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Engineering

Semantic Model Representation in Colombian Computer Law

Representación del Modelo Semántico en el Derecho Informático

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ABSTRACT

Ontological representations in different domains of reality enable the creation of conceptual relationships that can be coded to reuse and share knowledge. The present article proposes a semantic model representation in Colombian computer law through the methodological process of Methontology. This proposal is the first approximation of a legal semantic model in Colombia that allows structuring searches founded on inferences to obtain information with a high degree of relevance for lawful expert users. The queries of the proposed model are made by semantic content, contrasting to the current legal information search engines which execute queries by textual coincidence. .

keywords: Knowledge, conceptualization, semantics, computer law, model, inference, ontology.

RESUMEN

Las representaciones ontológicas en diferentes dominios de la realidad facilitan la creación de relaciones conceptuales que pueden codificarse para reutilizar y compartir conocimiento. El presente artículo propone una representación del modelo semántico en el derecho informático colombiano a través del proceso metodológico de Methontology. Esta propuesta es la primera aproximación de un modelo semántico legal en Colombia que permite estructurar búsquedas basadas en inferencias para obtener información con un alto grado de relevancia para usuarios expertos legales. Las consultas del modelo propuesto se realizan por contenido semántico, en contraste con los motores de búsqueda de información legal actuales que ejecutan consultas por coincidencia textual

Palabras clave: Conocimiento, conceptualización, semántica, derecho informático, inferencia, ontología.

1 | INTRODUCTION

The computer law interpretation and the useful knowledge extraction needs to guarantee the construction of the knowledge-based system, which contributes to consistency, reliability, and lack of ambiguity when

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retrieving information. The above provides the cooperative work between jurist and brings the support of knowledge between organizations in which interoperability between different systems is allowed. Hence, normative models allow the creation of the system semantics and an extendible and transformable model in different contexts.

The number of the judicial processes has been increasing progressively, making explicit the failures of the current mechanisms and access technics, update and information management; which is needed by the informatics law actors. In Colombia exists the perception of the ineffectiveness of the institutions to process procedures. However, since 9, 10 2014 has been established the need to focus efforts on "the adoption of information technologies to make the administration more open, participatory and innovative, in such a way that each entity shares its information for use and reuse of public data and thus promote transparency in the administration, the participation of the private sector in the adoption of policies and solutions, provide official data efficiently, timely and reliably " [1].

According to the Colombian judicial management indicator between 2012 and 2017, the judicial congestion percentage fluctuated among 37% and 48 % [2], measured as the processes accumulation generated by the lack of attention in legal offices considering the efficient leaving in the period and the issued inventory of the offices. The result of this indicator in Colombia is high compared with the value measured in countries of the European Union like Poland and Bulgaria, which did not have percentages beyond 23%for 2015 [3].

The justice process failures are related to reasons linked to lack of confidence in the management of officials, as well as, financial, infrastructure, and technological support of the country's judicial branch. Information Technology (IT) is used to take advantage of its functionalities as a replacement for old instruments. By affecting society, verification is reached that the use of IT in social and economic life raises important legal reflections [4]. According to the article entitled judicial congestion in the country, a problem of numbers? published by El Nuevo Siglo newspaper on September 8 of 2017, Colombia has an average of 10.95 judges per 100,000 inhabitants. The international standard, determined by the Organization for Economic Cooperation and Development (OECD), is 65 judges per 100,000 inhabitants [5].

In terms of public investment in new technologies for judicial proceedings, the Bank of Spain in its economic bulletin of November 2013 [6], suggests "the countries which invest a greater proportion of their budgets to new technologies, enjoy shorter judicial procedures. Specifically, a larger budget dedicated to the automation of the processes of courts is related to higher productivity of the judges, and the cases resolved by each judge is the measurement. When the country has a high degree of digital literacy, the favorable effect is greater". In Colombia, the delays and high congestion in the judicial process are due to manual administration, decentralization and the lack of immediacy of information, which even causes the expiration of terms in processes that require agility in the generation of judicial sentences. The search for legal information in Colombia is made through two legal services, as shown in Fig. 1.

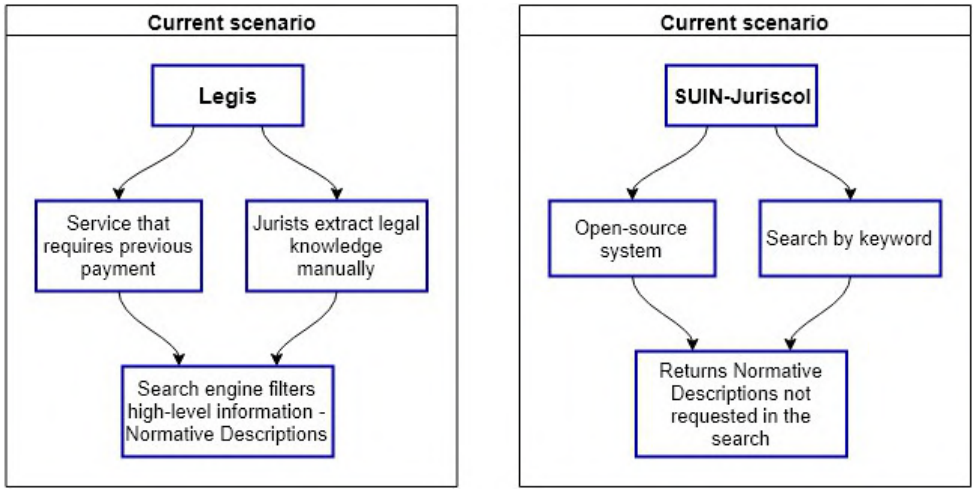


FIG. 1 Current legal information services.

The objective in this article is to present the creation of a semantic model in the legal domain applied to computer law in Colombia, through the methodological standpoint of Methontology. The function of this model is to facilitate the access to information with high relevance degree to computer law professionals, by analyzing the possible reusable aspects which make up other semantic models and open the door to the conceptualization of new legal tasks in the specific domain of interest. Due to the above, a common vocabulary and a set of inferences are obtained, which recover information with a high degree of relevance according to the user query or search, and can be interpreted either by humans and computers.

2 | MATERIALS AND METHODS

An ontology describes how some domain of reality is involved in a particular view. The ontology is related to organize and define terms collection. More precisely [7] validates 49 the idea of ontology as a joint effort to achieve standardization, by having explicit conceptualizations behind terminologies and models on domains of reality.

It is necessary to know the law role in the legal domain, "classifying laws into logically distinct categories has always been one of the greatest tasks of legal philosophy" [8]. All legal origins, laws, judgments, decrees, among others, represent the law as a whole; and the law classification presupposes the solution to the fundamental problem of the laws individualization. According to [9] "the concept of law as a legal practice is essential for the pre-reflective understanding of the law. Social control is achieved through legal practice. Mandates, norms, rules, principles or other kinds of authoritative directives are produced in legal practice.

Due to the no sufficient legal integrity (consistency) of unrelated normative wordings, they have a relevant involvement in the creation of model legal ontologies or core ontologies. While the core ontologies are high-level ontologies whose aim is the domain ontologies organization by new legal domains analysis

A norm can be understood as an abstraction with a partial description of a situation with a deontic qualifier [10], which indicates whether an event is prohibited, obligated or allowed [7-8]. Here, the basis of legal knowledge is pointed out with the differentiation between the legal domain model (world model or reality) and normative statements (legal origin), which is represented by reality terms.

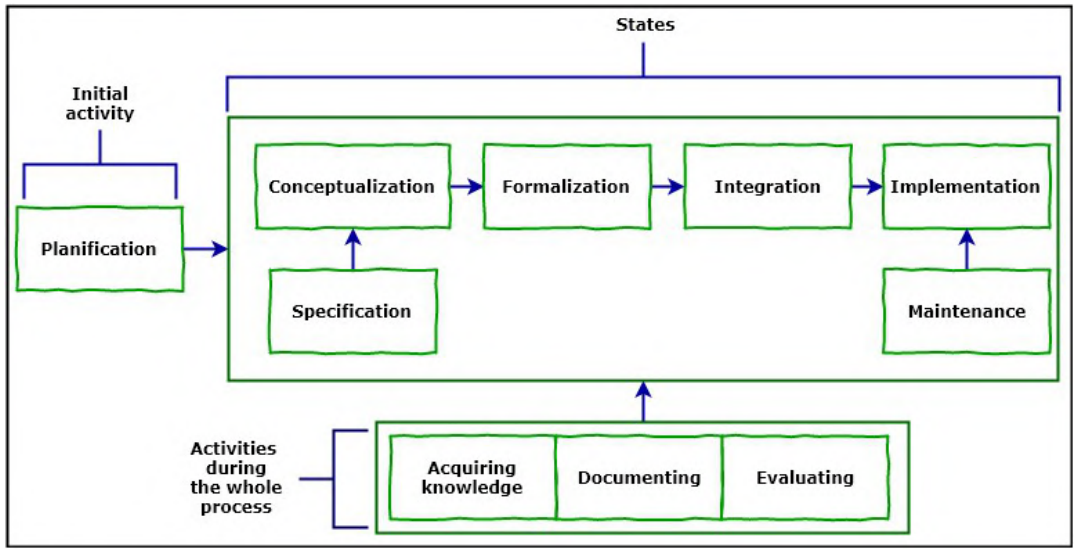


FIG. 2 Methontology overall phases

2.1 | Methodology to develop a legal ontology

Methontology offers a structured method to build ontologies. Its stages help to specify or define the purpose and scope, conceptualize, through a conceptual model to describe the area of the problem and its solution and formalize through a framework or a system of logical representation as shown in Fig. 2.

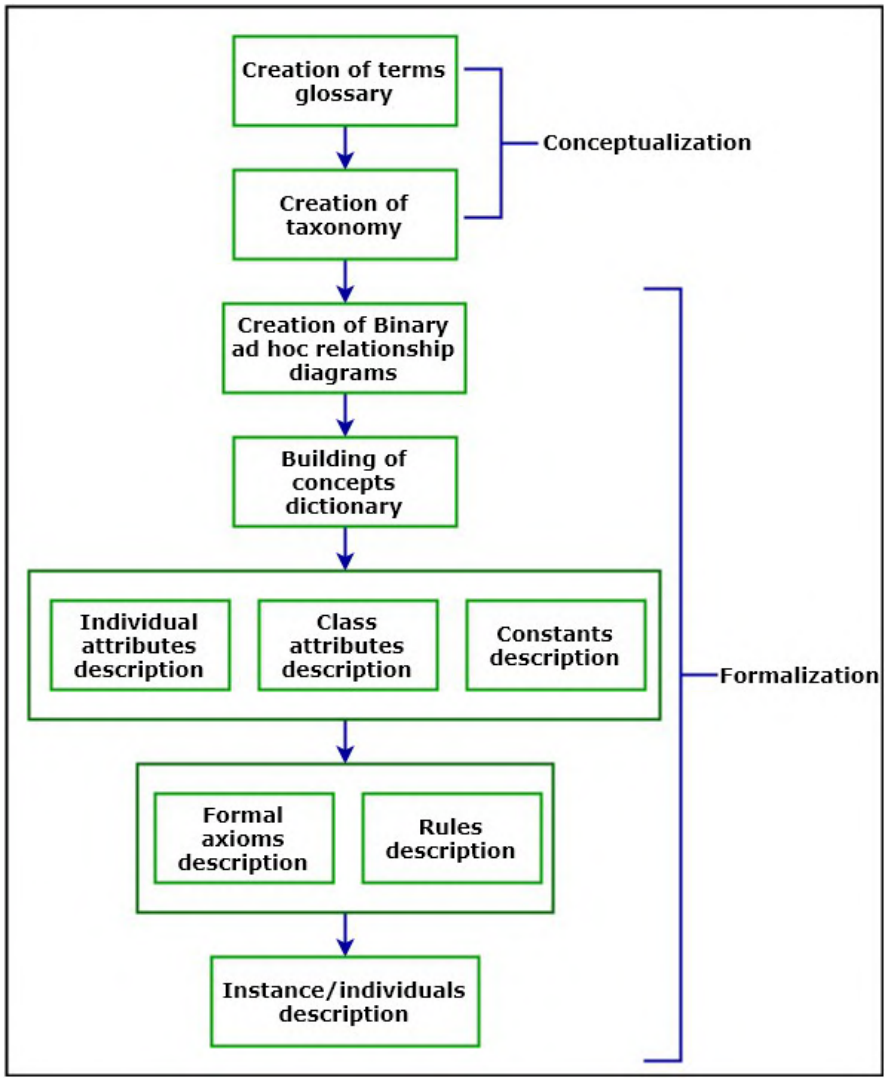


FIG. 3 Activities of conceptualization and formalization phases

The phases of conceptualizing Methontology, enable design and document the legal ontology. Within the formalization phase, the Formal axiom description refers to the non-contradiction principle, as a classic ontological principle and legal ontological as well, indicates that a proposition and its negation, both cannot be true simultaneously (Fig. 3).

2.2 | Integration

This phase adopted the Top-Down and Bottom-up analysis as a method, to integrate the legal ontology of computational law in Colombia, evaluating the procedures found in the literature.

2.2.1 | 2.2.1. Top-Dow and Bottom-up analysis

Fundamental or central ontologies are high-level ontologies, and their aim is organizing domain models by analyzing new legal structures.

The bottom-up analysis goes from specific concepts to the construction of a component by generalization; the first step in the process to create an ontology is the linguistic study on the existing data structures (documents, reports, among others), in order to extract domain concepts and relationships between them with the semi-automatic support of document analysis. The literature of jurisprudence in the legal philosophy is the basis of the top-down analysis of legal concepts. The development of concepts, from the general structures to specialized structures, is the principle of this sort of literature. Basic or primitive concepts constitute legal knowledge, which originates an ontology.

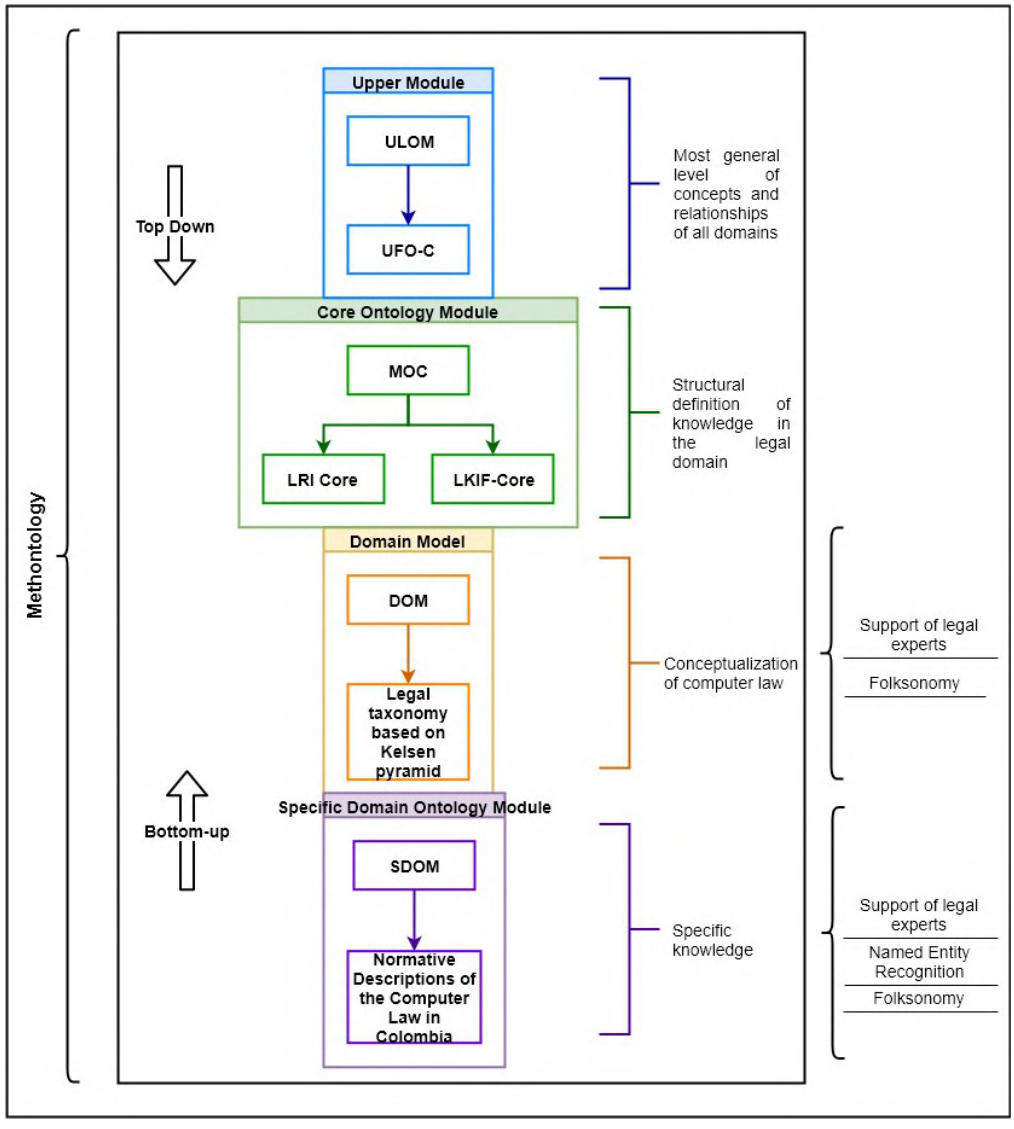


FIG. 4 Activities of conceptualization and formalization phases

According to [11], two main approaches are proposed to integrate ontologies and rules on semantic integration to form a legal reasoning model of the support system of legal decision: A modular intermediate exit approach (Fig. 4), and a homogeneous approach. These approaches allow the combination of top-down and bottom-up strategies through modularization techniques that are used to divide the ontology into four

(4) independent modules (upper level (ULOM), central (COM), domain (DOM), and domain-specific (SDOM)), which in turn are ontologies that can be reusable.

Ontological reuse or integration process is understood as a key factor for the development of profitable and high-quality ontologies [12]. Ontological reuse reduces the time and costs to build ontologies from zeros. In addition to reusing components of ontologies already validated, it increases the quality of the newly implemented ontologies. The expectation is to be able to reuse terms and definitions of existing central or fundamental ontologies that contain legal concepts. For this purpose, the construction of an ontology of reusable legal domain to model the legal aspects of the domain of computer law in Colombia, and its formalization through the use of modularization techniques are the biggest challenges into ontological engineering [13] [14] [15]. One of the best-known top ontologies is UFO (Unified Foundational Ontology) [16] and is developed to support conceptual and organizational modeling activities. UFO allows you to reuse concepts such as category, type, subtype, relator, role.

The Upper Module (ULOM) reuses the UFO-C concepts related to social entities such as Agents and Objects. The agents can be people or organizations, and the objects can be seen as a normative description of legal documents, in general, social objects. Normative descriptions define one or more rules/norms recognized by at least one social agent [11].

Core Ontology Module (COM) consists of a concepts series and common relationships in the legal domain, as a basis for more specific domain legal concepts. LRI Core and LKIF-Core contain legal concepts essential for the general understanding of the legal domain [17].

The Domain Model (DOM) is directly related to concepts of the legal domain in Colombia. The Specific Domain Ontology Module (SDOM) has the computer law concepts and relationships ensemble in Colombia.

The implementation and evaluation form the phases that allow reaching the set of results to verify and validate the semantic model at a conceptual level.

2.3 | Implementation

Protegé [18] has a series of semantic inference engines that allow generating knowledge and making inferences from axioms and rules expressed in OWL, as well as validating inconsistencies and redundant knowledge. The design of the ontology in terms of classes, properties of objects, properties of individuals, axioms, rules, and individuals is carried out in Protegé. In [19] the information recovery systems are analyzed and the differences with the data recovery systems are established. One of the most relevant differences is the fact of understanding the retrieval of information as a task that is carried out through induction through semantic relationships between classes of objects. The semantic engine built from the ontological model allows the retrieval of legal information.

2.3.1 | Evaluation

"Usually, the method evaluation consists of two parts: the verification that allows ensuring that the ontology was correctly constructed, and the validation that allows us to confirm that the ontology represents the real world" [20]. Protegé allows carrying out two types of verifications, the first one at the level of the execution of the semantic inference engine by using SPARQL queries, and the second is the verification of coherence and consistency of the debug analyzer at run time.

2.3.2 | Knowledgebase and descriptive logic

The Descriptive Logic (DL) is an evolution of the semantic networks used to represent taxonomic knowledge in many application areas, such as databases, software engineering, and artificial intelligence [21][22]. The characteristic of this logic is having a group of elements applied in expressions of concepts and roles, inferences of type TBOX (based on concepts) and ABOX (based on individuals) and inference mechanisms for the proper reasoning of TBOX and ABOX [23].

2.3.3 | CQI Syntax

The following three aspects characterize the Descriptive Logic system (DL): the constitutive group of structures of the language used to create the mentioned concepts and roles in TBOX and ABOX, the inferences types that can appear in TBOX and ABOX, and the inference mechanisms generated from reasoning about ontology.

The CQI Descriptive Logic proposed in [24], expresses a semantic of concepts interpretation as subsets of a domain and relationship roles, which is specified in Syntax and semantics of concepts and roles in CIQ [25].

3 | RESULTS AND ANALYSIS

Considering the methodological standpoint of Methontology, which proposes phases that go from reality domain understanding to the ontology implementation, below are the results of each one of these phases to achieve the legal ontology applied to computer law in Colombia.

TABLE 1 Fragment of the terms glossary.

Name	Description	Type
Statutory Decree	A normative statement that is issued by the National Government and whose subject matter must be regulated in principle by statutory law in compliance with the provisions of article 152 of the political charter.	Concept
Legislative Act	Standard issued by the Congress that aims to reform, add or repeal some text of the Political Constitution of Colombia [19].	Concept

TABLE 2 Fragment of the ad hoc binary relationships.

Origin Entity	Relationship	Target Entity
National Entity	Decrees	Norm
Norm	Is Decreed by	National Entity
National Entity	It is a corporate author	Norm
Norm	Has a corporate author	National Entity

3.0.1 | Legal documents

The selection of legal documents considered the legal relationship between them. The interrelation between these documents allows for achieving results to hardly observable searches with no explicitly represented information. A total of twelve (12) legal documents related to information technologies and IT law were selected (Sentences: C-741 of 1998, C-662 of 2000, and C-748 of 2011; Laws: 67 of 1917, 79 of 1993, 527 of 1999, 1266 of 2008, 1341 of 2009, and 1581 of 2012; Decrees: 542 of 2014, and 2433 of 2015; Normative Circulars: Register 1020894 of March the 7th of 2017).

3.0.2 | Legal documents.

Based on the legal documents previously mentioned, and with the support of a legal expert from the Universidad Externado de Colombia, was created the glossary of legal terms (Table 1).

To create the taxonomy of concepts was required an interpolation to the structure of laws in Colombia, which represents a hierarchical order of higher to lower law rank, according to Kelsen pyramid proposal [26].

3.1 | Formalization of the conceptual model

The ad hoc binary relationships are important for the formalization of the conceptual model. Table 2 shows the defined relationship between the identified concepts of the legal ontology applied to computer law in Colombia (origin entity) and its inverse (target entity).

The dictionary of concepts (Table 3) was created from the identification of individuals and relationships of

the binary relationships set (Table 2), for each concept in the taxonomy, related to computer law. Table 4 is a demonstration of the defined binary relationships description for computer law in Colombia, which specifies to each one the origin concept, cardinality, target concept, and inverse relationships.

TABLE 3 Fragment of the dictionary of concepts.

Concept Name	Individuals	Relationships
Mayoralty	-	Decrees / It is a corporate author of
Municipal Council – Mayoralty	–	Decrees / It is a corporate author of
Departmental Assembly	–	Decrees / It is a corporate author of
Congress	House of Representatives Senate of the Republic	Decrees / It is a corporate author of
District Council	–	Decrees / It is a corporate author of

TABLE 4 Fragment of Ad hoc binary relationships descriptions.

Relationship	Origin Concepts	Cardinality	Target Concept	Inverse Relationship
Decrees	Collective Social Agent	N	Normative description	Is Decreed by
Repeals	Legislative branch Article	N	Article Normative description	Is repealed by
It has corporate author	Normative description	N	Collective Social Agent	Is corporate author of
Has agreement	Normative description	N	Normative description Article	Is concordant

From the individual attributes identified by the dictionary of concepts, is created the description of each one. This description specifies the name, type, and cardinality (Table 5).

TABLE 5 Fragment of the individual attributes description.

Individual attribute name	Concept	Value type	Cardinality
Clarification vote	Jurisprudence	String of characters	(1,1)
Approval	Legislative act	String of characters	(1,1)
Legal aspect analyzed	Jurisprudence	String of characters	(1,1)
Bibliographic data	Jurisprudence Legislative act	String of characters	N
Debate	Legislative act	String of characters	(1,1)

The class attributes description, for this specific ontology, contains the concept, value type, cardinality, and values (Table 6).

TABLE 6 Class attributes list

Class attribute name	Concept	Value type	Cardinality	Values
Part	Jurisprudence	[active, passive]	(1,2)	active
Part	Jurisprudence	[active, passive]	(1,2)	passive

Table 7 shows the description of the constants obtained from the terms glossary of computer law in Colombia

TABLE 7 Constants list.

Name	Value type	Value	Measurement unit
Of legal age	Cardinal	18	Year

The formal axiom associated with the non-contradiction principle within legal ontology framework in Colombia for the binary relationship repeal, and the variables ?X and ?Y represent individuals of the Normative Description class (Table 8).

TABLE 8 Formal axiom for computer law legal ontology.

Axiom name	Description	Concepts	Relationships	Variables
Incompatibility	A repealed normative description cannot be equally valid with regard to which repeals it.	Normative description	Repeat	?X, ?Y
Pseudocode expression				
not exists (?X, ?Y) (normative description that repeals (?X) and repealed normative description (?Y) and normative description that repeals valid (?Y, ?X) and repealed normative description valid (?Y, ?X))				

The rules for legal ontology allows inferring computer law knowledge. For relationships "It has agreement" and "It is concordant to", an inference rule is established, in which there is legal agreement for two individuals that comprise either the Description Normative or Part Document class, if and only if for both individuals "It has a topic" or "it has a description" attributes have concepts in common. The variable ?X and ?A represent two individuals of the Normative Description class. The variables ?Z and ?B represent two individuals of the Document Part class. The variables ?Y and ?C represents the individual "it has a topic" attribute. Finally, the variables ?W and ?D represent the individual "It has a description" attribute (Table 9).

TABLE 9 Rules for computer law legal ontology.

Rule name	Description	Concepts	Attributes	Relationships	Variables
Legal agreement between normative descriptions	A normative description or one of its parts has a legal agreement with another normative description or one of its parts if the topic or description of both have common concepts.	Normative Description, Document Part.	Topic, Description.	It has agreement, It is Concordant to	?X, ?Y, ?Z, ?W, ?A, ?B, ?C, ?D
Pseudocode expression					
If [normative description](?X) or [document part](?Z) and it has a topic (?X ?Y) or it has a description (?X ?W) or it has a topic (?Z ?Y) or it has description (?Z ?W) == [normative description](?A) or [document part](?B) and it has a topic (?A ?C) and it has a description (?A ?D) or it has a topic (?B ?C) or it has a description (?B ?D)					

Table 10 presents a fragment of individuals that make up the legal ontology.

3.2 | Integration

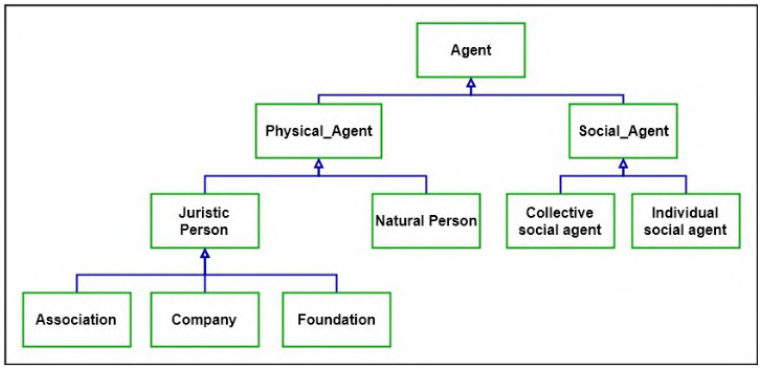
The bottom-up strategy consists of extracting the concepts and legal relationships from the textual resources (in computer law in Colombia) to model this knowledge as a domain and then as a specific domain (Fig. 5).

In relation to the superclass Agent, a hierarchical structure is proposed, which involves the concepts of

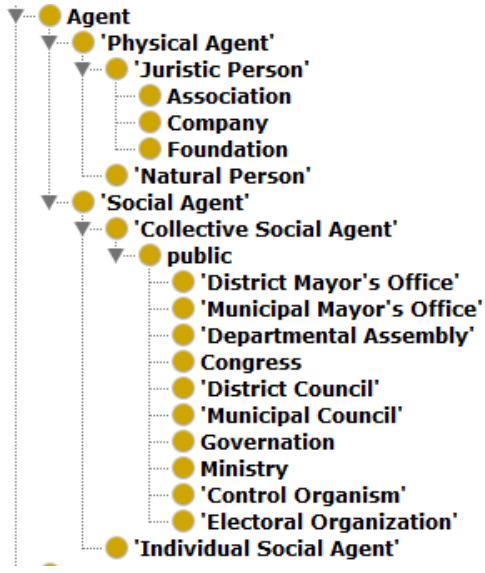
communal organizations of the Colombian state (Fig. 5), as a civic agent of a public nature.

TABLE 10 Fragment of individuals.

Individual name	Concept name
National Electoral Council	Electoral organization
General Comptroller Office	Control organism
House of Representatives	Congress
Attorney General's Office	Control organism
Senate of the Republic	Congress
Constituent Assembly	Reformatory Act of the Constitution



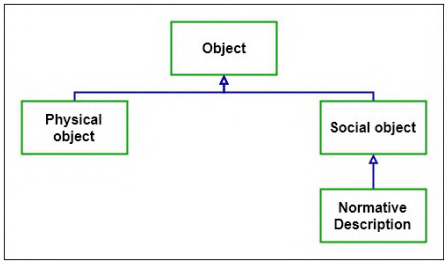
(a) UFO-C classes.



(b) UFO-C + legal ontology in protégé

FIG. 5 Domain.

According to the taxonomy of legal concepts in Colombia, the legal documentary structure of LKIF-Core is linked to the legal documentary structure in Colombia and extends beyond concepts of code, regulation, and statute (Fig. 6).



(a) LKIF-Core classes.

(b) LKIF-Core + legal ontology in protégé

FIG. 6 Domain.

An expert in Colombian legislation from the Universidad Externado de Colombia cooperated to build the

Domain Ontology Module (DOM) and Special Domain Ontology Module (SDOM).

3.3 | Implementation

Based on the information requirements by jurists of the Universidad Externado de Colombia, in Fig. 7 is presented one result obtained in the execution of SPARQL sentence in the SPARQL Query module of Protegé. Information requirement: Obtain the law and the publication date of normative descriptions published between 1991 and 2014. Sort the results based on the date of publication.

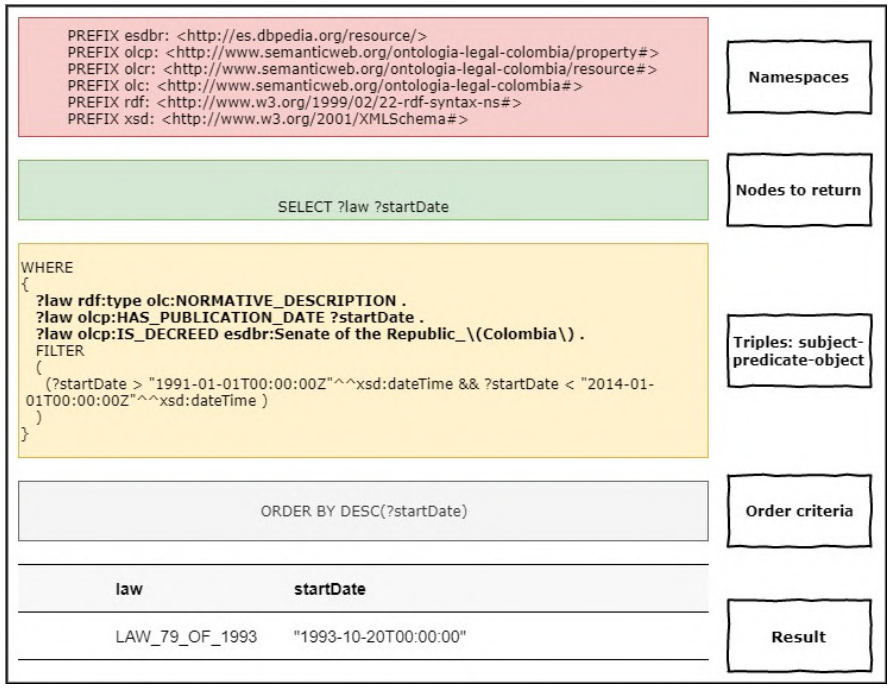


FIG. 7 Information requirement SPARQL query.

3.4 | Evaluation

The legal ontology inference proposal starts with K = (T, A) knowledge base concerning Normative Descriptions and Document Parts related to the legal ontology structure presented in the development through Methontology. The TBOX T component is described from 4 inferences, as shown in Table 11.

TABLE 11 TBOX inferences.

Inference	Description
Normative Description $\subseteq \forall$.(document part(Normative Description $\cup$ (Article $\prod$ Chapter $\prod$ Title)))	Each **Document Part** of an individual of a **Normative Description** is a normative description or an **Article, Chapter or Title.**
Article $\subseteq \forall$.(document part.$\perp$) $\prod \neg$ Normative Description	The individuals of the **Article, Chapter** and Title classes do not have children and are different from the individuals of the **Normative Description** class.
Social Object $\subseteq$ Normative Description $\prod \forall$ document part $^{-} \perp$	The **Social Object** instances are normative descriptions and have no predecessor **Normative Description**
Object $\equiv \exists$ (document part $^{-}$)* Social Object	Each individual of the **Object** class reaches an individual of the **Social Object** class in a finite number of steps through a string of **Document Part**$^{-}$.

The ABOX A component is described from two (2) inferences (Table 12). From K, the following inferences can be made: According to the TBOX inference, each individual s of the Object class reaches an individual of the Social Object class in a finite number of steps through a string of Document Part . By induction, if given a value n = 0, then s = s'. If s is an individual of Social Object, it is also an individual of Normative Description.

$$K \vDash \text{Object} \subseteq \text{Description Regulations} \bigcup \text{Part Document}$$

$$\text{Given a } \beta = \text{ Article 1, Title I, Chapter I and Article } 22111 \textbf{ then } : K \vDash \text{ Object } \beta$$

It is concluded that, according to the inference, Article 1, Title I, Chapter I and Article 22111 are individuals of the classes Normative Description and Document Part, while Decree 2433 is individual only of the Normative Description class. The basis of the ontology is already sitting, therefore, the module-based architecture can change or adapt the specific domain module, according to the interest legal discipline.

TABLE 12 ABOX inferences.

Inference	Description
Document part (a, b) Document part (b, c) Document part (a, c)	Having as a prerequisite the individuals a, b, c, and their **Document Part** relationship. It is expressed then a has as children b and c, and in its turn c is the child of b. This case is presented by having a normative description that has a Title (a), which in turn the Title has a **Chapter** (b) and that in turn, the Chapter has an **Article** (c).
Document part (Decree 2433, Article 1) Document part (Decree 2433, Title I) Document part (Decree 2433, Chapter I) Document part (Decree 2433, Article 22111) Document part (Title I, Chapter I) Document part (Chapter I, Article 22111) Descripción Normativa (Decree 2433)	Having the individuals **Decree 2433, Article 1, Title I, Chapter I** and **Article 22111**. It is expressed that **Decree 2433** has **Article 1, Title I, Chapter I** and **Article 22111** as children. Title I has as children to **Chapter I** and **Article 22111** and that Chapter I has as a child to **Article 22111**.

With the construction of a legal domain ontology applied to computer law in Colombia, it is possible to perform searches based on inferences, to obtain high relevance degree information for legal expert users, which simplifies the organization by concepts of the offered information through searches by meaning and not by textual content.

4 | CONCLUSIONS

Examining about the general concepts that are useful for a legal domain becomes a task of understanding reality from the fundamental concepts and how they are articulated with specific modeling concepts as described in the hierarchy of concepts Social Agent Collective Social Agent Public Agent [Congress, Government, Ministry, Electoral Organization]. Of course, this task leads to initially understand the specific domain and the hierarchical structure of the same by legal experts. The legal expert is who declares the relevance of the results of the engine of semantic inferences, understanding as a relevant result the set of concrete, verifiable and thrusts information. This information is strictly related to the semantic content requested through a query that establishes the criteria of binary relationships between individuals and goes beyond the repository of data explicitly represented.

The current search engines for legal information in Colombia, as SUIN-Juriscol and Legis, produce results with a low degree of relevance for the expert users of the legal domain, which implies spending a lot of time to find and debug the relevant records. This legal ontology in Colombia proposal provides a tool to facilitate the access to information with a high degree of relevance and semantic content (based on a legal taxonomy), which means returning information even when it was not explicitly represented in the search, by integrating

several domains of reality. The results of the semantic search allow linking information that eases the final user decision making with a greater degree of precision and short response time.

When searching for specific information on a legal resource such as the Article, Legis and SUIN-Juriscol only allow searches at the level of legal document types (decree, law, statutes), however, there is no clear taxonomic definition regarding the parts of the legal document. Finding the articles of a legal document that refer to "data", in the current search engines, will depend on a result based on content and at the level of types of legal documents, which implies a manual search and debugging later. The legal ontology in Colombia, in contrast, allows searches at the level of types of documents and parts of documents with the added value of producing results with semantic content, for example an article of a law (part of a document) that is related (e.g. repeals) with a decree (type of document).

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