	Analyzing contract robustness through a model of commitments	17--36	2011
Francesconi, Enrico	A Learning Approach for Knowledge Acquisition in the Legal Domain	219--233	2011
Hoekstra, Rinke	The MetaLex document server: Legal documents as versioned linked data	128--143	2011
Mazzega, Pierre; Bourcier, Daniele; Bourgine, Paul; Nadah, Nadia; Boulet, Romain; Casanovas, Pompeu; Sartor, Giovanni	A Complex-System Approach: Legal Knowledge, Ontology, Information and Networks	117--132	2011

Bueno, Tania C. D.; Hoeschl, Hugo C.; Stradiotto, Cesar K.	Ontojuris project: A multilingual legal document search system based on a graphical ontology editor	310--321	2010
Quaresma, Paulo; Gonçalves, Teresa	Using Linguistic Information and Machine Learning Techniques to Identify Entities from Juridical Documents	44--59	2010
Siekmann, J.; Wahlster, W.	Semantic Processing of Legal Texts : Where the Language of Law Meets the Law of Language	XII, 249 p.	2010
Venturi, Giulia	Legal language and legal knowledge management applications	3--26	2010

Table 11: Books about legal systems or legal technology

Theme: Ontologies in general/ Semantic web

Author	Title	Pages	Year
Casanovas, Pompeu; Pagallo, Ugo; Palmirani, Monica; Sartor, Giovanni	Law, Social Intelligence, nMAS and the Semantic Web: An Overview	1--10	2014
Peroni, Silvio	The Semantic Publishing and Referencing Ontologies	121--193	2014
Tang, Yong; Yang, Shihan; Chai, Jiwen; Liu, Shanmei	Extracting semantic information from chinese language patent claims	547--556	2013
Filipe, Joaquim; Institute for Systems; Technologies of Information, Control; Communication; International Conference on Knowledge Engineering; Ontology Development 4 2012.10.04-07 Barcelona; KEOD 4 2012.10.04-07 Barcelona; International Joint Conference on Knowledge Discovery, Knowledge Engineering; Barcelona, Knowledge Management (IC3K) 2012.10.04-07	Proceedings of the International Conference on Knowledge Engineering and Ontology Development Barcelona, Spain, 4-7 October, 2012 ; [one of the three integrated conferences that ... constitute the International Joint Conference on Knowledge Discovery, Kno		2012
Alberti, Marco; Gomes, Ana Sofia; Gonçalves, Ricardo; Leite, Joao; Slota, Martin	Normative systems represented as hybrid knowledge bases	330--346	2011
Allemang, Dean; Hendler, Jim	Semantic Web for the Working Ontologist: Effective modeling in RDFS and OWL	52--55	2011

Casellas, Nuria	Methodologies, tools and languages for ontology design	57--107	2011
Guizzardi, Giancarlo; Das Graças, Alex Pinheiro; Guizzardi, Renata S. S.	Design patterns and inductive modeling rules to support the construction of ontologically well-founded conceptual models in OntoUML	402--413	2011

Table 12: Books about ontologies in general

Theme: Artificial Intelligence - Machine Learning, Other themes

Author	Title	Pages	Year
Moreno-Díaz, Roberto; Pichler, Franz; Quesada Arencibia, Alexis	Computer aided systems theory -- EUROCAST 2017 : 16th International Conference, Las Palmas de Gran Canaria, Spain, February 19-24, 2017, Revised selected papers. Part II	480	2018
Alferes, Jose Julio; Bertossi, Leopoldo; Governatori, Guido; Fodor, Paul; scientist) Roman, Dumitru (Research	Rule technologies : research, tools, and applications : 10th International Symposium, RuleML 2016, Stony Brook, NY, USA, July 6-9, 2016. Proceedings	351	2016
Sartor, Giovanni; Rotolo, Antonino	AI and law	199--207	2013
Verheij, Bart.; Intelligence, A. C. M. Special Interest Group on Artificial.; ACM Digital Library.	Proceedings of the Fourteenth International Conference on Artificial Intelligence and Law		2013
Quaresma, Paulo; Gonçalves, Teresa	Using Linguistic Information and Machine Learning Techniques to Identify Entities from Juridical Documents	44--59	2010

Table 13: Books about artificial intelligence or machine learning

2.2.3. Conference Proceedings

Theme: Legal Ontologies

Author	Title	Pages	Year
Castro, Antonio P.; Calixto, Wesley P.; Gomes, Viviane M.; Veiga, Ernesto F.; Silva, Lais F. A.; Castro, Layza L. Oliveira P.; Barbosa, Jose Luiz Ferraz; Campos, Pedro H. M.	Ontology applied in the judicial sentences	1--6	2017
Chalkidis, Ilias; Nikolaou, Charalampos; Soursos, Panagiotis; Koubarakis, Manolis	Modeling and querying Greek legislation using semantic web technologies	591--606	2017
El Ghosh, Mirna; Abdulrab, Habib; Naja, Hala; Khalil, Mohamad	A criminal domain ontology for modelling legal norms	282--294	2017
Griffo, Cristine; Almeida, Joao Paulo A.; Guizzardi, Giancarlo; Nardi, Julio Cesar	From an Ontology of Service Contracts to Contract Modeling in Enterprise Architecture	40--49	2017
Hofman, Darra L.	Legally speaking: Smart contracts, archival bonds, and linked data in the blockchain		2017
de Kruijff, Joost; Weigand, Hans	Ontologies for commitment-based smart contracts	383--398	2017
Schmitz, P.; Francesconi, E.; Batouche, B.; Landercy, S. P.; Touly, V.	Ontological models of legal contents and users' activities for EU e-Participation services	99--114	2017
Al Khalil, Firas; Ceci, Marcello; Yapa, Kosala; O'Brien, Leona	SBVR to OWL 2 mapping in the domain of legal rules	258--266	2016
Bouaziz Mezghanni, Imen; Gargouri, Faiez	Towards an Arabic legal ontology based on documents properties extraction	1--8	2016
Kim, Wooju; Lee, Youna; Kim, Donghe; Won, Minjae; Jung, HaeMin	Ontology-based model of law retrieval system for R\&D projects	1--6	2016
Molnar, Balint; Beleczki, Andras; Benczur, Andras	Application of legal ontologies based approaches for procedural side of public administration: A case study in Hungary	135--149	2016
Santos, Cristiana; Rodriguez-Doncel, Victor; Casanovas, Pompeu; Van der Torre, Leon	Modeling relevant legal information for consumer disputes	150--165	2016

Cornoiu, Sorina; Valean, Honoriu	Improving legal information retrieval using the Wikipedia knowledge base, legal ontology and the Eurovoc Thesaurus	111--116	2015
Lamharhar, Hind; Chiadmi, Dalila; Benhlima, Laila	Ontology-based knowledge representation for e-government domain	1--10	2015
Onnoom, Boonyarin; Chiewchanwattana, Sirapat; Sunat, Khamron; Wichiennit, Nutcharee	An ontology framework for recommendation about a crime scene investigation	176--180	2015
Bakhshandeh, M.; Kolany-Raiser, B.; Antunes, G.; Yankova, S.-A.; Caetano, A.; Borbinha, J.	A digital preservation-legal ontology		2014
Capuano, Nicola; De Maio, Carmen; Salerno, Saverio; Toti, Daniele	A Methodology based on Commonsense Knowledge and Ontologies for the Automatic Classification of Legal Cases	1--6	2014
Capuano, Nicola; Salerno, Saverio; De Maio, Carmen	A knowledge based system for guidance and training on legal concepts	498--503	2014
Jo, Dae Woong; Kim, Myung Ho	Web-based semantic web retrieval service for law ontology	666--673	2014
Markovic, Marko; Gostojic, Stevan; Konjovic, Zora	Structural and semantic markup of complaints: Case study of Serbian Judiciary	15--20	2014
Mezghanni, Imen Bouaziz; Gargouri, Faiez	Learning of Legal Ontology Supporting the User Queries Satisfaction	414--418	2014
Dhouib, Karima; Gargouri, Faiez	Legal application ontology in Arabic	1--6	2013
Frosterus, Matias; Tuominen, Jouni; Wahlroos, Mika; Hyvoñen, Eero	The Finnish law as a linked data service	289--290	2013
Bruno, Giulia; Villa, Agostino	An ontology-based model for SME network contracts	85--92	2012
Ceci, Marcello; Palmirani, Monica	Ontology framework for judgment modelling	116--130	2012
Johnson, James R.; Miller, Anita; Khan, Latifur; Thuraisingham, Bhavani	Extracting semantic information structures from free text law enforcement data	177--179	2012
Taduri, Siddharth; Lau, Gloria T.; Law, Kincho H.; Kesan, Jay P.		146	2012
Johnson, James R.; Miller, Anita; Khan, Latifur	Law enforcement ontology for identification of related information of interest across free text documents	19--27	2011
Li, Ling; Dai, Hang	Building a change management model for e-government services evolution	87--92	2011

Ajani, Gianmaria; Boella, Guido; Lesmo, Leonardo; Martin, Marco; Mazzei, Alessandro; Radicioni, Daniele P.; Rossi, Piercarlo	Multilevel legal ontologies	136--154	2010
Gostojic, S.; Konjovic, Z.; Milosavljevic, B.	Modeling MetaLex/CEN compliant legal acts	285--290	2010

Table 14: Conference proceedings on legal ontologies

Theme: Legal systems / Legal technology

Author	Title	Pages	Year
Hasan, M. Mahmudul; Aganostopoulos, Dimosthenis; Loucopoulos, Pericles; Nikolaidou, Mara	Regulatory Requirements Compliance in e-Government System Development	441--449	2017
Norta, Alex	Designing a smart-contract application layer for transacting decentralized autonomous organizations	595--604	2017
Cyras, Vytautas; Lachmayer, Friedrich; Schweighofer, Erich	Views to legal information systems and legal sublevels	18--29	2016
Delmolino, Kevin; Arnett, Mitchell; Kosba, Ahmed; Miller, Andrew; Shi, Elaine	Step by step towards creating a safe smart contract: Lessons and insights from a cryptocurrency lab	79--94	2016
Idelberger, Florian; Governatori, Guido; Riveret, Regis; Sartor, Giovanni	Evaluation of logic-based smart contracts for blockchain systems	167--183	2016
Kosba, Ahmed; Miller, Andrew; Shi, Elaine; Wen, Zikai; Papamanthou, Charalampos	Hawk: The Blockchain Model of Cryptography and Privacy-Preserving Smart Contracts	839--858	2016
Araszkiewicz, Michal; Lopatkiewicz, Agata; Zienkiewicz, Adam; Zurek, Tomasz	Representation of an actual divorce dispute in the parenting plan support system	166--170	2015
Athan, Tara; Governatori, Guido; Palmirani, Monica; Paschke, Adrian; Wyner, Adam	LegalRuleML: Design principles and foundations	151--188	2015
Boella, Guido; Ruffini, Claudio; Simov, Kiril; Violato, Andrea; Stroetmann, Veli; Di Caro, Luigi; Graziadei, Michele; Cupi, Loredana; Salaroglio, Carlo Emilio; Humphreys, Llio; Konstantinov, Hristo; Marko, Kornel; Robaldo, Livio	Linking legal open data	171--175	2015
Calambas, Manuel Alejandro; Ordonez, Armando; Chacon, Angela; Ordonez, Hugo	B\'usqueda de Precedentes Judiciales Apoyada en Procesamiento de Lenguaje Natural y Clustering	372--377	2015

Son, Nguyen Truong; Phuong Duyen, Nguyen Thi; Quoc, Ho Bao; Nguyen, Le Minh	Recognizing logical parts in Vietnamese legal texts using conditional random fields	1--6	2015
Lemos, Julio	Computational Tools for Uniform Legal Interpretation: A Use Case	19--24	2014
Verheij, Bart; Francesconi, Enrico; Gardner, Anne	ICAIL 2013: The fourteenth international conference on artificial intelligence and law	81--82	2014
Athan, Tara; Boley, Harold; Governatori, Guido; Palmirani, Monica; Paschke, Adrian; Wyner, Adam	OASIS LegalRuleML	3	2013
Boella, Guido; Janssen, Marijn; Hulstijn, Joris; Humphreys, Llio; van der Torre, Leendert	Managing legal interpretation in regulatory compliance	23	2013
Bench-Capon, Trevor; Araszkiewicz, Micha{\l}; Ashley, Kevin; Atkinson, Katie; Bex, Floris; Borges, Filipe; Bourcier, Daniele; Bourgine, Paul; Conrad, Jack G.; Francesconi, Enrico; Gordon, Thomas F.; Governator, Guido; Leidner, Jochen L.; Lewis, David D.; Loui, Ronald P.; McCarty, L. Thorne; Prakken, Henry; Schilder, Frank; Schweighofer, Erich; Thompson, Paul; Tyrrell, Alex; Verheij, Bart; Walton, Douglas N.	A history of ai and law in 50 papers: 25 Years of the international conference on ai and law	215--319	2012
Barabucci, Gioele; Palmirani, Monica; Vitali, Fabio; Cervone, Luca	Long-term preservation of legal resources	78--93	2011
Mahfouz, T.; Kandil, A.	Construction legal decision support using Support Vector Machine (SVM)	879--888	2010
Wyner, Adam; Mochales-Palau, Raquel; Moens, Marie Francine; Milward, David	Approaches to text mining arguments from legal cases	60--79	2010

Table 15: Conference proceedings - Legal systems and legal technology

Theme: Ontologies in general/ Semantic web

Author	Title	Pages	Year
De Kruijff, Joost; Weigand, Hans	Understanding the blockchain using enterprise ontology	29--43	2017
Gavanelli, Marco; Lamma, Evelina; Riguzzi, Fabrizio; Bellodi, Elena; Riccardo, Zese; Cota, Giuseppe	Abductive logic programming for normative reasoning and ontologies	187--203	2017
de Kruijff, Joost; Weigand, Hans	Ontologies for commitment-based smart contracts	383--398	2017
Carvalho, Rodrigo; Goldsmith, Michael; Creese, Sadie	Applying Semantic Technologies to Fight Online Banking Fraud	61--68	2016
Czepa, Christoph; Tran, Huy; Zdun, Uwe; Tran Thi Kim, Thanh; Weiss, Erhard; Ruhsam, Christoph	Ontology-Based Behavioral Constraint Authoring	225--232	2016
Gao, Zhiyong; Liang, Yongquan	The ontology construction approach for the Chinese Tax Knowledge Domain	1693--1697	2016
Verdonck, Michael; Gailly, Frederik	Insights on the use and application of ontology and conceptual modeling languages in ontology-driven conceptual modeling	83--97	2016
Nardi, Julio Cesar; Falbo, Ricardo de Almeida; Almeida, Joao Paulo A.; Guizzardi, Giancarlo; Pires, Luis Ferreira; van Sinderen, Marten J.; Guarino, Nicola	Towards a Commitment-Based Reference Ontology for Services	175--184	2013
Ahmed, Mansoor; Anjomshoaa, Amin; Asfandeyar, Muhammad; Tjoa, A. Min; Khan, Abid	Towards an ontology-based solution for managing license agreement using semantic desktop	309--314	2010
Almeida, Jo??o Paulo A.; Cardoso, Evellin Cristine Souza; Guizzardi, Giancarlo	On the goal domain in the RM-ODP enterprise language: An initial appraisal based on a Foundational Ontology	382--390	2010

Table 16: Conference proceedings - Ontologies in general

3. A first approach to the field: representation of knowledge

A general objective for Artificial Intelligence field is the **development of techniques that allow a system to solve problems "intelligently",** that is, consider the available information and its context. Therefore, we can deduce that the capacity to represent and use knowledge will be an implicit requirement in the development of these systems.

Representation of knowledge discipline studies **how to specify knowledge in a format that supports problems resolution**, can be framed in the field of **symbolic Artificial Intelligence**, this means that knowledge is represented through **discrete units** (symbols) that can be **combined following rules**, forming a representation scheme.

A **representation schema** is an instrument to transform the domain knowledge into a symbolic language endowed it with syntax and semantics.

- **Syntax**: describes the possible ways to build and combine the elements of a language.
- **Semantic**: determines the meaning of the elements of language and the relationship between them.

The main objective is to **facilitate the extraction of conclusions** (inference) **from the knowledge** expressed in a computable form. The domain and problem to solve, will mark how to represent knowledge, but this way of representing knowledge is not trivial, and will **determine how we can manipulate it**.

3.1. Ontologies

The word ontology can have several meanings, in a philosophical sense, it refers to the branch of philosophy which deals with the nature and structure of “reality”, in the field of computer science it would mean: **formal specification of a shared conceptualization**, which is the definition of W.N. Borst which expands the definition of T.R. Gruber, widely accepted and cited. 5.6.[1]

If we develop this definition, we can draw these conclusions:

- An ontology is a representation of a domain that is explicitly materialized somewhere.
- An ontology is the result of a modeling of knowledge, this is known, shared and accepted by a community of experts, so it is not the vision of someone in particular.

Ontologies are technically defined by the following elements:

- **Concept**: These are the ontological categories.
- **Relationships**: Connect concepts semantically.
- **Instances**: They are concrete objects of the domain.
- **Attributes**: They are properties and their value. Value can be a concept of ontology.

For more information about ontologies and knowledge representation: [2] [3][4][5][6]

3.1.1. Ontologies Classification

In Computer Science, the most used ontology classification is the one proposed by N. Guarino [7]:

- **Top-Level Ontology**: describe general concepts such as time, space, objects, actions, etc.

- **Domain Ontologies**: Describe concepts related to a generic domain (for example: legal), instantiating concepts of high-level ontologies.

- **Task Ontologies**: They describe specialized vocabulary about some generic task or activity (for example: crime scenes [8][9]), they are developed from the specialization of high level ontologies.

- **Application ontologies**: describes concepts depending on both domain and task, which are often specializations.

These types of ontologies are related to each other, since as can be extracted from the previous definitions, there is a specialization relationship between them, as shown in the following image:

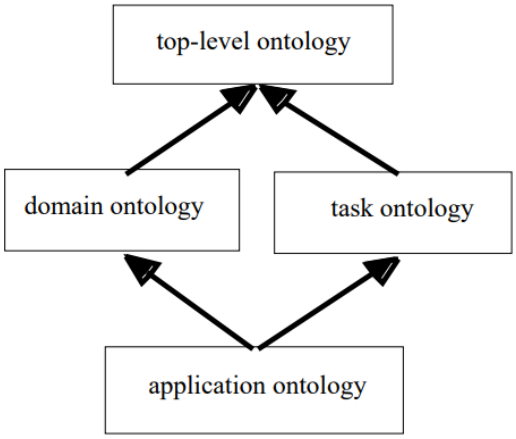


Illustration 4: Ontology kinds and their relationships of specialization

3.1.2. Design and creation of ontologies

Class hierarchy definition

There are three ways to build a class hierarchy to define the concepts [10]:

- **Top-down**: Firstly, classes that define the most general concepts of the domain are created; secondly these concepts are concretized and specialized.
- **Bottom-up**: At beginning, classes that define the most specific concepts are created; subsequently the more general classes that will group the first concepts are defined.
- **Top-down/bottom-up mix**: In a first step, main concepts of the domain are defined; in a second step, concepts will continue to be further specialized, or generalized grouping together more specific concepts.

Methodologies

Knowledge engineering field in general, and ontologies engineering in particular are still very young, and this implies that solid standards have not yet been established, a single correct way of making things has not been discovered, but a set of ontology construction methodologies are used more frequently by professionals in this area, although I

repeat: there is no adequate methodology for all cases, and this must be adapted to each case, even so, I make an enumeration of the most named:

- **Methontology** [11]: This methodology proposes the construction of an ontology starting from another more general ontology. It enumerates activities extracted from IEEE activities for software engineering: specification, conceptualization, formalization, integration, implementation, evaluation, documentation and maintenance. These activities form a life cycle based on evolutionary prototypes.
  For more information about Methontology: [12][13] [14]

- **OTKM** [15]: This methodology is more general, and focuses on facilitating the use and maintenance of the ontology, it distinguishes these activities: viability study, taking requirements, refinement, evaluation and evolution.
  For more information about OTKM: [16]

- **Text2Onto** [17]: It really is a framework for ontologies construction, which integrates data mining algorithms for its construction.
  For more information about Text2Onto: [18]

- **SENSUS** [19]: This methodology originally started from the SENSUS ontology, but in reality it can be based on any other. Follow a top-down approach, and it distinguishes these activities: Initial set of seed concepts, linking seed concepts in the reference ontology, completion of intermediate concepts, inclusion of other relevant concepts, inclusion of concepts with a large number of graph paths that pass through them.
  For more information about SENSUS: [20]

- **Grüninger & Fox** [10]: This methodology includes these activities: capture of scenarios, informal questions formulation, specification of concepts, formal competence questions formulation, ontology development and evaluation. This methodology is the result of experience acquired in the Toronto Virtual Enterprise Project (TOVE) [21].

To go deeper in construction methodologies: [22][23][24][25][26]

3.2. Data representation standards

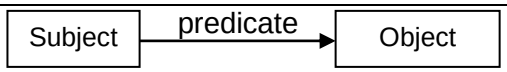
The most used formats for knowledge representation by ontologies in general and in legal ontologies in particular are listed below, some specialized thesaurus format is also mentioned, since Lexis ontology references the Eurovoc thesaurus [27]:

- **Extensible Markup Language (XML)[1]:** is a markup language that defines a set of rules for encoding documents in a format that is both human-readable and machine-readable.

[1] https://en.wikipedia.org/wiki/XML [Accessed 14 Dec. 2018]

- **Resource Description Framework (RDF)[2]:** It is a XML standard developed by W3C, originally used to represent metadata, but it has evolved to the point that it allows writing "metainformation" and integrating several data sources, even with different schemes.
  For more information and examples about RDF, consult these references: [28][29][30][31][32]

  This standard relates entities, through binary relationships (statements), these statements are represented by the triplet: Subject - Predicate - Object
  The following table shows the different ways to represent these triplets:

Graphical form	
Triplet	subject - predicate - object
Relational form	predicate (subject, object)

RDF/XML	`<rdf:Description rdf:about="subject">`
	`  <ex:predicate>`
	`  <rdf:Description rdf:about="object"/>`
	`  </ex:predicate>`
	`</rdf:Description>`

Table 17: Different ways to represent a RDF triplet

- **Resource Description Framework Schema (RDFS)**[3]: It is a semantic extension of RDF, also developed by W3C. It is a primitive language of ontologies that provides the basic elements for the description of ontologies (originally vocabularies), intended to structure RDF resources.
  For more information about RDFS: [33]

- **Simple Knowledge Organization System (SKOS/RDF)[4]:** It is a standard developed by the W3C, and built on RDF. It has been designed for representation of a thesaurus, classification schemes, taxonomies, subject-heading systems, or any other type of structured controlled vocabulary.
  For more information and examples about SKOS: [34]

- **Web Ontology Language (OWL)[5]:** It is a family of languages for structured ontologies definition. This standard is built on RDFS and has several sublanguages: Lite, DL and Full. They range from minor to greater expressiveness, to greater expressiveness, greater computational complexity.
  For more information and examples about OWL, consult these references:
  [35][36][37][38][39][40][41][42][20][43][44]

[2] https://en.wikipedia.org/wiki/Resource_Description_Framework [Accessed 14 Dec. 2018]
[3] https://en.wikipedia.org/wiki/RDF_Schema [Accessed 14 Dec. 2018]
[4] https://en.wikipedia.org/wiki/Simple_Knowledge_Organization_System [Accessed 14 Dec. 2018]
[5] https://en.wikipedia.org/wiki/Web_Ontology_Language [Accessed 14 Dec. 2018]

- **Semantic Web Rule Language (SWRL)[6]:** It is a semantic web language that is used to define rules and logic, combined with both OWL DL and OWL Lite.
  The rules have a form of implication between an antecedent (body) and a consequent (head). The intended meaning can be read as: provided that the conditions specified in the antecedent are met, the conditions specified in the consequent must also be met.

```
Example: hasParent(?x1,?x2) ∧ hasBrother(?x2,?x3) ⇒ hasUncle(?x1,?x3)
```

- **SPARQL Protocol and RDF Query Language (SPARQL)[7]:** It is a **semantic query language** for databases capable of recovering and manipulating data stored in RDF format, it was developed by W3C.
  SPARQL allows for a query to consist of triple patterns, conjunctions, disjunctions, and optional patterns.

```
PREFIX codes: <http://www.ontolaw.com/codes>
SELECT * WHERE
{
      ?name codes:family "Civil Law"
}
```

For more information about how SPARQL is used in ontologies: [45][46]

4. Legal Ontologies

After years of research [47], optimal principles have not yet been reached regarding the creation of ontologies for information systems. Attempts to formalize legal activity have been made for a long time, especially because the cause-effect relationship in legal precedents can be seen with confidence [48]. During '90s, systems based on logical inference methods were developed [49]; these systems provided the need to establish relationships between the results obtained and the original legal texts; after the investigation evolved towards the methods of formation of conclusions. Later, the "ontological scheme" came to be used as a basis for legal knowledge in intelligent systems [50], and currently, the principle of data description is the mechanism most used in the modeling of knowledge in the legal domain.
To deepen the representation of legal knowledge theory: [51] [52][53][54][55][56]

4.1. Legal systems

In the modern world there are two major legal traditions, both have been developed in parallel, but differ widely in their sources, processes and concepts, so these traditions lead to different judicial structures, circumstances that undoubtedly condition later the legal ontologies design and development, in order to treat, store and retrieve information in the most optimal way possible.

[6] https://en.wikipedia.org/wiki/Semantic_Web_Rule_Language [Accessed 14 Dec. 2018]
[7] https://en.wikipedia.org/wiki/SPARQL [Accessed 15 Dec. 2018]

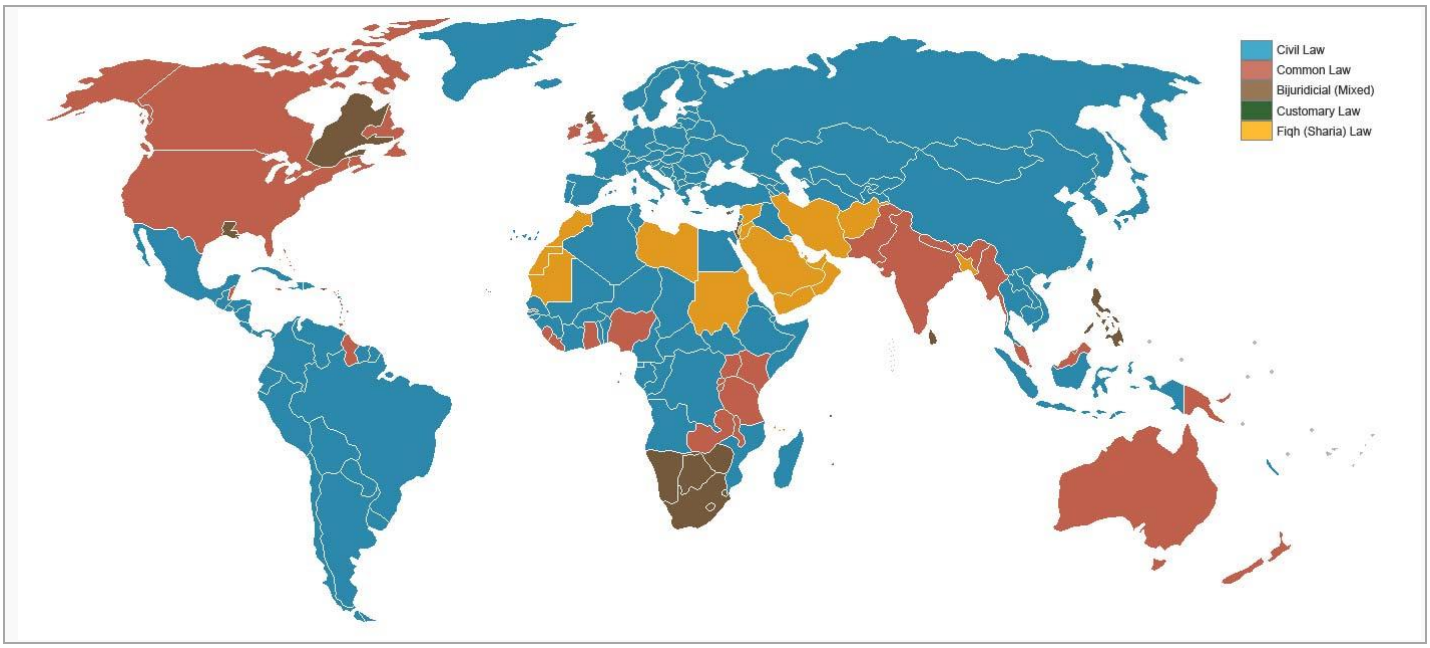


Illustration 5: World map with the legal systems of each country[8]

As we can see in the map, around 80 countries adopt the common law system, and around 150 countries adopt fundamentally the civil law system.

Rest systems can be considered a hybrid, for example, the Philippines, Sri Lanka, South Africa, Israel, and Cyprus would have a mixed system between civil law and common law. Other countries such as Nigeria, Bangladesh Malaysia or Pakistan would have a common law system mixed with Islamic law (Sharia). In the case of India, it would be a mix of common law, civil law, religious and customary laws.

Civil law systems descend all from the old Roman Empire and are based on the codification of written legal codes; on the contrary, common law systems are descended from the English tradition, and their expansion throughout the world through the British Empire and they are not based mainly on written codes, but on court cases and precedents.

Another feature is that civil legal systems are always based on a written constitution, however, in common law is not always the case, for example, the US has a written Constitution, while the United Kingdom does not have it as such.

It can be deduced that the judicial role within the common law system is active in terms of law-making, and passive within civil law systems.

Legal reasoning style in common law system countries is an inductive method, analogical reasoning, analyzing case by case, and using precedents with force of law. On the other hand, in Roman civil tradition countries, a deductive reasoning method is used, applying abstract codifications of the law, relegating the use of precedents as support for legal writings. [57]

[8] https://en.wikipedia.org/wiki/File:LegalSystemsOfTheWorldMap.png [Accessed 15 Dec. 2018]

4.2. Legal domain standards

- **Architecture for Knowledge-Oriented Management of African Normative Texts using Open Standards and Ontologies (Akoma Ntoso)[9]:** Akoma Ntoso is an initiative of UN program "Africa i-Parliament Action Plan", that defines a set of simple technology-neutral electronic representations in XML format of parliamentary, legislative and judiciary documents.

  The XML schemes of Akoma Ntoso make explicit the structure and semantic components of the digital documents so as to support the creation of high-value information services that deliver the power of ICTs and increase efficiency and accountability in parliamentary, legislative and judiciary contexts.

- **CEN MetaLex[10]**: It is an initiative of the European Committee for Standardization (CEN Workshop on an Open XML Interchange Format for Legal and Legislative Resources). It is also a standard XML schema, similar to Akoma Ntoso, in fact, both are part of ESTRELLA project, and they reached an agreement on the abstract structure of legal documents to achieve the interoperability of standards (CEN MetaLex Workshop, 2006, 2008). The difference between both is that MetaLex is developed on epistemological models based on cognitive sciences, and Akoma Ntoso is closer to legal texts, from a normative point of view. The core ontology LKIF [*see* 4.4] uses MetaLex standard.
  For more information, consult: [58][59]

- **LegalXML**[11]: LegalXML is a section of the non-profit Organization "Organization for the Advancement of Structured Information Standards" (OASIS), this section develops open standards for electronic filing of court documents, legal citations, transcripts, criminal justice intelligence systems, etc. The basic component, as its own name indicates is the XML language, and it is created on the basis of Akoma Ntoso. [60]

  The members of OASIS that participate in this section are from different areas: developers, application providers, government agencies, lawyers, lawyers, academics, etc. And they are divided into several committees, according to their purpose, which for LegalXML are:

  - **OASIS Legal Citation Markup (LegalCiteM) TC:** Developing an open standard for machine-readable tagging of legal citations.
  - **OASIS LegalDocumentML (LegalDocML) TC:** Advancing worldwide best practices for the use of XML in legal documents.
  - **OASIS LegalRuleML TC:** Enabling legal arguments to be created, evaluated, and compared using rule representation tools. [61]
  - **OASIS LegalXML Electronic Court Filing TC:** Using XML to create and transmit legal documents among attorneys, courts, litigants, and others.
  - **OASIS LegalXML eContracts TC:** Enabling the efficient creation, maintenance, management, exchange, and publication of contract documents and terms.
  - **OASIS LegalXML eNotarization TC:** Developing technical requirements to govern self-proving electronic legal information.

[9] http://www.akomantoso.org/ [Accessed 16 Dec. 2018]
[10] http://www.metalex.eu/ [Accessed 16 Dec. 2018]
[11] http://www.legalxml.org/ [Accessed 16 Dec. 2018]

- **OASIS LegalXML Integrated Justice TC:** Facilitating the exchange of data among justice system branches and agencies for criminal and civil cases.
- **OASIS LegalXML Lawful Intercept TC:** Production of a structured, end-to-end lawful interception process framework consisting of XML standards and authentication mechanisms, including identifiable related XML standards and XML translations of ASN.1 modules.
- **OASIS LegalXML Legislative Documents, Citations, and Messaging TC:** Standardizing markup for legislative documents and a simple citation for non-legislative documents.
- **OASIS LegalXML Online Dispute Resolution TC:** Using XML to allow public access to justice through private- and government-sponsored dispute resolution systems.
- **OASIS LegalXML Legal Transcripts TC:** The purpose of this TC was to develop an XML compliant syntax for representing legal transcript documents either as stand-alone structured content, or as part of other legal records.

For more information on standards, consult these references: [62][63][64][65][16][66][67][68]

4.3. Features of legal information and design challenges

Legal information has its own features that differentiate it from other types of information and poses some design challenges for systems in general, and ontologies in particular, which must be resolved in order for the information to be practical. The main characteristics that must be taken into account can be divided into three groups: proper to the language, to the legal system, and techniques.
These references deal with legal information features: [69][70][71][72][66][73]

4.3.1. Derived from language

- **Logical/syntactic structures of language:** Language has an imprecise nature sometimes, sometimes, the conjunction 'and' has to be interpreted as the disjunction 'or' or vice versa.

- **Vague language:** Sometimes a vague language is used on purpose, so very changing social environments can be accommodated without constantly changing the text.

- **Polysemy of concepts:** On the one hand, in the legal domain, a concept may have a meaning different from the usual one in the ordinary language. On the other hand, the same concept can have different meanings for different jurisdictions.

- **Groups of synonyms:** Legal language is different from the rest, so a legal concept may have a distinct set of synonyms than ordinary language.

- **Unstructured text:** Although legal texts are usually presented with a structure, and for the same type of document, several structures coincide, they do not always occupy the same place, and some structures may even be omitted.

4.3.2. Derived from legal system

- **Multiple jurisdictions**: we live in a globalized world, and there are supranational organizations that generate legal information, this information must be adapted later in each country, ontologies have to be able to model these differences.

- **Time limitations:** Legislation is somewhat dynamic, the society changes, and this legislation has to adapt, so there is current information, repealed, updated, et
  Generally, in different legal systems, these principles prevail:
  - *Lex superior derogat legi inferiori:* A superior rank law or codified in a superior code, repeals the previous ones.
  - *Lex posterior derogat priori:* A more recent law repeals an old one that deals with the same subject.
  - *Lex specialis derogat generali*: A more specific law on a subject prevails over a more generalist law.
- **Updates and consolidated texts:** Sometimes a compendium of several regulations are elaborated in a single regulation, or only some articles are updated, but historical information should not be lost.

- **Cross-references:** frequently, legal information refers to other legal information. For example, it is very common to find, within the same code, that one article refers to another.

- **Classification of information:** legal information is not usually found with clear classification.

- **High substantial variability:** derived from the dynamics of society, changes in information occur frequently.

- **Legal norms fragmentation:** Norms that regulate a society domain, or rule's elements, are contained in different codes, laws or other legislation elements. [41]

4.3.3. Technical features

- **Different databases:** information is usually located in different databases, in different networks, with different formats, etc.

- **The volume of information:** the volume of legal information is very high, and it increases rapidly.

- **Reliable information:** resulting information must be truthful and obtained from trusted sources. In addition, the retrieval of information must be adapted to the query, for example, if I want to see a current regulation, it would not be correct to see a repealed text.

- **Update and availability:** Information must be constantly updated, and historical data must remain

- **Accessibility:** Normally, traditional legal information, on paper, has not taken into account this purpose, in addition, there are different sources of information, a large volume of information, cross-references, etc. Advances are being made to make legal information available to everyone thanks to initiatives such as Linked Open Data and Open Government Data. [74]

4.4. Legal core ontologies

According to the above, we have seen how, despite being a very young research domain, decades of intensive research in legal domain ontologies have been accumulated, so, there is already a more or less established base, and more or less mature by which you can start new projects, this has already been picked up by some ontology construction methodologies [*see* 3.1.2]**3.1.2**, as we have seen.

There is a set of legal ontologies that usually serve as a basis for these new projects, these ontologies are called "legal core ontologies", and there are some of these ontologies that are repeated quite frequently in new projects, these core ontologies are frequently used as a basic structure of a legal domain new ontologies, as frameworks, or as application ontologies [*see* 3.1.1]. That is why it has been decided write this point, before entering in analysis of the latest research in this domain.

For more information about foundational or core ontologies, consult these references: [75][76][77][78][79][80]

4.4.1. Functional Ontology of Law (FOLaw)

Was launched in 1994 by A. Valente, is based on theories of H. Kelsen and Hart and Bentham (norms are rules, which can only be observed or violated). It is written with the language of ontologies ONTOLingua, and has a purpose-oriented to knowledge and functional (meta-level knowledge, normative knowledge, responsibility knowledge, creative knowledge and reactive knowledge) [81]

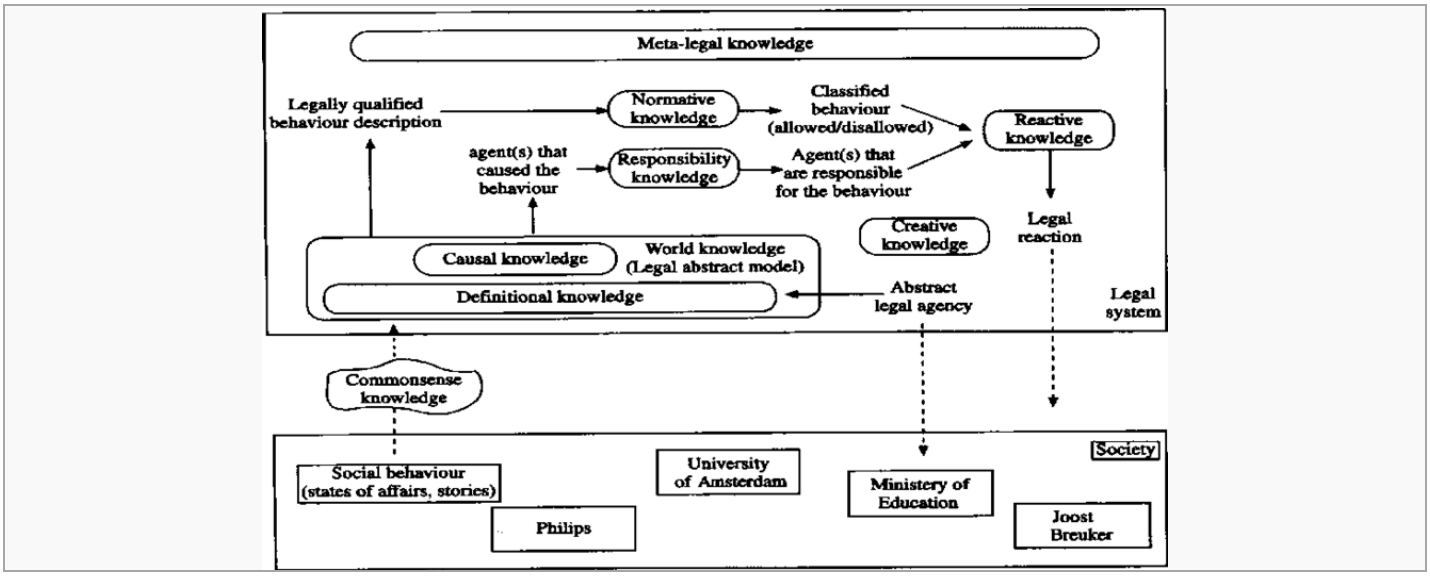


Illustration 6: FOLaw: a functional ontology for law (Valente, A., 1995).

4.4.2. Core Legal Ontology (CLO)

Launched in 2003 [82], it is the result of ISTC-CNR and ITTIG-CNR collaboration, it is written in the ontology language OWL DL [*see* 3.2]. This ontology is built on the foundations of a generalist ontology: DOLCE+ (a Descriptive Ontology for Linguistic and Cognitive Engineering)[12]. The purpose of this ontology is to organize legal concepts and their relationships with physical, cognitive, social, property… legal words based on properties formally defined in DOLCE+. It admits three types of legal tasks for civil law tradition countries [*see* 4.1]:

- Conformity check.
- Legal advice.
- Comparison of norms.

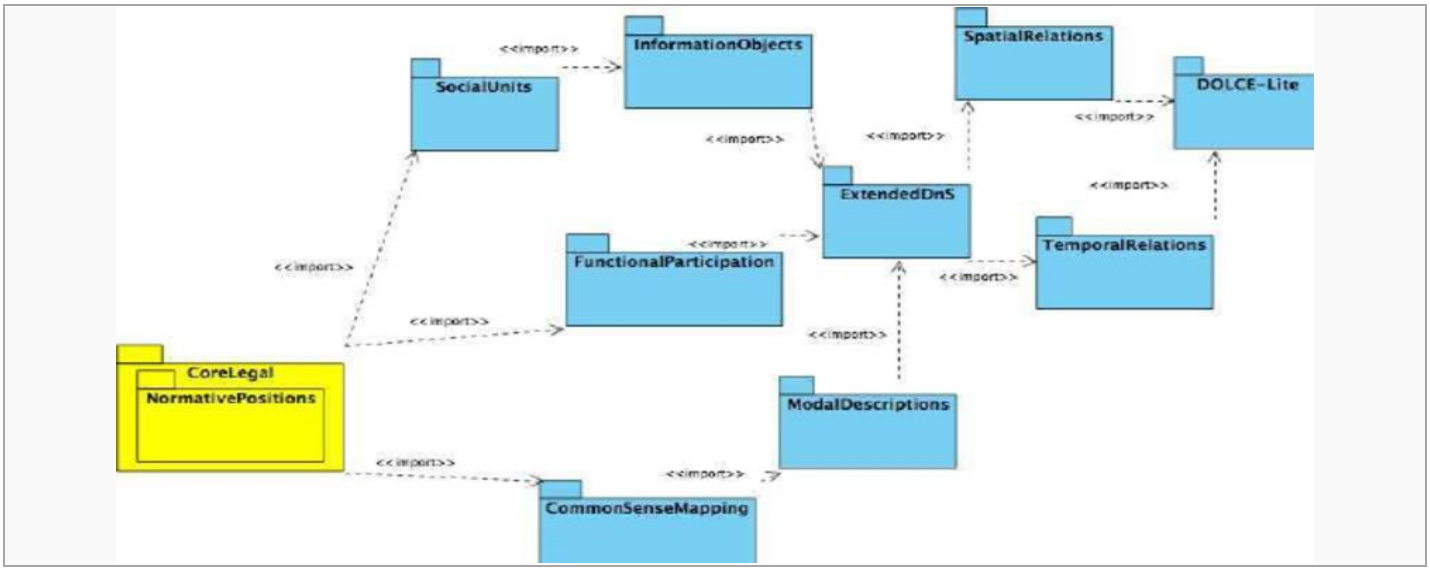


Illustration 7: CLO ontology dependencies and its relationship with DOLCE +

4.4.3. LRI - Core Ontology

Launched in 2004 by the Leibniz Center for Law Research Group [83], also, as the previous ontology, it is written in OWL DL. But in this case, it is based on several foundational ontologies: DOLCE, SUO, the John's Sowa ontology. This ontology is composed of two levels:

- A foundational ontology: it composes the most abstract level, and contains several concepts related to common sense instead of laws, included in five major categories: physical, mental, abstract, roles and occurrence.
- Legal core ontology: it is a more concrete level, with specialized concepts of the domain.

The general purpose of this ontology is to serve as a basis for the creation of new domain ontologies [*see* 3.1.1].
In the following illustration, the two highest layers of the LRI-Core ontology are observed:

[12] http://www.loa.istc.cnr.it/old/DOLCE.html [Accessed 17 Dec. 2018]

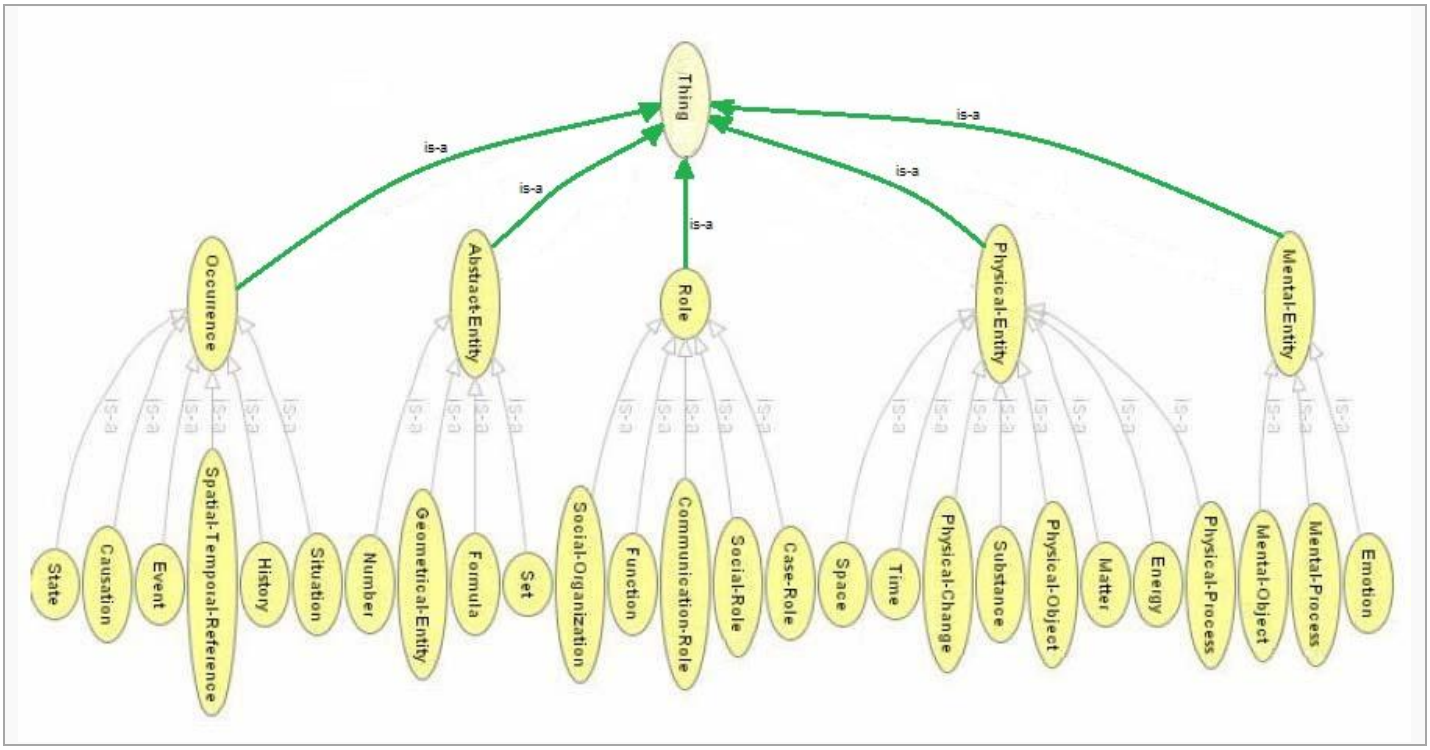


Illustration 8: two top-level layers from LRI-Core ontology

4.4.4. LKIF - Core Ontology

LKIF- Core ontology[13] is also developed by the Leibniz Center for Law Research, in ESTRELLA project (see CEN MetaLex in point 4.2), this ontology is considered the successor of LRI-Core ontology. [84]

The purpose of this ontology is to translate the legal knowledge contained in different sources and different formats and achieve the interoperability of the different legal knowledge systems. Several methodologies have been followed for design and development, for example, for common sense concepts modeling, it has been created clusters of independent concepts, and each has been developed with its related concepts, instead of the typical top-down approach, idea taken from Hayest (1985). For the rest, ideas of Grüninger, Unchold and King have been followed. (*see* 3.1.2) [10]

The ontology consists of 13 modules, each of which describes a set of closely related concepts of both common sense and legal domains. It is organized in three levels:

- Top Level: they are the concepts of its predecessor LRI-Core ontology.
- Intentional Level: Models the behavior of an intelligent agent from a legal perspective. The main concepts are:
    - Agent
    - Role
    - Action

[13] http://www.leibnizcenter.org/general/lkif-core-ontology

- Propositional_Attitudes
- Expressions

- Legal Level:
  - Norm: text of a situation
    - Obligation and Prohibition are equivalent.
    - Permission: in a higher level than Obligation and Prohibition.
  - Situation: indicated as Qualified (Allowed, Disallowed)

In the following image, the two highest levels of the ontology are observed:

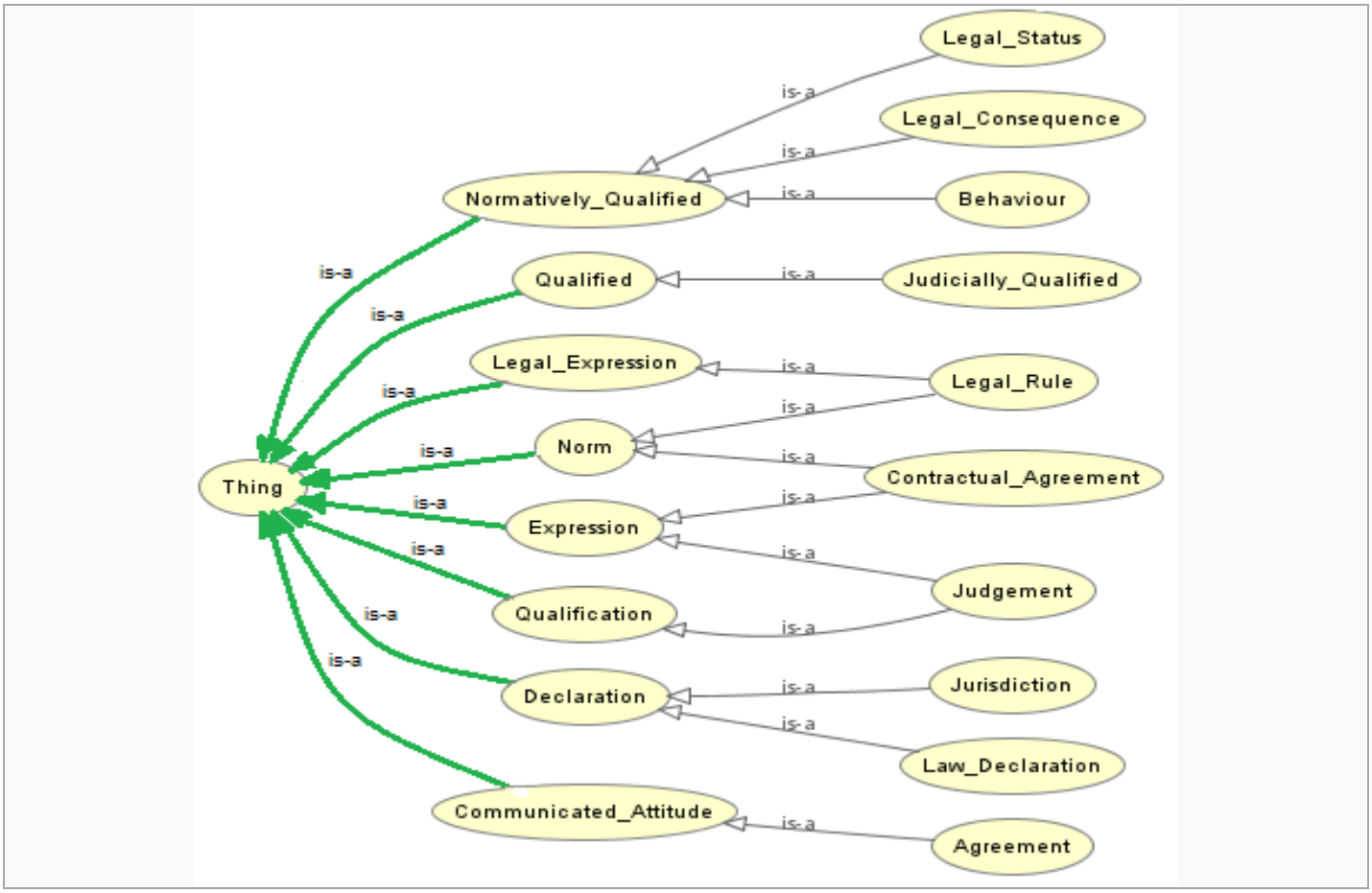


Illustration 9: two top-level layers from LKIF-Core ontology

4.4.5. Legal Taxonomy Syllabus (LTS)

It is not really a core ontology, but a working framework whose one component is an ontology, this tool is called European Legal Taxonomy Syllabus (ELTS). [85][86]

ELTS is formed by an ontology scheme, a web-based tool adapted to the scheme, and a legal ontology (European consumer law domain ontology).

The function of this tool is to consolidate the legal knowledge codified in different languages, and different jurisdictions, thus solving two of the major problems of this domain. Originally, this tool is used by the Uniform Terminology project on EU consumer protection law as an ontology. [87]

In the following illustration, the location of the same legal concept is represented, codified in two different jurisdictions/languages, according to the LTS ontological scheme:

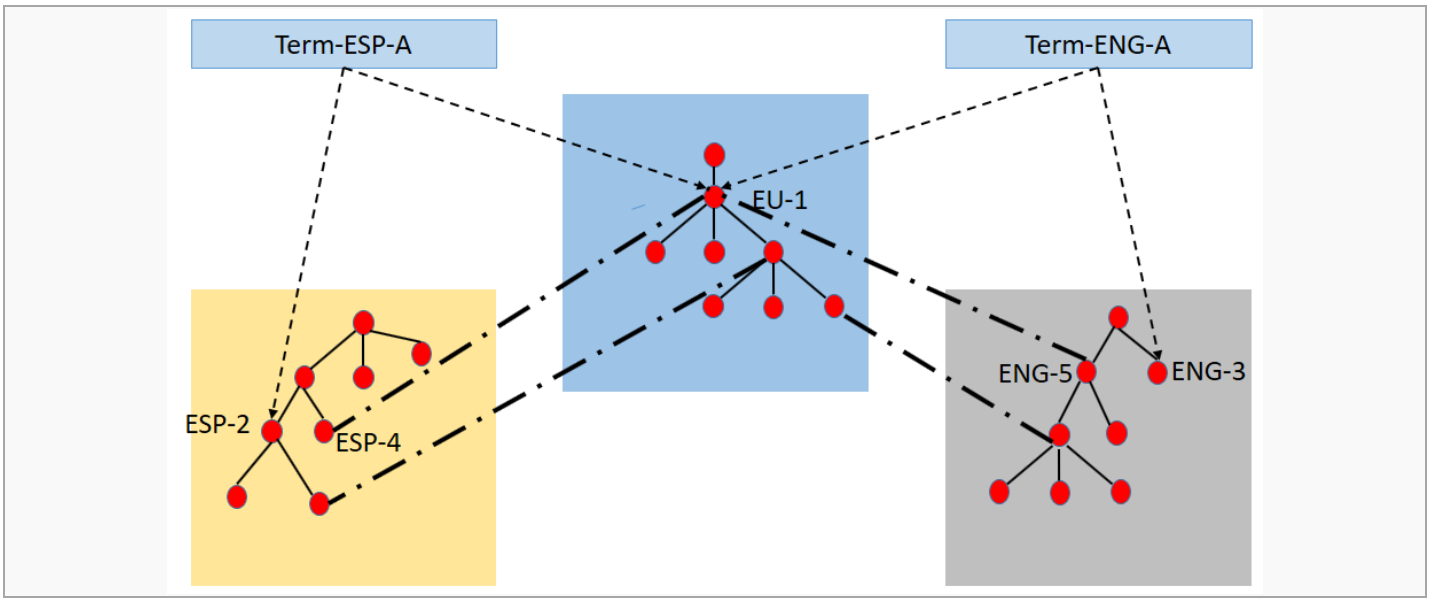


Illustration 10: a legal concept in LTS scheme

For more information about legal knowledge modeling practice:
[88][89][90][91][88][92][93][94][95][96][93][97][98][99][100][101][102][103]

5. Analysis and description of selected ontologies

In this section, we will review the legal ontologies proposed in some scientific articles of the last eight years, as well as a trip around the world, to show how a legal system or language [104] would affect the design of an ontology. It begins within the EU, with LEXIS ontology and the Eurovoc thesaurus [27] to present a design technique in which an ontology works together with a thesaurus to enrich searches. Next, Eunomos ontology is exposed [105], as an example of a multilingual and multijurisdictional ontology design technique. Third, an ontology designed for the Ukrainian legal system [106] and how language can affect the design is exposed, since the Ukrainian language has a lot of synonyms. Fourth, an ontology focused on the search of precedents of the Japanese civil court is exposed [107]; Japan has a mixed legal system, so the emphasis here is on one feature of common law systems: the precedent as a source of law [108]. Finally, a Chinese legal ontology [109] is exposed and how a core ontology has been used to adapt it to an oriental legal system, based on civil law and oriental customs.

5.1.1. Eurovoc and LEXIS

In this section Eurovoc Thesaurus and LEXIS legal ontology are analyzed, the information has been extracted mainly from Cornoiu and Valean, 2013. [27]

The purpose of this system is to reduce the existing gap between common sense knowledge and legal knowledge and to provide a solution to the problem of searching complete legal texts, through an intelligent system consisting of a thesaurus and an ontology, since ontology-based searches generate better results.

The Eurovoc Thesaurus is multilingual and was built specifically to process information from EU institutions. It could be considered as a legal ontological scheme model (is an extension of SKOS/RDF), centered on four relations between concepts:

- SYN (Synonimy)
- NT (Narrower Term)
- BT (Broader Term)
- RT (Related Term)

On the other hand, there is the LEXIS ontology, which captures and structures interrelated legal information about the legislative process in order to allow better access. In this system, the ontology has the role of proving dictionaries for the tagging, storage, and retrieval of legislative information, and also the classification of legal documentation.

The core class of the ontology core is "Legal Element". Other classes are:

- Preparatory acts
- Legal Frameworks
- Legal Rules
- Arguments
- Activities

The union between these two elements is done thanks to the *hasTag* object property added to the ontology. This property allows to expand the queries from the ontology but has the disadvantage that it must be added manually to the concepts.

The following code represents the declaration of the *hasTag* property:

```
<owl:ObjectProperty rdf:ID=”hasTag”>
<rdfs:domain rdf:resource=”#Legal_Element”/>
<rdfs:range rdf:resource=”&j.1;Concept”/>
<owl:inverseOf rdf:resource=”#isTagOf”/>
</owl:ObjectProperty>
```

5.1.2. Eunomos

In this section Eunomos system ontology is analyzed, the information has been extracted mainly from Boella, 2016. [105] This system operates in the context of EU legislative projects, originally specialized in Italian legislation (a civil law system).

Legal information contained in this system has been created according to the XML Legislative standard [*see* 4.2]. On the other hand, the ontology has been created following the ontological scheme and LTS methodology [*see* 4.4.5].

The purpose of this ontology is to relate in a strict way the legal knowledge with the legislative sources, this is achieved with the ontology since it contains the concepts used in legislation.

This ontology, according to the methodology followed (LTS) is oriented to be multilingual and works with several jurisdictions. Structurally makes a clear distinction between "Legal concept" and "Legal Term", being legal concepts the own ontology concepts, which form a taxonomy; and the legal terms, refer to these concepts to give a semantic meaning. The problem of temporality solves it by including the REPLACED BY relationship.

5.1.3. Ukraine legal activity

In this section I analyze a legal ontology of the domain of legal activity in Ukraine (civil law system), it does not have a specific denomination. The information is extracted from Getman and Karasiuk, 2014. [106]

This work emphasizes the incorporation of concepts to an ontology in a semi-automatic way and proposes a crowdsourcing method among people with legal knowledge to fill in the ontology of concepts, something similar to Wikipedia.

The methodology followed for this ontology is its own, distinguishing these activities:

- Location of concepts
- Definition of the height of the ontology (ontology graph levels)
- Distribution of concepts by levels
- Building relationships

For ontology creation, the following characteristics have been taken into consideration:

- Synonymy of definitions (ontology nodes)
- Limitations of the specific formulations of normative documents in time
- Availability of obligatory connection of definitions (ontology nodes) with the strict formulations of normative documents.

The following illustration represents the concept 'legislation' and its relationships with phrases in which it is contained, and synonyms, since, in general, Ukrainian has a large number of synonyms for a concept, compared to English, for example.

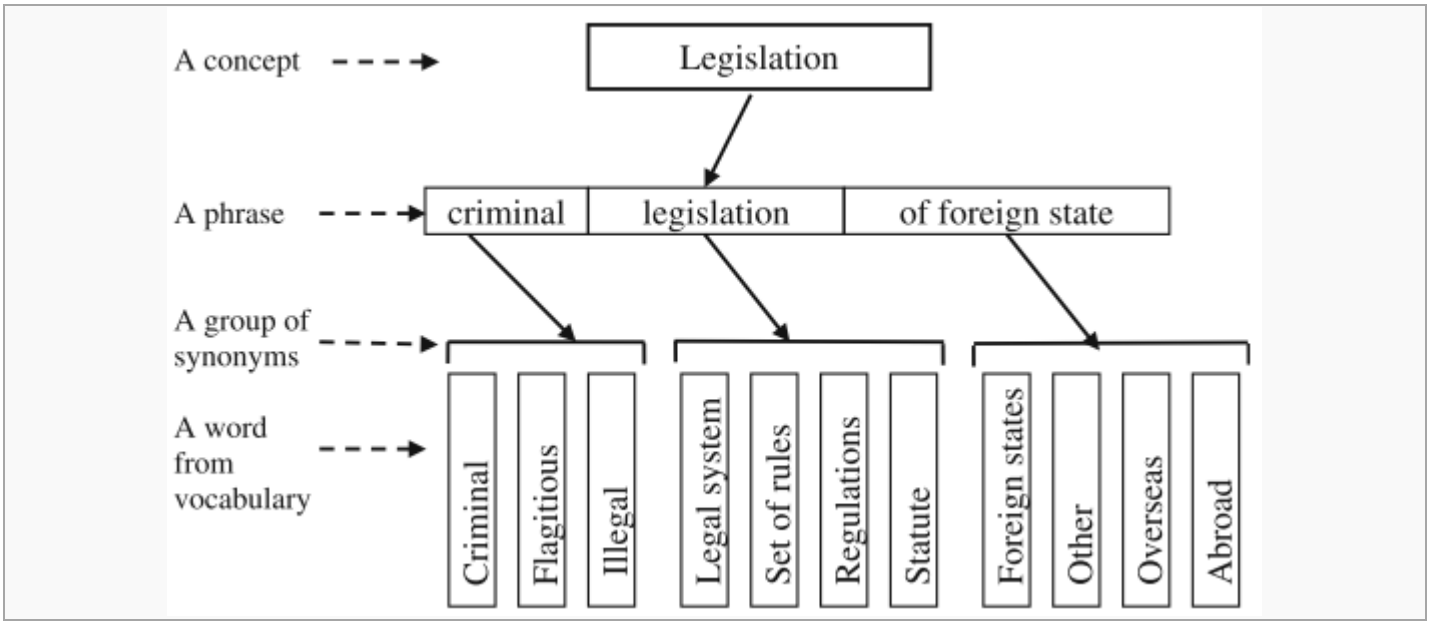


Illustration 11: Verbal display of concepts and relationships for Ukraine legal ontology

5.1.4. Precedent Retrieval System for Japanese Civil Trial

The legal system in Japan is mixed, encompassing characteristics of common law, Japanese traditions, and above all, civil law systems. The information in this section has been extracted from Kiryu, Ito, Kasahara, Hatano and Fujii, 2011. [107]

For this ontology, OWL language has been used together with SPARQL language to make queries. The ontology is divided into two other ontologies:

- Law term ontology: expresses terms, which are, that are the "state", "action" and "relations" decided by law referred to in "ontology for Requirement and Effect"
- Requirement and Effect ontology: contains the effects of the law, and the ultimate facts presupposed.

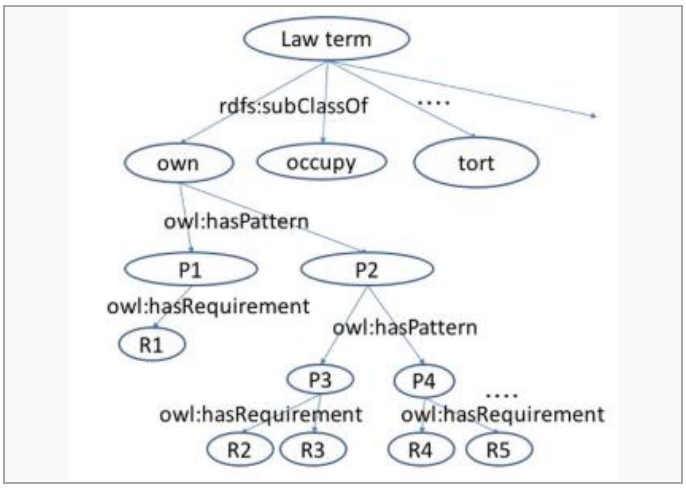


Illustration 12: Law term ontology

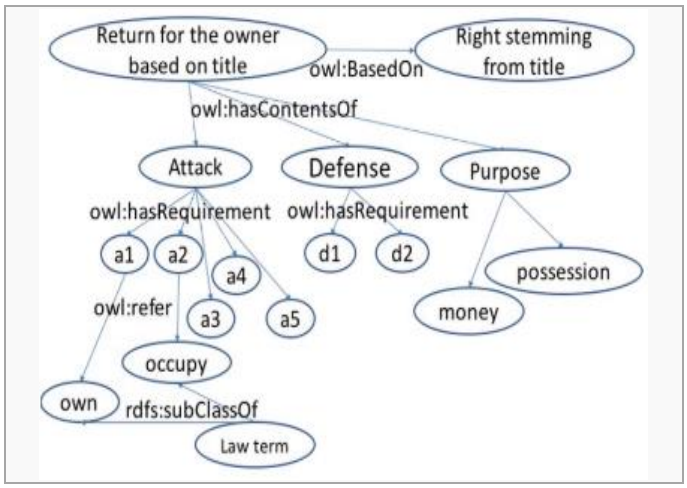


Illustration 13: Requirement and Effect Ontology

5.1.5. System for recovery of Chinese legal provisions

Information in this section is based on the system proposed in the articles by Tang, Q, Wang, Y and Zhang, M., 2012. [109] [110][111]

This ontology tries to follow the structure and methodology proposed by Hoekstra for the core ontology LKIF. It tries to achieve interconnectivity between other systems, in order to share common knowledge regarding both legal concepts and common sense.

The main idea that has been taken in this ontology is that the law is composed of basic concepts, rules and principles.

This ontology is divided into two other ontologies:

- Legal concepts module: a legal concept is divided into three sub-concepts: person concept, material concept, and fact concept.
- Norms module: the rules contain rules, and principles.

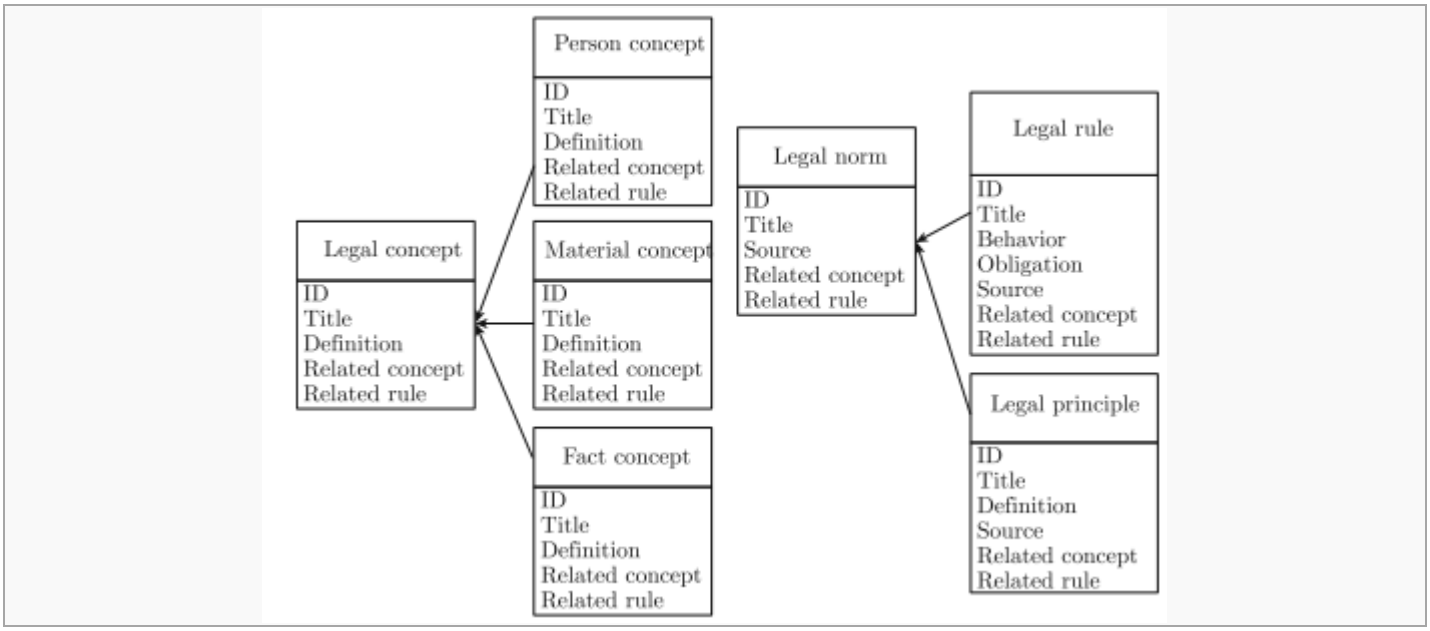


Illustration 14: Hierarchy of legal concept and legal norm modules with their main attributes

6. Conclusions

The historical tendency has been from a single ontology for everything, until it has come to divide the domain into several sub-domains, and then join these ontologies.

Currently, there is a considerable amount of scientific documentation related to legal ontologies. Despite the amount of information that exists, there are still no well-established and absolutely correct technical principles for the development of legal ontologies, at the moment, it would be rather "the art of design and creation of legal ontologies"

Although there are some methodologies that can help when designing an ontology, these are not absolute, and projects often use a mixture of ideas from various methodologies, even mixed with ideas from the designers given by the context, from a project in concrete.

A large number of projects take ideas or follow the methodology of Hoekstra and its LKIF ontology, since the tendency nowadays is to separate the "norm" from the "situation", either with these same terms, or with others, but in essence, it is the same.

7. Work Evolution/ Analysis

7.1. First Phase:

- It has managed to meet the times for the tasks set in the first phase of this research work.

- I have encountered difficulties with the integration of the UOC library with some databases, for example:
  .1. I could not log in "ebscohost" to access the full pdf text of the articles since authentication through the Shibboleth Consortium always made an error in selecting the UOC as an institution. This has made my job much more difficult, since it is essential to work with "Web Of Science", which is the most important repository, together with Scopus.
  .2. When changing from the ACM database to any other, I had to restart the web browser.

  Despite these difficulties, it has been possible to obtain a good bibliographic base to start working on the analysis phase and start the second phase on time.

- I have become aware of the importance of this phase for the rest of the work, I think it is the cornerstone of everything.
- I was surprised by the great difference between open access resources and copyrighted resources.
- The use of filters in the databases has been fundamental, since the concept of ontology is related, and gave results in fields as different as philosophy, medicine, public health, mathematics, education, economics, genetics, chemistry, etc.

7.2. Second Phase

- Much time has been spent on the project in the classification and reading of reviews.
- There are some articles that seemed to deal with legal ontologies, but not really. For example an article on ontologies of crime scenes.
- On the date of delivery of PAC3, there are only written introductory points, very generalist.
- The PAC3 delivery is the last part of development, in a research project, development and memory go hand in hand, so it is decided to deliver everything in the PAC4 on time.

7.3. Delivery of Memory

- The memory has been delivered on time with all the complete sections.
- No difficulties were found.

8. Future Research Line

This article is a review, so that in a few years, probably, it will be somewhat old-fashioned, and the topics will have to be updated every so often.

Just as there are no established robust methodologies for the creation of ontologies, there is no methodology for the evaluation of ontologies. It would be an advance to go this way, to be able to compare correctly and objectively similar

ontologies, this would allow us to improve methodologies, and not incur in certain failures or bottlenecks in the systems.

9. Analysis and self-evaluation

This has been my first contact with research in computer science.

I am quite satisfied with the result, I believe that the work forms itself a didactic unit on legal ontologies, also with a mixed technical-legal vision.

I believe that the enumeration of the standards, methodologies and core ontologies is well structured, understandable, and quite coherent.

Perhaps the analysis of recent ontologies has not been homogeneous since in some reviews a piece of information appeared and in others, other information, I would like to have done more extensive analysis and listing the same items more or less for each ontology, for example methodology, core ontology, complete structure. But I have detected that many ontologies took ideas from the LRI or LKIF ontology but nothing was mentioned, others used the methodology METHONTOLOGY, and neither.

However, in general, I think the result has been satisfactory, and a reader with little knowledge, can acquire and assimilate the concept of ontology (from the point of view of computer science), and legal ontology in particular, with everything that surrounds this world: methodologies, standards, and core ontologies.

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11. Annex

Comparative Analysis of Legal Ontologies

A literature review

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***Abstract*— The purpose of this research work is to provide a reference review for people interested in the design and creation of ontologies in the field of law.**

The reader is put in context within ontologies in general, and legal ontologies in particular, standards and methodologies are reviewed. Then, the subject is listed, listing the most important standards for legal ontologies, different legal systems that exist, most important foundational ontologies, and analyzing the most recent domain ontologies created in various legal systems throughout the world.

Finally, we come to the conclusion that historical evolution has tended to divide the same domain into several ontologies, that there is no single correct methodology, that one can be used, or create a new one, or take several ideas from various methodologies. And finally, the importance of the methodology of Hoekstra and its legal ontology LKIF and the separation between norm and situation

Keywords*— *Legal ontology; legal knowledge modelling; legal semantic web.

In this final research work, the study of legal ontologies has been addressed in a generalist way. It has been wanted to give a very didactic approach so that any reader with some basic knowledge can put themselves in the situation and be able to follow the reading comfortably. The need for this work arises because there is a considerable amount of research in the field of legal ontologies, and we want to make a compendium of what is most important in this domain, not only from the technical point of view, but from the legal point of view, since the different existing legal systems have been exposed, and it has been wanted to analyze a series of systems and ontologies spread all over the world.

In section I a first approach to ontologies in general, the reader will find a classification of ontologies, methodologies, and several commonly accepted standards. Section II deals with legal ontologies, the reader will find the different legal systems, the most important specific standards, the characteristics and peculiarities of legal information, and the most important core ontologies, which are widely used as a basis in today's projects. In Section III, a series of ontologies in recent projects are analyzed: Eurovoc, eunomos, a Ukrainian system, another Japanese system, and another Chinese system. Conclusions are in section IV.

I. FIRST APPROACH TO THE FIELD: REPRESENTATION OF KNOWLEDGE

A general objective for Artificial Intelligence field is the development of techniques that allow a system to solve problems "intelligently", that is, consider the available information and its context. Therefore, we can deduce that the capacity to represent and use knowledge will be an implicit requirement in the development of these systems.

Representation of knowledge discipline studies how to specify knowledge in a format that supports problems resolution, can be framed in the field of symbolic Artificial Intelligence, this means that knowledge is represented through discrete units (symbols) that can be combined following rules, forming a representation scheme.

A representation schema is an instrument to transform the domain knowledge into a symbolic language endowed it with syntax and semantics.

- Syntax: describes the possible ways to build and combine the elements of a language.
- Semantic: determines the meaning of the elements of language and the relationship between them.

The main objective is to facilitate the extraction of conclusions (inference) from the knowledge expressed in a computable form. The domain and problem to solve, will mark how to represent knowledge, but this way of representing knowledge is not trivial, and will determine how we can manipulate it.

A. ONTOLOGIES

The word ontology can have several meanings, in a philosophical sense, it refers to the branch of philosophy

which deals with the nature and structure of “reality”, in the field of computer science it would mean: formal specification of a shared conceptualization, which is the definition of W.N. Borst which expands the definition of T.R. Gruber, widely accepted and cited. [1] If we develop this definition, we can draw these conclusions:

- An ontology is a representation of a domain that is explicitly materialized somewhere.
- An ontology is the result of a modeling of knowledge, this is known, shared and accepted by a

community of experts, so it is not the vision of someone in particular.

Ontologies are technically defined by the following elements:

- Concept: These are the ontological categories.
- Relationships: Connect concepts semantically.
- Instances: They are concrete objects of the domain.
- Attributes: They are properties and their value. Value can be a concept of ontology.

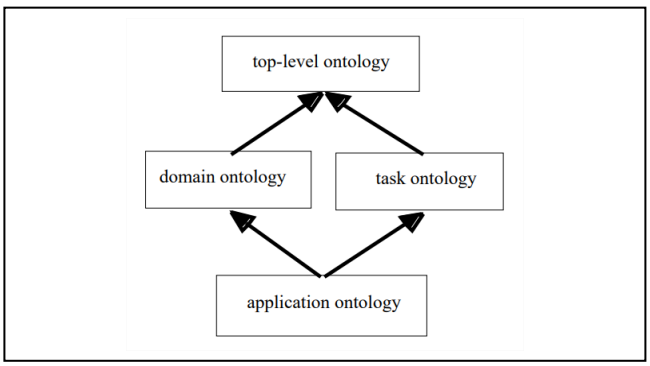
B. ONTOLOGIES CLASSIFICATION

In Computer Science, the most used ontology classification is the one proposed by N. Guarino [2]:

- Top-Level Ontology: describe general concepts such as time, space, objects, actions, etc.
- Domain Ontologies: Describe concepts related to a generic domain (for example: legal), instantiating concepts of high-level ontologies.
- Task Ontologies: They describe specialized vocabulary about some generic task or activity (for example: mercantile contract terminology), they are developed from the specialization of high level ontologies.
- Application ontologies: describes concepts depending on both domain and task, which are often specializations of both the related ontologies

These types of ontologies are related to each other, since as can be extracted from the previous definitions, there is a specialization relationship between them, as shown in the following image:

Fig. 1. Ontology kinds and their specialization relationships



C. DESGN AND CREATION OF ONTOLOGIES

CLASS HIERARCHY DEFINITION

There are three ways to build a class hierarchy to define the concepts [3]:

- Top-down: Firstly, classes that define the most general concepts of the domain are created; secondly these concepts are concretized and specialized.
- Bottom-up: At beginning, classes that define the most specific concepts are created; subsequently the more general classes that will group the first concepts are defined.
- Top-down/bottom-up mix: In a first step, main concepts of the domain are defined; in a second step, concepts will continue to be further specialized, or generalized grouping together more specific concepts.

METHODOLOGIES

Knowledge engineering field in general, and ontologies engineering in particular are still very young, and this implies that solid standards have not yet been established, a single correct way of making things has not been discovered, but a set of ontology construction methodologies are used more frequently by professionals in this area, although I repeat: there is no adequate methodology for all cases, and this must be adapted to each case, even so, I make an enumeration of the most named:

- Methontology [4]: This methodology proposes the construction of an ontology starting from another more general ontology. It enumerates activities extracted from IEEE activities for software engineering: specification, conceptualization, formalization, integration, implementation, evaluation, documentation and maintenance. These activities form a life cycle based on evolutionary prototypes.
- OTKM [5]: This methodology is more general, and focuses on facilitating the use and maintenance of the ontology, it distinguishes these activities: viability study, taking requirements, refinement, evaluation and evolution.
- Text2Onto [6]: It really is a framework for ontologies construction, which integrates data mining algorithms for its construction.
- SENSUS [7]: This methodology originally started from the SENSUS ontology, but in reality it can be based on any other. Follow a top-down approach, and it distinguishes these activities: Initial set of seed concepts, linking seed concepts in the reference ontology, completion of intermediate concepts, inclusion of other relevant concepts, inclusion of concepts with a large number of graph paths that pass through them.
- Grüninger & Fox [3]: This methodology includes these activities: capture of scenarios, informal questions formulation, specification of concepts, formal competence questions formulation, ontology development and evaluation. This methodology is the result of experience acquired in the Toronto Virtual Enterprise Project (TOVE) [8].

D. DATA REPRESENTATION STANDARDS

The most used formats for knowledge representation by ontologies in general and in legal ontologies in particular are

listed below, some specialized thesaurus format is also mentioned, since Lexis ontology references the Eurovoc thesaurus [9]:

• Extensible Markup Language (XML)[14]: is a markup language that defines a set of rules for encoding documents in a format that is both human-readable and machine-readable.

• Resource Description Framework (RDF)[15]: It is a XML standard developed by W3C, originally used to represent metadata, but it has evolved to the point that it allows writing "metainformation" and integrating several data sources, even with different schemes.

This standard relates entities, through binary relationships (statements), these statements are represented by the triplet: Subject - Predicate - Object

The following table shows the different ways to represent these triplets:

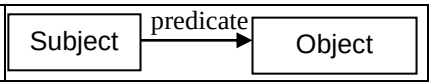
Graphical form	
Triplet	subject - predicate - object
Relational form	predicate (subject, object)
RDF/XML	<rdf:Description rdf:about="subject"> <ex:predicate> <rdf:Description rdf:about="object"/> </ex:predicate> </rdf:Description>

Fig. 2. Different ways to represent a RDF triplet

• Resource Description Framework Schema (RDFS)[16]: It is a semantic extension of RDF, also developed by W3C. It is a primitive language of ontologies that provides the basic elements for the description of ontologies (originally vocabularies), intended to structure RDF resources.

• Simple Knowledge Organization System (SKOS/RDF)[17]: It is a standard developed by the W3C, and built on RDF. It has been designed for representation of a thesaurus, classification schemes, taxonomies, subject-heading systems, or any other type of structured controlled vocabulary.

• Web Ontology Language (OWL) [18]: It is a family of languages for structured ontologies definition. This standard is built on RDFS and has several sublanguages: Lite, DL and Full. They range from minor to greater expressiveness, to greater expressiveness, greater computational complexity.

• Semantic Web Rule Language (SWRL)[19] : It is a semantic web language that is used to define rules and logic, combined with both OWL DL and OWL Lite.

The rules have a form of implication between an antecedent (body) and a consequent (head). The intended meaning can be read as: provided that the conditions specified in the antecedent are met, the conditions specified in the consequent must also be met.

Example: hasParent(?x1,?x2) ∧ hasBrother(?x2,?x3) ⇒ hasUncle(?x1,?x3)

•SPARQL Protocol and RDF Query Language (SPARQL) [20]: It is a semantic query language for databases capable of recovering and manipulating data stored in RDF format, it was developed by W3C. SPARQL allows for a query to consist of triple patterns, conjunctions, disjunctions, and optional patterns.

II. LEGAL ONTOLOGIES

After years of research, optimal principles have not yet been reached regarding the creation of ontologies for information systems. Attempts to formalize legal activity have been made for a long time, especially because the cause-effect relationship in legal precedents can be seen with confidence. During the '90s, systems based on logical inference methods were developed [10]; these systems provided the need to establish relationships between the results obtained and the original legal texts; after the investigation evolved towards the methods of formation of conclusions. Later, the "ontological scheme" came to be used as a basis for legal knowledge in intelligent systems [11], and currently, the principle of data description is the mechanism most used in the modeling of knowledge in the legal domain.

A. LEGAL SYSTEMS

In the modern world there are two major legal traditions, both have been developed in parallel, but differ widely in their sources, processes and concepts, so these traditions lead to different judicial structures, circumstances that undoubtedly condition later the legal ontologies design and development, in order to treat, store and retrieve information in the most optimal way possible.

[14] en.wikipedia.org/wiki/XML [Accessed 14 Dec. 2018]
[15] en.wikipedia.org/wiki/Resource_Description_Framework [Accessed 14 Dec. 2018]
[16] en.wikipedia.org/wiki/RDF_Schema [Accessed 14 Dec. 2018]
[17] en.wikipedia.org/wiki/Simple_Knowledge_Organization_System [Accessed 14 Dec. 2018]
[18] en.wikipedia.org/wiki/Web_Ontology_Language [Accessed 14 Dec. 2018]
[19] en.wikipedia.org/wiki/Semantic_Web_Rule_Language [Accessed 14 Dec. 2018]
[20] en.wikipedia.org/wiki/SPARQL [Accessed 15 Dec. 2018]

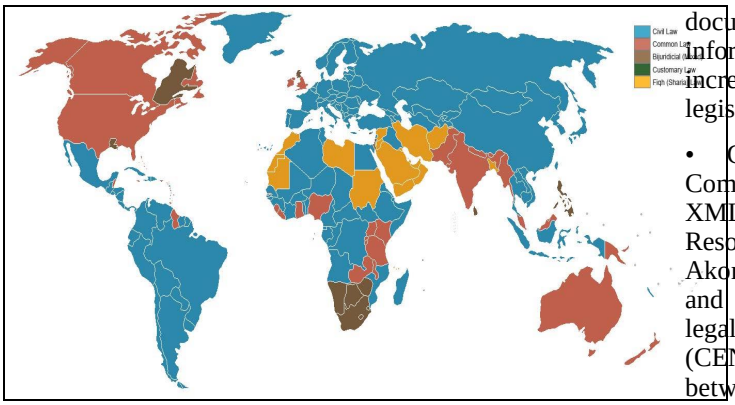


Fig. 3. World map with the legal systems of each country[21]

As we can see in the map, around 80 countries adopt the common law system, and around 150 countries adopt fundamentally the civil law system. Rest systems can be considered a hybrid, for example, the Philippines, Sri Lanka, South Africa, Israel and Cyprus would have a mixed system between civil law and common law. Other countries such as Nigeria, Bangladesh Malaysia or Pakistan would have a common law system mixed with Islamic law (Sharia). In the case of India, it would be a mix of common law, civil law, religious and customary laws. Civil law systems descend all from the old Roman Empire, and are based on the codification of written legal codes; on the contrary, common law systems are descended from the English tradition, and their expansion throughout the world through the British Empire and they are not based mainly on written codes, but on court cases and precedents. Another feature is that civil legal systems are always based on a written constitution, however, in common law is not always the case, for example, the US has a written Constitution, while the United Kingdom does not have it as such. It can be deduced that the judicial role within the common law system is active in terms of law-making, and passive within civil law systems. Legal reasoning style in common law system countries is an inductive method, analogical reasoning, analyzing case by case, and using precedents with force of law. On the other hand, in Roman civil tradition countries, a deductive reasoning method is used, applying abstract codifications of the law, relegating the use of precedents as support for legal writings. [12]

B. LEGAL DOMAIN STANDARDS

• Architecture for Knowledge-Oriented Management of African Normative Texts using Open Standards and Ontologies (Akoma Ntoso)[22] : Akoma Ntoso is an initiative of UN program "Africa i-Parliament Action Plan", that defines a set of simple technology-neutral electronic representations in XML format of parliamentary, legislative and judiciary documents. The XML schemas of Akoma Ntoso make explicit the structure and semantic components of the digital documents so as to support the creation of high-value information services that deliver the power of ICTs and increase efficiency and accountability in parliamentary, legislative and judiciary contexts.

• CEN MetaLex [23]: It is an initiative of the European Committee for Standardization (CEN Workshop on an Open XML Interchange Format for Legal and Legislative Resources). It is also a standard XML schema, similar to Akoma Ntoso, in fact, both are part of ESTRELLA project, and they reached an agreement on the abstract structure of legal documents to achieve the interoperability of standards (CEN MetaLex Workshop, 2006, 2008). The difference between both is that MetaLex is developed on epistemological models based on cognitive sciences, and Akoma Ntoso is closer to legal texts, from a normative point of view. The core ontology LKIF uses MetaLex standard.

• LegalXML[24] : LegalXML is a section of the non-profit Organization "Organization for the Advancement of Structured Information Standards" (OASIS), this section develops open standards for electronic filing of court documents, legal citations, transcripts, criminal justice intelligence systems, etc. The basic component, as its own name indicates is the XML language, and it is created on the basis of Akoma Ntoso. The members of OASIS that participate in this section are from different areas: developers, application providers, government agencies, lawyers, lawyers, academics, etc. And they are divided into several committees, according to their purpose, which for LegalXML are:

-OASIS Legal Citation Markup (LegalCiteM) TC: Developing an open standard for machine-readable tagging of legal citations.

-OASIS LegalDocumentML (LegalDocML) TC: Advancing worldwide best practices for the use of XML in legal documents.

- OASIS LegalRuleML TC: Enabling legal arguments to be created, evaluated, and compared using rule representation tools.

- OASIS LegalXML Electronic Court Filing TC: Using XML to create and transmit legal documents among attorneys, courts, litigants, and others.

- OASIS LegalXML eContracts TC: Enabling the efficient creation, maintenance, management, exchange, and publication of contract documents and terms.

- OASIS LegalXML eNotarization TC: Developing technical requirements to govern self-proving electronic legal information.

- OASIS LegalXML Integrated Justice TC: Facilitating the exchange of data among justice system branches and agencies for criminal and civil cases.

- OASIS LegalXML Lawful Intercept TC: Production of a structured, end-to-end lawful interception process framework consisting of XML standards and authentication mechanisms,

[21] en.wikipedia.org/wiki/File:LegalSystemsOfTheWorldMap.png [Accessed 15 Dec. 2018]
[22] www.akomantoso.org/ [Accessed 16 Dec. 2018]
[23] www.metalex.eu/ [Accessed 16 Dec. 2018]
[24] www.legalxml.org/ [Accessed 16 Dec. 2018]

including identifiable related XML standards and XML translations of ASN.1 modules.

- OASIS LegalXML Legislative Documents, Citations, and Messaging TC: Standardizing markup for legislative documents and simple citation for non-legislative documents.

- OASIS LegalXML Online Dispute Resolution TC: Using XML to allow public access to justice through private- and government-sponsored dispute resolution systems.

- OASIS LegalXML Legal Transcripts TC: The purpose of this TC was to develop an XML compliant syntax for representing legal transcript documents either as stand-alone structured content, or as part of other legal records.

C. FEATURES OF LEGAL INFORMATION AND DESIGN CHALLENGES

Legal information has its own features that differentiate it from other types of information and poses some design challenges for systems in general, and ontologies in particular, which must be resolved in order for the information to be practical. The main characteristics that must be taken into account can be divided into three groups: proper to the language, to the legal system, and techniques.

DERIVED FROM LANGUAGE

• Logical/syntactic structures of language: Language has an imprecise nature sometimes, sometimes, the conjunction 'and' has to be interpreted as the disjunction 'or' or vice versa.

• Vague language: Sometimes a vague language is used on purpose, so very changing social environments can be accommodated without constantly changing the text.

• Polysemy of concepts: On the one hand, in legal domain, a concept may have a meaning different from the usual one in the ordinary language. On the other hand, the same concept can have different meanings for different jurisdictions.

• Groups of synonyms: Legal language is different from the rest, so a legal concept may have a distinct set of synonyms than ordinary language.

• Unstructured text: Although legal texts are usually presented with a structure, and for the same type of document, several structures coincide, they do not always occupy the same place, and some structures may even be omitted.

DERIVED FROM LEGAL SYSTEM

• Multiple jurisdictions: we live in a globalized world, and there are supranational organizations that generate legal information, this information must be adapted later in each country, ontologies have to be able to model these differences.

• Time limitations: Legislation is somewhat dynamic, the society changes, and this legislation has to adapt, so there is current information, repealed, updated, etc

Generally, in different legal systems, these principles prevail:

- *Lex superior derogat legi inferiori*: A superior rank law or codified in a superior code, repeals the previous ones.

- *Lex posterior derogat priori*: A more recent law repeals an old one that deals with the same subject.

- *Lex specialis derogat generali*: A more specific law on a subject prevails over a more generalist law.

• Updates and consolidated texts: Sometimes a compendium of several regulations are elaborated in a single regulation, or only some articles are updated, but historical information should not be lost.

• Cross-references: frequently, legal information refers to other legal information. For example, it is very common to find, within the same code, that one article refers to another.

• Classification of information: legal information is not usually found with clear classification.

• High substantial variability: derived from the dynamics of society, changes in information occur frequently.

• Legal norms fragmentation: Norms that regulate a society domain, or rule's elements, are contained in different codes, laws or other legislation elements. [13]

TECHNICAL FEATURES

• Different databases: information is usually located in different databases, in different networks, with different formats, etc

• The volume of information: the volume of legal information is very high, and it increases rapidly.

• Reliable information: resulting information must be truthful and obtained from trusted sources. In addition, the retrieval of information must be adapted to the query, for example, if I want to see a current regulation, it would not be correct to see a repealed text.

• Update and availability: Information must be constantly updated, and historical data must remain

• Accessibility: Normally, traditional legal information, on paper, has not taken into account this purpose, in addition, there are different sources of information, a large volume of information, cross-references, etc. Advances are being made to make legal information available to everyone thanks to initiatives such as Linked Open Data and Open Government Data. [14]

D. LEGAL CORE ONTOLOGIES

According to the above, we have seen how, despite being a very young research domain, decades of intensive research in legal domain ontologies have been accumulated, so, there is already a more or less established base, and more or less mature by which you can start new projects, this has already been picked up by some ontology construction methodologies, as we have seen. There is a set of legal ontologies that usually serve as a basis for these new projects, these ontologies are called "legal core ontologies", and there are some of these ontologies that are repeated quite frequently in new projects, these core ontologies are frequently used as a basic structure

of a legal domain new ontologies, as frameworks, or as application ontologies. That is why it has been decided to write this point, before entering in an analysis of the latest research in this domain.

FUNCTIONAL ONTOLOGY OF LAW (FOLAW)

Was launched in 1994 by A. Valente, is based on theories of H. Kelsen and Hart and Bentham (norms are rules, which can only be observed or violated). It is written with the language of ontologies ONTOLingua and has a purpose-oriented to knowledge and functional (meta-level knowledge, normative knowledge, responsibility knowledge, creative knowledge, and reactive knowledge) [15].

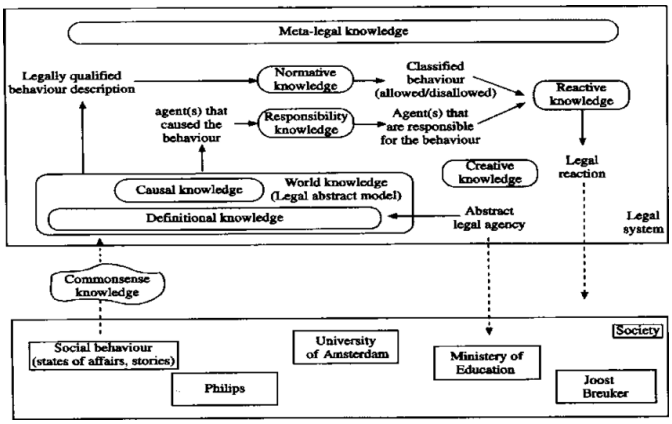


Fig. 4. FOLaw: a functional ontology for law (Valente, A., 1995).

CORE LEGAL ONTOLOGY (CLO)

Launched in 2003 [16], it is the result of ISTC-CNR and ITTIG-CNR collaboration, it is written in the ontology language OWL DL. This ontology is built on the foundations of a generalist ontology: DOLCE+ (a Descriptive Ontology for Linguistic and Cognitive Engineering)[25]. The purpose of this ontology is to organize legal concepts and their relationships with physical, cognitive, social, property… legal words based on properties formally defined in DOLCE+. It admits three types of legal tasks for civil law tradition countries:

- Conformity check.
- Legal advice.
- Comparison of norms.

[25] www.loa.istc.cnr.it/old/DOLCE.html [Accessed 17 Dec. 2018]

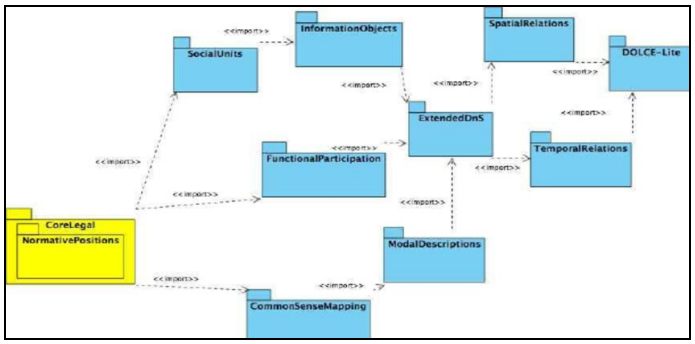


Fig. 5. CLO ontology dependencies and its relationship with DOLCE +

LRI - CORE ONTOLOGY

Launched in 2004 by the Leibniz Center for Law Research Group [17], also, as the previous ontology, it is written in OWL DL. But in this case, it is based on several foundational ontologies: DOLCE, SUO, the John's Sowa ontology. This ontology is composed of two levels:

•A foundational ontology: it composes the most abstract level, and contains several concepts related to common sense instead of laws, included in five major categories: physical, mental, abstract, roles and occurrence.

•Legal core ontology: it is a more concrete level, with specialized concepts of the domain.

The general purpose of this ontology is to serve as a basis for the creation of new domain ontologies.

In the following illustration, the two highest layers of the LRI-Core ontology are observed:

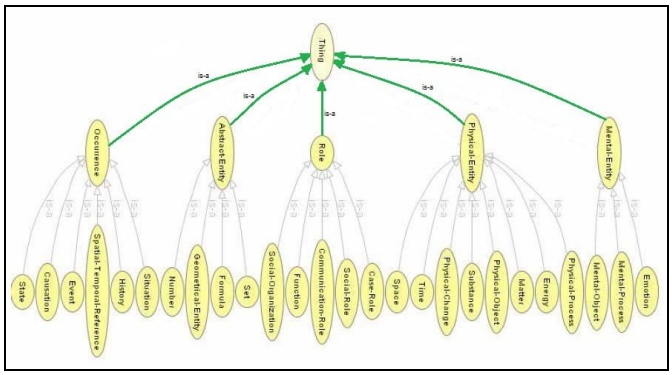


Fig. 6. Two top-level layers from LRI-Core ontology

LKIF - CORE ONTOLOGY

LKIF- Core ontology is also developed by the Leibniz Center for Law Research, in ESTRELLA project (see CEN MetaLex), this ontology is considered the successor of LRI-Core ontology. [18] The purpose of this ontology is to translate the legal knowledge contained in different sources and different formats and achieve the interoperability of the different legal knowledge systems. Several methodologies have been followed for design and development, for example, for common sense concepts modeling, it has been created clusters of independent concepts, and each has been developed with its related concepts, instead of the typical top-down approach, idea taken from Hayest (1985). For the rest, ideas of

Grüninger, Unchold and King have been followed. [3] The ontology consists of 13 modules, each of which describes a set of closely related concepts of both common sense and legal domains. It is organized in three levels:

• Top Level: they are the concepts of its predecessor LRI-Core ontology.

• Intentional Level: Models the behavior of an intelligent agent from a legal perspective. The main concepts are: Agent, Role, Action, Propositional_Attitudes, Expressions.

• Legal Level: Norm: text of a situation; Obligation and Prohibition are equivalent.: Permission: at a higher level than Obligation and Prohibition.; Situation: indicated as Qualified (Allowed, Disallowed). In the following image, the two highest levels of the ontology are observed:

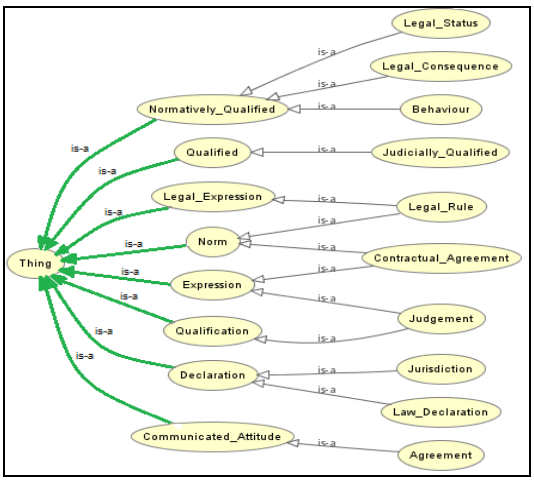


Fig. 7. Two top-level layers from LKIF-Core ontology

LEGAL TAXONOMY SYLLABUS

It is not really a core ontology, but a working framework whose one component is an ontology, this tool is called European Legal Taxonomy Syllabus (ELTS). [19] ELTS is formed by an ontology scheme, a web-based tool adapted to the scheme, and a legal ontology (European consumer law domain ontology). The function of this tool is to consolidate the legal knowledge codified in different languages, and different jurisdictions, thus solving two of the major problems of this domain. Originally, this tool is used by the Uniform Terminology project on EU consumer protection law as an ontology. [20] In the following illustration, the location of the same legal concept is represented, codified in two different jurisdictions/languages, according to the LTS ontological scheme:

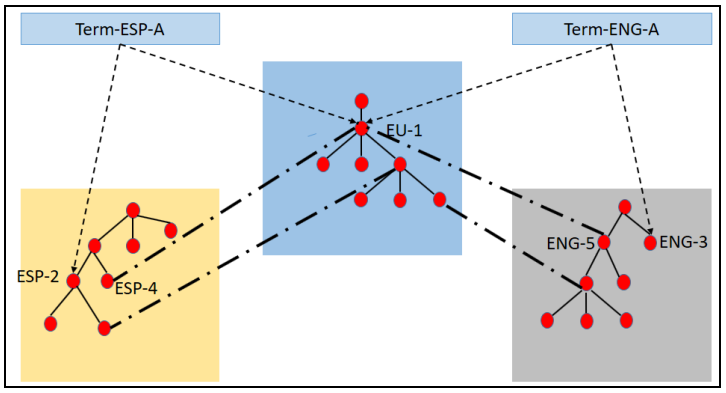


Fig. 8. A legal concept in LTS scheme

III. ANALYSIS AND DESCRIPTION OF SELECTED ONTOLOGIES

In this section, we will review the legal ontologies proposed in some scientific articles of the last eight years, as well as a trip around the world, to show how a legal system or language would affect the design of an ontology. It begins within the EU, with LEXIS ontology and the Eurovoc thesaurus [9] to present a design technique in which an ontology works together with a thesaurus to enrich searches. Next, Eunomos ontology [21] is exposed, as an example of a multilingual and multijurisdictional ontology design technique. Third, an ontology designed for the Ukrainian legal system [22] and how language can affect the design is exposed, since the Ukrainian language has a lot of synonyms. Fourth, an ontology focused on the search of precedents of the Japanese civil court is exposed [23]; Japan has a mixed legal system, so the emphasis here is on one feature of common law systems: the precedent as a source of law. Finally, a Chinese legal ontology [24] is exposed and how a core ontology has been used to adapt it to an oriental legal system, based on civil law and oriental customs.

A. *EUROVOC and LEXIS*

In this section Eurovoc Thesaurus and LEXIS legal ontology are analyzed, the information has been extracted mainly from Cornoiu and Valean, 2013. [9]

The purpose of this system is to reduce the existing gap between common sense knowledge and legal knowledge and to provide a solution to the problem of searching complete legal texts, through an intelligent system consisting of a thesaurus and an ontology, since ontology-based searches generate better results. The Eurovoc Thesaurus is multilingual and was built specifically to process information from EU institutions. It could be considered as a legal ontological scheme model (is an extension of SKOS/RDF), centered on four relations between concepts: SYN (Synonymy), NT (Narrower Term), BT (Broader Term), RT (Related Term). On the other hand, there is the LEXIS ontology, which captures

and structures interrelated legal information about the legislative process in order to allow better access. In this system, the ontology has the role of proving dictionaries for the tagging, storage, and retrieval of legislative information, and also the classification of legal documentation. The core class of the ontology core is "Legal Element". Other classes are: Preparatory acts, Legal Frameworks, Legal Rules, Arguments, Activities. The union between these two elements is done thanks to the hasTag object property added to the ontology. This property allows to expand the queries from the ontology but has the disadvantage that it must be added manually to the concepts. The following code represents the declaration of the hashTag property:

<owl:ObjectProperty rdf:ID=”hasTag”>

<rdfs:domain rdf:resource=”#Legal_Element”/>

<rdfs:range rdf:resource=”&j.1;Concept”/>

<owl:inverseOf rdf:resource=”#isTagOf”/>

</owl:ObjectProperty>

B. EUNOMOS

In this section Eunomos system ontology is analyzed, the information has been extracted mainly from Boella, 2016. [21] This system operates in the context of EU legislative projects, originally specialized in Italian legislation (a civil law system). Legal information contained in this system has been created according to the XML Legislative standard. On the other hand, the ontology has been created following the ontological scheme and LTS methodology. The purpose of this ontology is to relate in a strict way the legal knowledge with the legislative sources, this is achieved with the ontology since it contains the concepts used in legislation. This ontology, according to the methodology followed (LTS) is oriented to be multilingual and works with several jurisdictions. Structurally makes a clear distinction between "Legal concept" and "Legal Term", being legal concepts the own ontology concepts, which form a taxonomy; and the legal terms, refer to these concepts to give a semantic meaning. The problem of temporality solves it by including the REPLACED BY relationship.

C. UKRAINE LEGAL ACTIVITY

In this section I analyze a legal ontology of the domain of legal activity in Ukraine (civil law system), it does not have a specific denomination. The information is extracted from Getman and Karasiuk, 2014. [22]

This work emphasizes the incorporation of concepts to an ontology in a semi-automatic way and proposes a crowdsourcing method among people with legal knowledge to fill in the ontology of concepts, something similar to Wikipedia. The methodology followed for this ontology is its own, distinguishing these activities:

• Location of concepts

• Definition of the height of the ontology (ontology graph levels)

• Distribution of concepts by levels

• Building relationships

For ontology creation, the following characteristics have been taken into consideration:

• Synonymy of definitions (ontology nodes)

• Limitations of the specific formulations of normative documents in time

• Availability of obligatory connection of definitions (ontology nodes) with the strict formulations of normative documents.

The following illustration represents the concept 'legislation' and its relationships with phrases in which it is contained, and synonyms, since, in general, Ukrainian has a large number of synonyms for a concept, compared to English, for example.

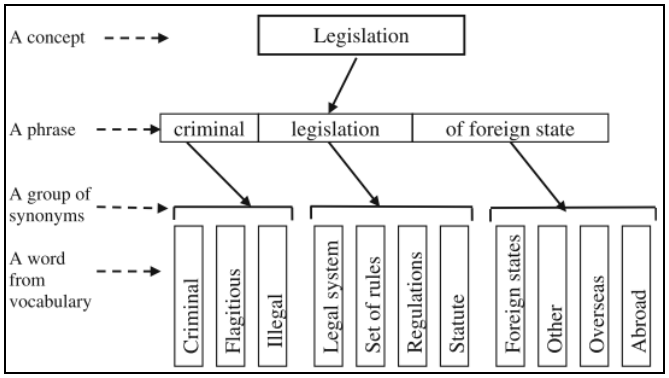


Fig. 9. Verbal display of concepts and relationships for Ukraine legal ontology

D. PRECEDENT RETRIEVAL SYSTEM FOR JAPANESE CIVIL TRIAL

The legal system in Japan is mixed, encompassing characteristics of common law, Japanese traditions, and above all, civil law systems. The information in this section has been extracted from Kiryu, Ito, Kasahara, Hatano and Fujii, 2011. [23] For this ontology, OWL language has been used together with SPARQL language to make queries. The ontology is divided into two other ontologies:

• Law term ontology: expresses terms, which are, that are the "state", "action" and "relations" decided by law referred to in "ontology for Requirement and Effect"

• Requirement and Effect ontology: contains the effects of the law, and the ultimate facts presupposed.

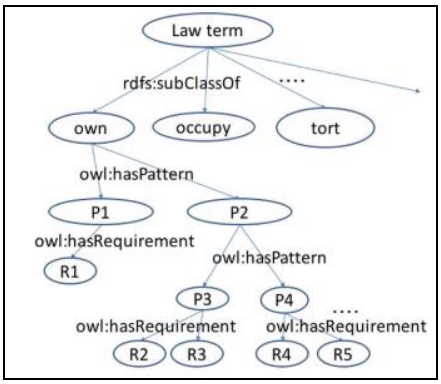


Fig. 10. Law term ontology

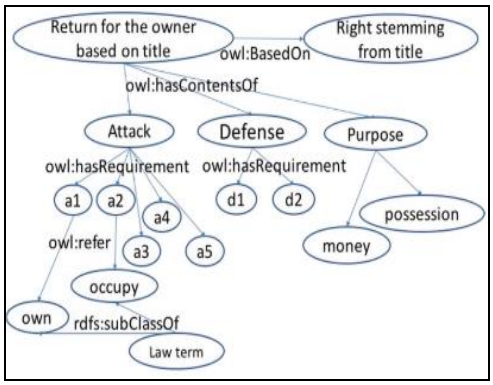


Fig. 11. Requirement and Effect Ontology

E. SYSTEM FOR RECOVERY OF CHINESE LEGAL PROVISIONS

Information in this section is based on the system proposed in the article by Tang, Q, Wang, Y and Zhang, M., 2012. [24] This ontology tries to follow the structure and methodology proposed by Hoekstra for the core ontology LKIF. It tries to achieve interconnectivity between other systems, in order to share common knowledge regarding both legal concepts and common sense. The main idea that has been taken in this ontology is that the law is composed of basic concepts, rules, and principles. This ontology is divided into two other ontologies:

• Legal concepts module: a legal concept is divided into three sub-concepts: person concept, material concept, and fact concept.

• Norms module: the rules contain rules and principles.

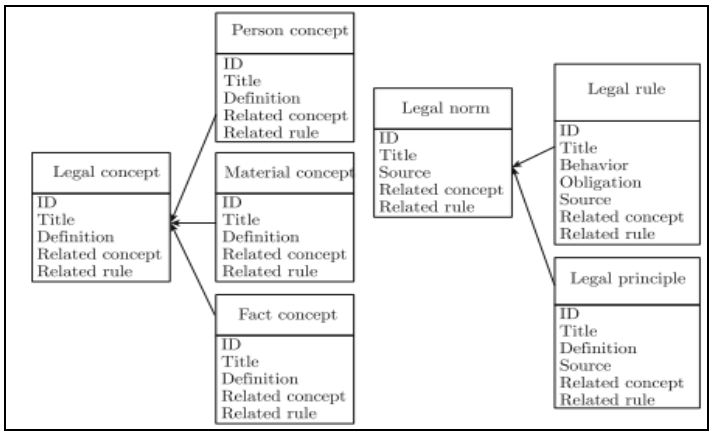


Fig. 12. Hierarchy of legal concept and legal norm modules with their main attributes

IV. CONCLUSIONS

1. The historical tendency has been from a single ontology for everything, until it has come to divide the domain into several sub-domains, and then join these ontologies.

2. Currently, there is a considerable amount of scientific documentation related to legal ontologies. Despite the amount of information that exists, there are still no well-established and absolutely correct technical principles for the development of legal ontologies, at the moment, it would be rather "the art of design and creation of legal ontologies"

3. Although there are some methodologies that can help when designing an ontology, these are not absolute, and projects often use a mixture of ideas from various methodologies, even mixed with ideas from the designers given by the context, from a project in concrete.

4. A large number of projects take ideas, or follow the methodology of Hoekstra and its LKIF ontology, since the tendency nowadays is to separate the "norm" from the "situation", either with these same terms, or with others, but in essence, it is the same.

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