Universitat Autònoma de Barcelona

Interpretation and Knowledge Modeling of Patents

Simone Rosa Nunes Reis

Universitat Autònoma de Barcelona

Facultat de Dret

Departament de Ciència Política i Dret Públic

Interpretation and Knowledge Modeling of Patents

Dipositat a la Universitat Autònoma de Barcelona
com a requeriment per al grau de Doctorat en Dret

per

Simone Rosa Nunes Reis

Bellaterra, Juliol 2019

Directors: Dr. Pompeu Casanovas Romeu (also tutor)
Dr. Jordi Carrabina I Bordoll

Resum

Durant els darrers anys, l'economia del coneixement ha anat creixent progresivament. Vivim en un moment molt especial on tots els camps del coneixement humà estan sent profundament afectats pels desenvolupaments tecnològics. Una gran quantitat d'incubadores i startups tecnològiques apareixen a diferents llocs del món. Moltes ciutats diferents volen esdevenir referents tecnològics i la tecnologia està afectant un nombre cada cop més gran de dominis del coneixement, fins i tot els tradicionals com l'agricultura.

La tecnologia té valor, i aquest valor es pot transformar en propietat, la propietat intel·lectual. Una d'aquestes formes de propietat intel·lectual són les patents, les quals protegeixen les invencions. Les cartes de patent concedeixen drets de propietat a les invencions. La gran activitat de recerca i desenvolupament tecnològic dels darrers anys han generat molts invents, que tenen un impacte econòmic i afecten el desenvolupament humà. La propietat intel·lectual d'aquests invents és important per a la interacció dels diferents actors d'una economia global.

Aquesta tesi estudia com s'interpreten les patents. Es proposa un enfocament semiòtic per a la interpretació de les patents (S.R.N. Reis et al, 2019). Aquest enfocament considera una patent com un missatge que conté diverses afirmacions individuals que representen drets de patent individuals. Des d'un punt de vista semiòtic, cada reivindicació esdevé un signe que representa un dret de patent. La principal contribució de la tesi és la descripció detallada de com interpretar les reivindicacions i com representar la visualment la seva cobertura amb els diagrames de Venn.

D'aquesta aportació principal se'n deriven unes altres quatre aportacions, com a aplicacions del cos principal del treball. La primera contribució derivada consisteix en tècniques de gamificació per explicar els conceptes implicats en la interpretació de patents. La segona és la proposta de mètriques per avaluar la qualitat de les patents. La tercera contribució és l'aplicació de les mètriques proposades per avaluar la qualitat de patents d'exemple de la UAB i la UFRGS. La quarta contribució derivada és una aproximació o proposta de modelat del coneixement de les patents centrada en les seves reivindicacions.

La tesi conclou amb un capítol que defensa la regla de "tots els elements", que s'utilitza per a interpretar les patents. Aquesta tesi és una contribució significativa per entendre millor els drets proporcionats per una patent i, per tant, a la millora de la redacció dels documents de patents.

Abstract

During the last years, the economy of knowledge has become more and more prevalent. This is represented by the large number of technology incubators and startups that are appearing in different places around the world. Many different cities want to be the next technology hub, and technology is affecting more and more traditional fields like agriculture. We live in a very special moment in time where all fields of human knowledge are being profoundly impacted by technological developments.

Technology has value, and this value can be transformed into property, intellectual property. One of these forms of intellectual property is patents, which protect inventions. Letters of patent grant property rights over inventions. The great number of technology developments in recent years has generated many inventions. These inventions have economic impact and affect the human development. The intellectual property of these inventions is important for the development of the different actors in a global economy.

This thesis study how patents are interpreted. A semiotic approach for the interpretation of patents is proposed (S.R.N. Reis et al, 2019). This approach views a patent as a message that contains several individual claims that represent individual patent rights. From a semiotic stand point each claim is then a sign that represents a patent right. The main contribution of the thesis is to describe in detail how claims are interpreted and represent the coverage visually with Venn diagrams.

From the main contribution, four contributions are derived, as applications of the main body of work. The first derived contribution consists in gamification techniques to explain the concepts involved in patent interpretation. The second derived contribution is the proposition of metrics to evaluate patent quality. The third derived contribution is the application of the proposed metrics to evaluate the quality of patents by UAB and UFRGS. The fourth derived contribution is an approach for knowledge modeling of patents focusing on patent claims.

The thesis concludes with a chapter that is a defense of the all-element rule, used to interpret patents. This thesis is a significant contribution to better understanding the rights provided by a patent, and therefore to write better patent documents.

Acknowledgements

I would like to thank my Thesis Director and Tutor, Prof. Pompeu Casanovas for his guidance throughout this work. Prof. Pompeu Casanovas was instrumental in my main publications. First, by suggesting the AICOL conference as a vehicle for publication, then suggesting many useful references to enrich the work while it was taking shape. This resulted in a book chapter published by Springer (S.R.N. Reis et al, 2018). Second, Prof. Pompeu Casanovas knowledge was also fundamental to shape the Semiotics of the Law paper (S.R.N.Reis et al, 2019). Besides revising and suggesting important modifications, he caught some early mistakes that were important for the development of the full paper. Finally, I thank Prof. Pompeu Casanovas for trusting in this work from the beginning and for making it possible by accepting me at the PhD in Law.

I would also like to thank my Thesis Director Prof. Jordi Carrabina also for trusting in this work from the beginning. Without his trust and initial effort, this work would not be possible. If this work has a multidisciplinary approach is also due to his advice to improve the thesis. I also thank him for always bringing my attention to the importance of making good public presentations. I am fully aware that communication skills will be determinant for my professional future, and the practice will help me to keep improving in this aspect.

I also thank Pilar Alcaraz for all of her support and kindness. She was always helpful in solving my doubts and providing all the answers to my e-mails.

I thank André for all of his emotional and financial support during the thesis. As this work is multidisciplinary, he acted many times as my translator to communicate with other fields, due to his experience as a Professor.

In a more spiritual tone, I thank my Guardian Angel and all my protective Saints for helping me to complete this phase of my life with success.

Finally, thanks to my family. As first of all, it is our upbringing and our families that make us capable of living a life that is good for us and useful for the society.

Publication List

This Thesis is based in part on (and led to) the following published articles and conferences:

S.R.N.Reis et al, 2016a. Reis, Simone R.N.; Reis, André I.; Carrabina, Jordi; Casanovas, Pompeu. Patent Interpretation using Boolean Logic and Venn Diagrams. In: IWLS, 2016, Austin, Texas, EUA. IWLS 2016 Proceedings. New York: ACM/IEEE, 2016.

S.R.N.Reis et al, 2016b. Reis, Simone R.N.; Reis, André I.; Carrabina, Jordi; Casanovas, Pompeu. Modeling Patent Claims in Patent Ontologies for Patent Value Assessment. In: AICOL 2016, 2016, Nice. AICOL 2016 Proceedings, 2016.

S.R.N. Reis et al, 2018. Reis, Simone R.N.; Reis, André I.; Carrabina, Jordi; Casanovas, Pompeu. Contributions to Modeling Patent Claims when Representing Patent Knowledge. In: U.Pagallo, M.Palmirani, P.Casanovas, G.Sartor (eds.) AICOL-VI. Revised Selected Papers, LNAI 10791, Heidelberg: Springer. http://dx.doi.org/10.1007/978-3-030-00178-0_9

S. R. N. Reis et al, 2019. Reis, Simone R.N.; Reis, André I.; Carrabina, Jordi; Casanovas, Pompeu. Semiotic Aspects in Patent Interpretation. Int J Semiot Law (2019) 32: 359. https://doi.org/10.1007/s11196-018-9599-0

After the thesis, chapters 7, 8, 9, 10 and 11 will lead (individually or combined) to additional publications.

Table of contents

1. Introduction

Law is part of human communication, and as any other form of human communication it carries a certain level of ambiguity or subjectivity (T. Endicott, 2011) (V.M. Colapietro, 1988) (S.Ramakrishna and A.Paschke, 2014). For instance, Ramakrishna S. and A. Paschke state that "*In general, laws are designed to be vague. Their vagueness is to accommodate different possible scenarios under which a law can be applied*" (S. Ramakrishna and A.Paschke, 2014). In order to reduce this level of ambiguity, effective means of interpretation or clarification are necessary. In many cases, the interpretation of law text is fixed by countless court decisions interpreting the laws (A.L.Durham, 2018). These countless decisions can be considered as pragmatics to interpret the law. There is a whole field of modeling legal knowledge. For instance, Casanovas et al discuss the role of pragmatics in the web of online data (P.Casanovas et al, 2017). One application is to provide intelligent information technology support for judges to easily access professional legal knowledge (Benjamins et al, 2004). This is especially important to provide support for newly appointed judges, as pointed out by Casanovas (P.Casanovas et al, 2005).

In the specific field of patent law, Ramakrishna and Paschke introduced Elementary Pragmatics (EPs) to deal with norms/precedents/guidelines as accessory information to patent law (S. Ramakrishna and A.Paschke, 2014) (S. Ramakrishna, 2013). It is important to say that the legal system for intellectual property is mostly based on common law, i.e. important decisions on how to interpret patent claims come from judge decisions, not from statutory law (A.L.Durham, 2018). This is observed by Nard (C.A. Nard, 2010) in the case of USA patent law:

> "It should therefore come as no surprise to learn that a significant portion of U.S. patent law, including some of the most important and controversial patent law doctrines, is either built upon judicial interpretation of elliptical statutory phrases, or is devoid of any statutory basis whatsoever. Thus, while Congress and the courts each have a hand in

> constructing the latticework of patent law, judges – not the authors of Lex scripta – are the principal architects." (C.A. Nard, 2010)

One example of important accessory pragmatic information for patent law is the so-called all-element rule, which describes how to determine if a patent is infringed. The basic idea of the rule is that a product infringing a patent must present all elements (features) recited in a patent claim.

This thesis will address the important field of patent interpretation and knowledge modeling for intellectual property, especially the case of patents. It is a field of extreme importance as the current society is more and more relying on technological advances, and many of these innovations are protected through patents. The research questions we will address include the following. How a patent is interpreted? What exactly is covered or protected by a patent? Can this be represented visually? How the quality of a patent is measured? Is it possible to have specific metrics to evaluate and improve the quality of patent applications? How to evaluate if a person understands patent interpretation and coverage? How to represent patent knowledge in such a way that it is possible to visualize and evaluate quality more easily?

This thesis is divided in 12 chapters. In the following, the content and motivation for each subsequent chapter is described. Also, the main contributions presented throughout this document are highlighted. The text of some chapters is partially derived from publications made during my thesis. For this reason, small repetitions of text may happen in distinct chapters. When this repetition occurs, it is also for self-completeness of the chapters. In this sense, some important citation may appear more than once throughout the thesis, in distinct chapters. Additionally, due to the text that is shared with works where I am the first author, I sometimes use plural pronouns like *we* and *our* in this document, as I have co-authors in the papers published in the scope of my thesis.

Concerning the organization of the thesis, chapter 2 presents the state of the art. This is necessary to have an overview of what has been done in this field, so that the contributions of the thesis can be more clearly highlighted with respect to previous works. As this chapter

presents several distinct basic concepts, references are made to the chapters that will use the concepts.

The patent law in different countries is discussed in chapter 3. A review of patent law agreements among countries is also presented.

The all-element rule is discussed in detail in chapter 4. This includes the presentation of claim structure and the concept of claim element.

Some software tools for reasoning about patents are based on special types of logic such as Deontic Logic and Description logic. Chapter 5 reviews these types of logic and discusses how to represent the all-element rule in this type of logic. Although minor, the representation of the all-element rule in Description Logic and Deontic Logic is the first contribution of this thesis.

A semiotic approach for patent interpretation, based on the all-element rule, is proposed in chapter 6. The chapter also discusses how to visualize patent coverage using Venn diagrams. This chapter presents significant contributions to patent interpretation.

Chapter 7 discusses how to evaluate the understanding of the general public concerning the quality of patents. This is done through a gamification approach. Some synthetic examples of patent applications and granted patents are introduced. Gamification is done through a series of questions to evaluate knowledge about patent interpretation and patent quality, based on the proposed synthetic examples.

Metrics to evaluate patent quality are proposed in chapter 8. These metrics are based on the semiotic approach for patent interpretation introduced in chapter 6. These metrics are also a significant contribution of this thesis.

The metrics proposed in Chapter 8 are put to practice in Chapter 9, by evaluating patents from UAB and UFRGS using these metrics. This is done to evaluate the methodology introduced by this thesis with real life examples.

Contributions to modeling patent claims when representing patent knowledge are presented in Chapter 10. Previous approaches to modeling patent knowledge did not take into

account the claim section of a patent in sufficient detail. In this chapter, the modeling of claims is discussed in detail. This is a significant contribution of this thesis, as the claims determine the coverage of a patent.

A defense of the all-element rule is presented in chapter 11. The logic behind the all-element rule is discussed. The positive aspects of using the all-element rule are highlighted, emphasizing that these qualities tend to make the rule universally adopted with time. Negative and potentially catastrophic consequences of not using the all-element rule are pointed out.

Chapter 12 concludes this thesis. The contributions are highlighted and directions for future works are pointed out.

2. State of the art

2.1. About this Chapter

This chapter presents the state-of-the-art for the context of this thesis. The work will mainly focus on patents, with the goal of understanding how patents are interpreted and how to measure the quality of patents. Another objective is to establish criteria for the inventors to write patents that maximize the scope of protection and therefore the value of the patents. This goal has a multidisciplinary nature on itself, so several distinct topics will be reviewed. In order to facilitate the reading, references are made to the chapters that will use the concepts.

2.2. Types of Intellectual Property

Intellectual property is an umbrella term referring to a form of property associated with knowledge that is useful in the production of goods or services. Intellectual property can also be referred as intangible property. In some countries, intellectual property can be divided into industrial property and literary and artistic property (INPI, 2015). Industrial property is more related to creations that are useful in a productive process and include patents, industrial designs and commercial trademarks. Literary and artistic property is related to copyright author rights associated to literary or artistic works, including software copyright.

Intellectual property is a broad definition, and different authors can provide distinct (yet compatible) definitions for the term. In order to better understand intellectual property, it can be useful to contrast two definitions from distinct authors.

Intellectual property, according to DeMatteis et al (B.DeMatteis et al, 2006) is a set of

> "*creative ideas and expressions of the human mind that have commercial value and receive the legal protection of a property right*". (B.DeMatteis et al, 2006)

David Pressman (D.Pressman, 2006) gives the following alternative definition.

> "*intellectual property (sometimes called intangible property) refers to any product of the human mind or intellect, such as an idea, invention, expression, unique name, business method, industrial process, or chemical formula, which has some value in the marketplace and that ultimately can be reduced to a tangible form, such as a computer, a chemical, a software-based invention, a gadget, a process, etc.*" (D.Pressman, 2006)

Notice that the definition by Pressman is more verbose, but it lacks the fact that intellectual property is granted under a legal system. However, Pressman complements his definition by further stating that:

> "Intellectual property law, accordingly, covers the various legal principles that determine: who owns any given intellectual property; when such owners can exclude others from commercially exploiting the property; and the degree of recognition that the courts are willing to afford such property (that is, whether they will enforce the owner´s offensive rights)". Therefore, the role of a legal system is acknowledged by Pressman, whom further states that: "in short, intellectual property (IP) law determines when and how a person can capitalize on a creation". (D.Pressman, 2006)

Intellectual Property is an umbrella term, and legal rights are granted for more specific forms or types of intellectual property. In the following, the specific nature of different types of intellectual property is discussed, for the sake of completeness, even if this thesis is more concerned specifically about patents.

2.2.1. Trademarks

Trademarks are distinctive elements that identify the providers of goods and services. They correspond to brand names and logos, used in commercial products and services to identify the provider. Trademarks are a form of industrial property, as brands and logos are used to identify products and services. Trademarks can be obtained through specific request or in some specific cases by usage. For more information on trademarks, we refer the reader to the work of Fishman (S.Fishman, 2016).

2.2.2. Copyrights

Copyrights are a form of intellectual property intended to protect works of authorship, usually associated to the production of cultural or artistic goods such as books, paintings, films and even software code. Copyrights cover the particular form used by an artist or author to express an idea. Copyrights do not cover content, but the form used by the author. The acquisition of copyrights does not require registration, and copyrights are granted when the work assumes a tangible form. It is still possible and advisable to register copyright as a proof of authorship at a certain date. Copyright are a form of literary and artistic property. For more information on trademarks, we refer the readers to the work of S.M. McJohn (S.M. McJohn, 2018).

2.2.3. Patents

As stated before, patents are the main interest of this thesis. Patents are a type of intellectual property aimed to protect inventions that are useful in the production of goods. In other words, as stated by the World Intellectual Property Office, patents can protect

> “a product or a process that generally provides a new way of doing something, or offers a new technical solution to a problem”. (WIPO, 2019a)

In order to obtain a patent, it is necessary to file a patent application describing the invention to a patent office authorized to grant patent rights. More specific legal details on this will be presented in chapter 3, for the moment, it will be sufficient to understand that patents are different from trademarks, copyrights and other forms of intellectual property (S.Johnson, 2015).

2.2.4. Other Forms of Intellectual Property

Besides copyrights, trademarks and (utility) patents, there are other forms of intellectual property. These include plant patents, design patents, integrated circuit layout design protection, trade secrets, confidential information and rights associated to unfair competition. Plant patents allow seeking protection for new types of plants obtained through artificially assisted breeding. Design patents protect new ornamental forms, shapes or designs of existing products. Integrated circuit layout design protection is a form of copyright directed to layout or topography of integrated circuits (ICs or "chips"). Trade secrets are an option when an inventor or a company does not want to disclose internal processes and decide to keep the information secret. The confidential information can be protected with non-disclosure agreements (NDAs). Finally, unfair competition laws can also provide protection for intellectual property. For more information on different forms of intellectualproperty, we refer the readers to the work of Johnson (S.Johnson, 2015).

2.3. Basic Concepts

This section presents the basic concepts used in this work. We first describe some concepts of semiotics. Then we introduce a patent document as a message divided into four message

sub-sections. There is a natural association of the structure of a patent document with the roles the patent subsections play in a semiotic perspective in the interpretation of the patent document. Additionally, our analysis of patent coverage performs patent interpretation based on set theory and represents it visually through Venn diagrams. These concepts are discussed in the following sub-sections.

2.3.1. Semiotics

The field of semiotics involves several concepts. We will discuss three approaches to semiotics. Firstly, Umberto Eco (U.Eco, 1976.) focuses on the semiotics of communication, defining "*a communicative process as the passage of a signal (not necessarily a sign) from a source (through a transmitter, along a channel) to a destination*." This view will be used to analyze patents as a message divided into message sub-sections with specific functions, as it will be discussed in chapter 6.

The second standpoint is that communication in Peircean semiotics is divided into Syntax, Semantics and Pragmatics (J.J.Liszka, 1996) (J.Zeman, 1977) (U.Eco, 1976b) (C.W. Morris, 1938) (J.F. Sowa, 2000) (I. Skoczeń, 2016) (S.C. Levinson, 1983) (C.K. Ogden and I.A. Richards, 1923). Syntax deals with patterns of formation of sentences and phrases from words. Semantics studies the meaning of words (signs). Pragmatics can be considered as accessory information to a message, which facilitates the correct interpretation in a given context.

The third standpoint is the Peircean triad of interrelated concepts of interpretant, sign-vehicle, and referent. Ogden and Richards presented a view of semiotics based on the meaning triangle (which dates back to ancient Greece) where a set of signs (words, phrases) relate abstract concepts in the mind (of a reader/writer/listener/speaker) to physical objects in the world (C.K. Ogden and I.A. Richards, 1923). Figure 2.1 presents a meaning triangle for a cat named Yojo J.F. (Sowa, 2000) (C.K. Ogden and I.A. Richards, 1923) (B.Carter and D.Knight, 2008), where the name Yojo (sign) can bring to the mind of the caretaker the concept (mental image of Yojo) of the cat it refers to (the object, i.e., the physical cat). Notice that in Figure 2.1,

the mental image of Yojo, denoted as Concept, corresponds roughly to both Peirce´s interpretant notion as well as to Saussure´s signified notion. Similarly, the name Yojo, denoted as Sign in Figure 2.1, corresponds to both Peirce´s sign-vehicle notion as well as to Saussure´s signifier notion. Finally, the object (i.e., the real cat) in Figure 2.1 corresponds to Peirce´s referent notion, which is not contemplated by Saussure (K.M. Collins, 2010).

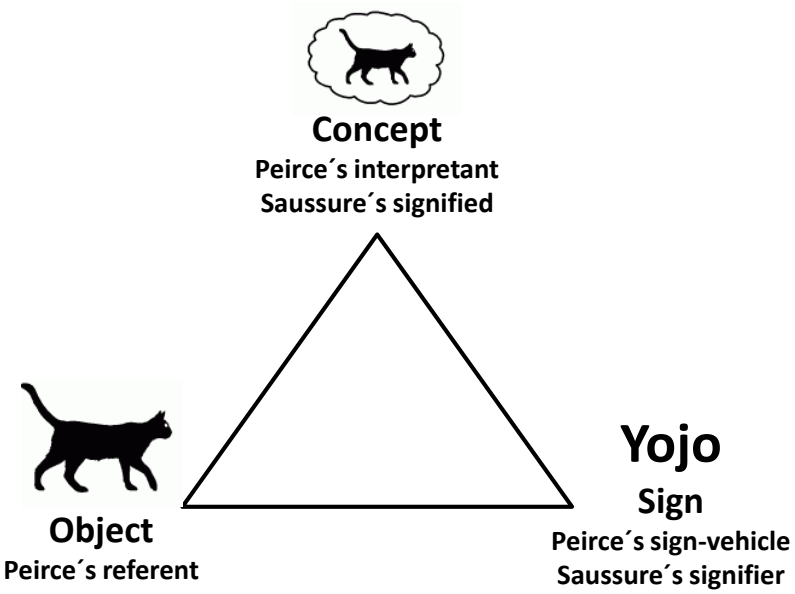


Figure 2.1: Meaning Triangle: semiotics is based on viewing language as a set of signs (words, phrases) that can relate an abstract concept in the mind (of a reader/writer/listener/speaker) with an object that exists in the physical world.

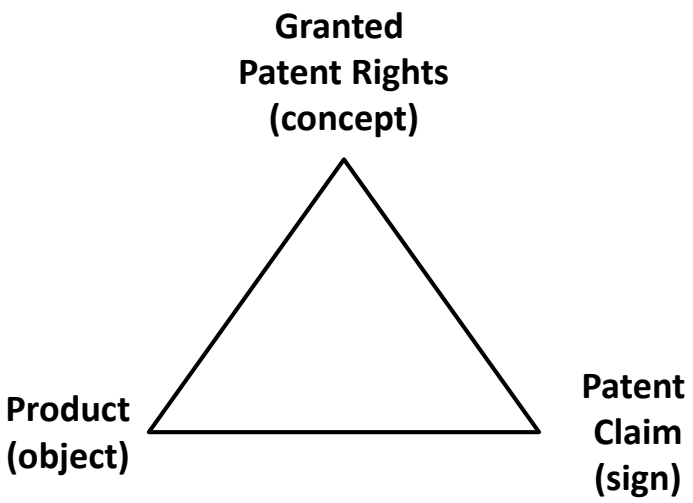


Figure 2.2: Meaning Triangle for patents: semiotics, a patent is a signs (made of words, phrases and drawings) that can relate an abstract concept in the mind (the granted patent rights) with an object that exists in the physical world (a product).

Figure 2.2 shows a meaning triangle adapted for patents, where a patent claim is a sign that expresses a patent right. This notion is further detailed in Figure 2.3, for a T-shirt patent. The patent claim is a complex sign, a single phrase composed of several words. It requires much effort to make a patent interpretation that can be used to form a mental image of the property right (concept) granted by a patent claim. Once this mental image of the granted patent right is (correctly) formed, it is possible to determine if a product (object) is covered or not by the patent claim. However, a patent is a message that is broader than its claims, as presented in Figure 2.4. A patent document is a message, describing several inter-related rights, one for each claim as a sign. In this work we investigate as the claims (viewed as signs) are interpreted in the broader scope of a patent (as a message, containing the signs).

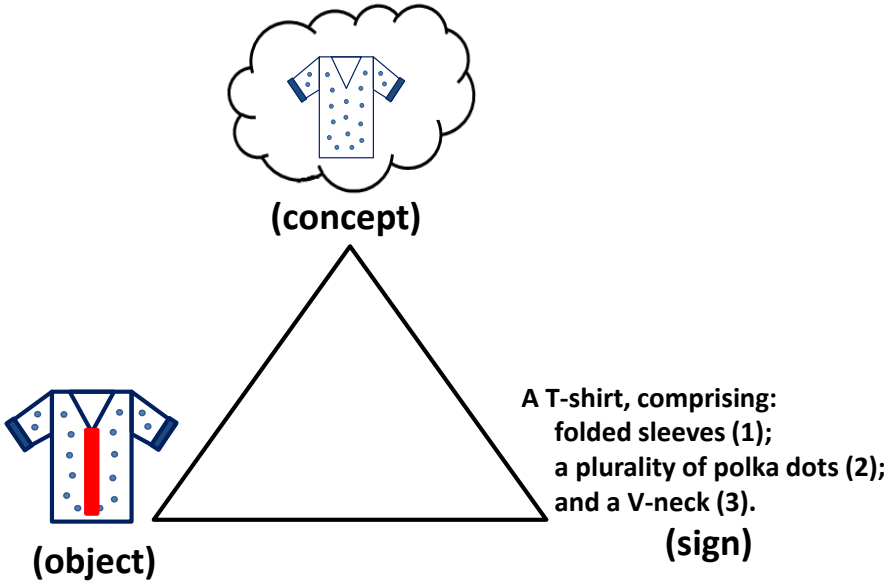


Figure 2.3: Meaning triangle for a T-shirt patent: Patent claim as a sign.

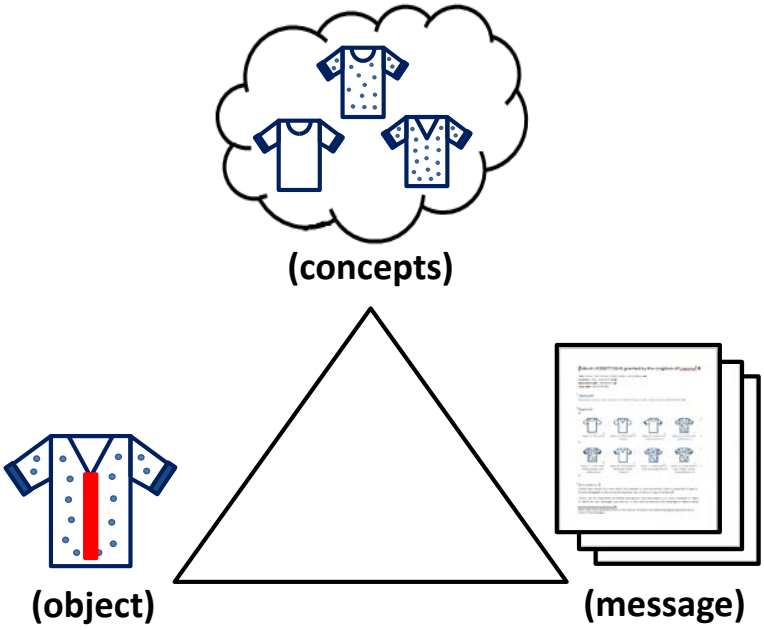


Figure 2.4: Meaning triangle for a T-shirt patent: Patent as a message containing several concepts (claims).

2.3.2. Patent as a Right and as a Communication of Knowledge

The idea of a patent as a message is very present in the patent system, as illustrated in Figure 2.5. The patent legislation principle is that an inventor discloses some knowledge to the society, and in return, the inventor receives some property rights as a reward for teaching the society how to do something useful and new (A.I. Reis and R.G. Fabris, 2009).

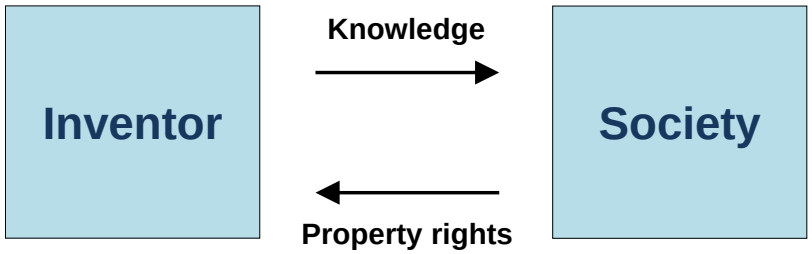


Figure 2.5: The principle of patent legislation: rewarding inventors for knowledge disclosure.

It is important to notice that the communication depicted in Figure 2.5 occurs through the patent document as a message. Therefore, the patent document has a double purpose. The first purpose of a patent document is to communicate some knowledge from the inventor to the society in such a way that members of this society can understand and reproduce the know-how that is disclosed by the inventor. The second purpose of a patent document is the statement of the patent rights granted to the inventor. These rights are an award for the inventor, but also a public document that communicates to the entire society the rights that have been granted to the inventor (A.I. Reis and R.G. Fabris, 2009) (S. R. N. Reis and A. I. Reis, 2013).

A patent is an intellectual property right that grants exclusivity to the patent owner. Patent rights are described with words and drawings (S. R. N. Reis and A. I. Reis, 2013). Patent interpretation (E.Manzo, 2014) consists in determining whether a product is covered or not by a patent, through comparing: (1) a given product against the (2) description provided by the

words and drawings in the patent. The result of patent interpretation can thus have two issues. It can be decided that the patent covers a certain product, and therefore the patent owner has exclusivity rights for the product. Alternatively, it can be decided that the patent does not cover the product and therefore the patent owner has no saying about commercial aspects involving the product.

2.3.3. The Structure of a Patent

A patent document typically has four sections: abstract, description, drawings and claims (S. Ramakrishna and A.Paschke, 2014). In this sense, the message communicated between the society and the inventor is divided into four sub-sections. These sub-sections have different functions in the communication process, so it may be preferable, or even necessary, to communicate specific signals through specific sub-sections.

The claim sub-section determines the coverage of patent (E.Manzo, 2014) (P.Corcoran, 2015) (M.I.Rackman, 1978) (P.Emma, 2005) (K.Osenga, 2006). For this reason, our study will center on patent claims. Patent claims are interpreted with the so-called all-element rule (S.-J. Wang, 2008) (R. Schechter, J. Thomas, 2007) that states that a product is covered by a patent when the product contains all the elements recited in at least one of the claims of the patent. Wang (S.-J. Wang, 2008) describes how to legally avoid patent infringement, based on claim interpretation and explicitly describes the all-elements rule. The all-element rule is also explicitly described in the work of Schechter and Thomas (R.Schechter, J.Thomas, 2007). The need for the all-elements rule arises from the fact that patent law in itself is vague, as laws are many times designed to be vague (T. Endicott, 2011) (S. Ramakrishna and A.Paschke, 2014) (S. Ramakrishna, 2013). For instance, according to Ramakrishna and Paschke (S. Ramakrishna and A.Paschke, 2014): "*In general, laws are designed to be vague. Their vagueness is to accommodate different possible scenarios under which a law can be applied*". For this reason, Ramakrishna and Paschke (S. Ramakrishna and A.Paschke, 2014) (S. Ramakrishna, 2013) introduced Elementary Pragmatics (EPs) to deal with norms/precedents/guidelines as accessory

information to patent law. The all-element rule is not a law, but is an important accessory rule in patent law.

The patent structure is typically divided into four sections: abstract, description, drawings and claims, as illustrated in Figure 2.6. Although the patent application is a message from a semiotics perspective, this message is divided into four sub-sections with specific functions. The abstract sub-section has the purpose of making the patent more easily retrievable in databases. In this sense, the abstract has no legal consequences in the legal coverage of the patent. The claim sub-section in the patent request describes what the inventors expect to be covered, i.e., legally protected, by the patent. Ultimately, it is the claim sub-section that communicates the legal rights granted through the patent. The remaining two sub-sections (description and drawings) have an auxiliary role in understanding the content of the claims. The claims must be understood with the help of the description and drawings.

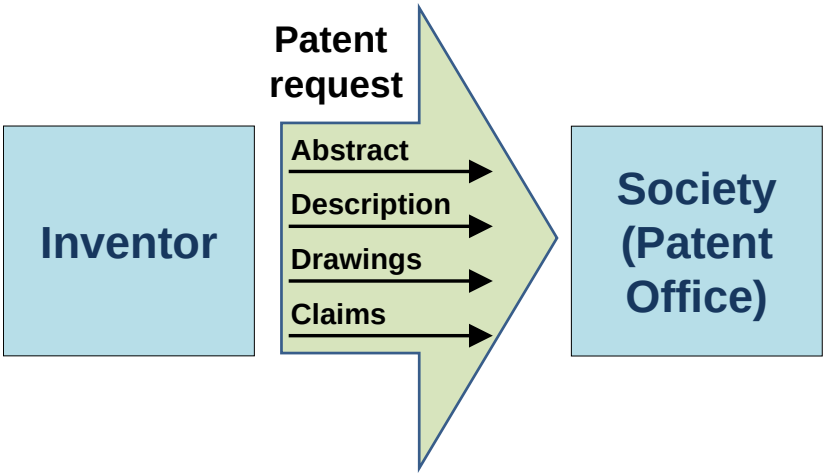


Figure 2.6: A patent application is divided in four sections: Abstract, description, drawings and claims.

2.3.4. Set Theory

Set theory has many applications; it is able to describe membership of elements to a set (H.Parks et al, 2000). A given element *e* can belong to a set or it may not belong to the set. For instance, if an element *e* belongs to a set *S*, we write $e \in S$. If an element *e* does not belong to a set *S*, we write $e \notin S$. A convenient concept in set theory is the concept of universal set, i.e. the set of all existing elements. In the next sub-section we further explain set theory by visually representing operations between sets using Venn diagrams.

2.3.5. Venn Diagrams

Venn diagrams are a graphical representation of sets, which include the notions of elements pertaining or not pertaining to a set (F.Ruskey and M.Weston, 1997). For instance, Figure 2.7 shows two sets S1={e2, e3} and S2={e3, e4} with a common element e3. In this case we say that the intersection between S1 and S2 is $S1 \cap S2 = \{e3\}$. Figure 2.7 also illustrates an element e1 such that $e1 \notin S1$ and $e1 \notin S2$. Obviously, $e1 \in U$, where U is the Universal set.

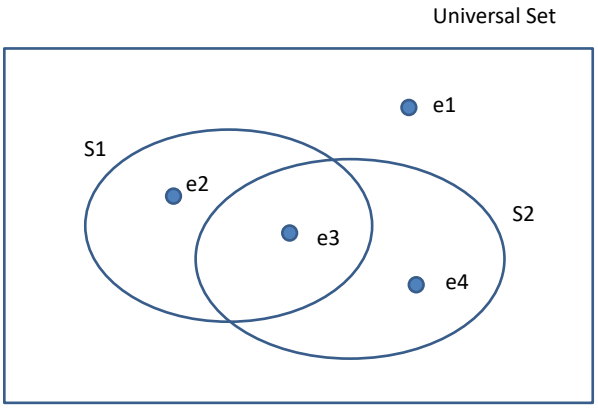


Figure 2.7: Two sets S1={e2, e3} and S2={e3, e4} with a common element e3.

Figure 2.8 illustrates an additional (and different) example of Venn diagram where sets S1={e2, e3, e4} and S2={e3, e4} are in a configuration where S1 contains S2, which is expressed by S1 $\supset$ S2. It is also possible to say that S2 is contained by S1, which is expressed by S2 $\subset$ S1. Figure 2.8 also illustrates an element e1 such that $e1 \notin S1$ and $e1 \notin S2$. Obviously, $e1 \in U$, where U is the Universal set. When a set S1 contains another set S2, it can be said that S2 is a subset of S1. In this sense, both S1 and S2 are subsets of the universal set. This can be represented as S1 $\subset$ U and S2 $\subset$ U.

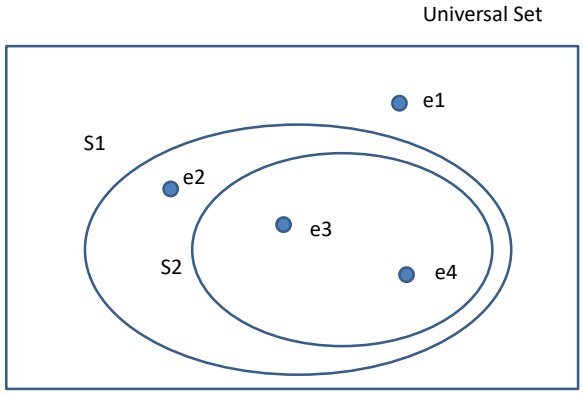


Figure 2.8: Two sets S1={e2, e3, e4} and S2={e3, e4}, such that S1 $\supset$ S2.

2.4. Visualizing Patent Coverage with Sets and Venn Diagrams

In this thesis, patent coverage is represented by using Venn diagrams. The basic idea is shown in Figure 2.9, where patent coverages are represented as sets. Figure 2.9 illustrates a universal set with eight elements and three subsets C1, C2 and C3. The C1 subset is the broader subset, with five elements. The subset C3 is the narrower subset, with two elements. The subset C2 has three elements. The subsets were named C1, C2 and C3 as a patent will normally consist of several claims, with individual coverage for each claim. This means, each claim will correspond to a subset of the universal set. Additionally, in many cases, there will be a containment relationship among the claims. For instance, in Figure 2.9, the relationship C1 $\supset$ C2 $\supset$ C3 is observed. This means that claim C1 is the broader claim, such that claim C2 is a subset

of claim C1 (i.e. C1 ⊃ C2) and also claim C3 is a subset of claim C1 (i.e. C1 ⊃ C3). Additionally, claim C3 is a subset of claim C2 (i.e. C2 ⊃ C3).

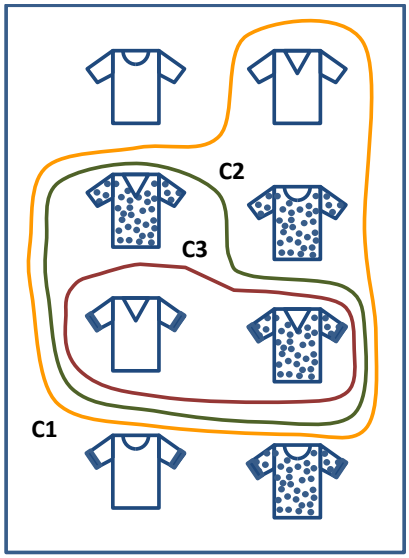


Figure 2.9: Illustrating patent coverage with Venn diagrams.

The point we are making in this section is that the relationship among claims can be represented visually with Sets and Venn diagrams. The visualization of the relationship among claims with Venn Diagrams was initially exploited by Brainard (T.D. Brainard, 2000), without considering the all-element rule. I recently discovered that Prof. Pascual Segura makes use of Venn diagrams to teach patent drafting in courses offered in Spain. Indeed, Prof. Segura was kind enough to share with us a manuscript that was intended for WIPO but remained unpublished and that is extensively used in his courses on patent drafting (P.Segura, 2019). Compared to Brainard, Prof. Segura makes use of the all-element rule to justify the relationship among different claims of a patent.

On the topic of representing patent coverage with the help of Venn diagrams, a more in depth analysis is made in my thesis. The proposed approach considers that patent claims are made of words and words define sets. In the chapter 6 we will discuss: (1) how a property expressed through words define sub-sets of a set (section 6.3); and (2) how the legal rule

known as the all-element rule is commonly used to interpret patent claims based on the properties listed in each claim (section 6.5).

2.5. Law and the Semantic Web

The work of Casanovas, Pagallo, Sartor and Ajani list the following three characteristics as focus for the development of the area of law and the semantic web: (i) language and complex systems in law; (ii) ontologies and the representation of legal knowledge; (iii) argumentation and logics (P.Casanovas et al, 2010) (U.Pagallo et al, 2018). These concepts permeate this thesis, leading to a better understanding and interpretation of patents. An example of language and complex systems is the semiotic approach for patent interpretation as well as the derivation of visualization of patent coverage for different claims by using Venn diagrams and set theory, as discussed in the chapter 6. The representation of legal knowledge focusing on patent claims presented in chapter 10 can be considered a contribution to ontologies and the representation of legal knowledge. Chapter 5 presents a contribution for argumentation and logics in the legal domain, by modeling the all-element rule (chapter 4) in two different types of logic: Description Logic and Deontic Logic.

2.6. Contributions of this chapter

In this chapter the basic concepts necessary to understand this thesis were presented. Next chapter will present a review of the legal system for patents.

3. A Review of the Legal System for Patent Law

3.1. About this Chapter

This chapter discusses patent law in different countries. A review of patent law agreements among countries is also presented.

3.2. Vagueness and Law

Law is part of human communication, and like any other form of human communication, it carries a certain level of vagueness (T. Endicott, 2011) (V.M. Colapietro, 1988) (S. Ramakrishna and A.Paschke, 2014). According to Endicott (T. Endicott, 2011), "law certainly is something that can be communicated by the use of signs. If it were not so, then the law would be incapable of ruling the life of the community. What is more, law is something that actually is communicated." Additionally, S.Ramakrishna and A.Paschke state that "In general, laws are designed to be vague (S. Ramakrishna and A.Paschke, 2014). Their vagueness is to accommodate different possible scenarios under which a law can be applied". In order to reduce this level of ambiguity, effective means of interpretation or clarification are necessary. In this sense, Endicott also highlights that "a community can only achieve the rule of law if its institutions communicate standards for the life of the community that are not too vague for their purposes."

In the specific case of patent interpretation, the international community (WIPO, 2019a) is starting to rely more and more upon the so-called all-element rule for patent coverage interpretation (S.-J. Wang, 2008) (R. Schechter, J. Thomas, 2007). This rule is not part of the law

itself, but it serves as pragmatics for the patent law, explaining how patent coverage should be determined.

The legal system for intellectual property is mostly based on common law, i.e. important decisions on how to interpret patent claims come from judge decisions, not from statutory law (A.L.Durham 2004). This is observed by Nard (Nard 2010) in the case of USA patent law:

> "It should therefore come as no surprise to learn that a significant portion of U.S. patent law, including some of the most important and controversial patent law doctrines, is either built upon judicial interpretation of elliptical statutory phrases, or is devoid of any statutory basis whatsoever. Thus, while Congress and the courts each have a hand in constructing the latticework of patent law, judges – not the authors of Lex scripta – are the principal architects." (Nard 2010)

In the following sections we describe intellectual property law, mainly from a statutory point of view. We start by discussing the global legal framework and actors, and then we discuss specific countries and cooperation treaties.

3.3. Global Legal Framework and Actors in Patents

Patent law is essentially a national right. Patents are granted by individual countries to be valid on their territory. For instance, in the case of Spain, the Spanish Civil Code, established by the Real Decree of July 24th 1889 (Spain, 1889) states in the Chapter IV, Article 10 of the Private Norms of International law that the industrial and intellectual property rights will be protected inside Spanish territory in accordance with Spanish Law, without prejudice of the established by international treaties. The original text in Spanish and the translated text in English are shown in Table 3.1.

Table 3.1: Real Decree of July 24th 1889 (Spain, 1889), concerning intellectual and industrial property rights.

Original Spanish Text From (Spain, 1889)	Version translated to English by the author
4. Los derechos de propiedad intelectual e industrial se protegerán dentro del territorio español de acuerdo con la ley española, sin perjuicio de lo establecido por los convenios y tratados internacionales en los que España sea parte.	4. The intellectual and industrial property rights will be protected within the Spanish territory under Spanish Law, notwithstanding the provisions of international conventions and treaties to which Spain is a party".

As an essentially national right, a patent granted by any country is therefore not enforceable outside its own territory. In order to provide regulation for patent application and analysis made simultaneously in multiple countries, cooperation treaties exist among countries. However, the final patents are granted by each country, possibly with different final claims in distinct countries. The differences could come from variations in the specific law, and also due to distinct examination processes. Additionally, the individual country patents are only enforceable separately in the country they were granted, through national tribunals.

Each country has a patent office, responsible for registering and concession of different types of industrial property. For instance the Brazilian patent office is the INPI - Instituto Nacional da Propriedade Industrial; while the Spanish patent office is the OEPM - Oficina Española de Patentes y Marcas. Agreements among countries can lead to the establishment of a supra-national patent office. One example is the EPO – European Patent Office, which is a regional patent office corresponding to the agreement among European countries. Another example is the WIPO – World Intellectual Property Organization, which is a self-funded agency of the United Nations that acts as an international patent office associated to the PCT – Patent Cooperation Treaty and the Paris Convention for the Protection of Industrial Property. The PCT agreement includes 152 countries from all continents (considering May 2019). In the remainder of this section, the patent Law of several individual countries will be discussed, followed by a presentation of the different agreements existing among countries.

3.4. Patent law in different countries

This section discusses patent law in different countries. We discuss the patent law of Spain, Brazil, USA, Australia and Canada. Special emphasis is given for the text of the law regulating patent claims.

3.4.1. Patent Law in Spain

The OEPM (Oficina Española de Patentes y Marcas, which translates in English as Spanish Office of Patents and Trademarks), established by the Law 17/1975 (Spain, 1975), is the public office from the Spanish government that is responsible to register and grant different types of industrial property. The main laws that establish industrial property rights in Spain are discussed in the following.

In the beginning of the work for this thesis, the main law regarding industrial property in Spain was the Law 11/1986, from March 20th (Spain, 1986a). The Law 11/1986 is regulated by the Real Decree 2245/1986 (Spain, 1986b), from October 10th, which approves the rules for the execution of the Law 11/1986, concerning patents. Patent law in Spain changed during the work of this thesis, as the old law from 1986 (Spain, 1986a) was valid only until March 31st 2017. On April 1st 2017 the new law 24/2015, from July 24th (Spain, 2015) entered into effect.

Concerning patent protection both the old law 11/1986 (Spain, 1986a) and the new law 24/2015 (Spain, 2015) state with exactly the same words that:

> "The claims define the object for which protection is requested. The claims must be clear and concise and they must be based on the description." (Law 11/1986, Article 26th) (Law 24/2015, Article 28th)

This article state that the claims define the object for which protection is requested (and granted, when the patent is issued), meaning that the scope of protection of a patent is given by the claim section of the patent. The article further states that the claims must be based in the description section of the patent. As already discussed in chapter 2, a patent document is generally divided in four parts: abstract, description, drawings and claims. The above article states that the claims determine the object to be legally protected, and that the claims must be based on the description. This article has the goal to state that it is not possible to claim legal protection for and object that has not been detailed in the description section of the respective patent.

However, there are some differences between the two laws, concerning the scope of protection given by the claims. These differences are in the articles 60th of law 11/1986 (Spain, 1986a) and the article 68th of law 24/2015 (Spain, 2015).

The article 60th of Law 11/1986 (Spain, 1986a) was divided in two paragraphs and it stated that:

> "1. The extent of protection conferred by the patent or patent application is determined by the content of the claims. The description and drawings serve, however, to interpret the claims.
>
> 2. For the period before the granting of the patent, the extent of protection is determined by the claims of the application as it had been made public. This notwithstanding, the patent, as it has been granted, shall determine retroactively the protection referred to, provided that the protection has not been extended ."
>
> (Law 11/1986, Article 60th)

The first paragraph of this article stated that the extent of protection is legally given by the claims; the description section and the drawings section of a patent are used to interpret the claims and determine the scope of protection. This is standard in patent law, and similar texts appear for several distinct countries, as it will be seen later on. The second paragraph of the above article states that when the final granted claims have an extended scope of protection

with respect to the claims in the original application, the originally published claims with narrower scope of protection should be used to seek retroactive protection. This article has the goal to avoid that someone publish an application with narrow claims (that are not infringed by competition) while pursuing a patent with broad claims (that are indeed infringed by competition).

The correspondent article 68th of Law 24/2015 (Spain, 2015) is slightly modified and divided in three paragraphs. It states that:

> 1. The scope of the protection conferred by the patent or patent application is determined by the claims. The description and drawings serve to interpret the claims.
>
> 2. For the period prior to the granting of the patent, the scope of protection is determined by the claims of the application as it is published. This notwithstanding, the patent, as it has been granted or modified in the course of opposition proceedings , appeal, limitation or revocation shall determine retroactively the protection referred to, provided that the protection has not been extended.
>
> 3. To determine the scope of protection under paragraphs 1 and 2 above shall be duly taken into account all equivalent elements to one element indicated in the claims.
>
> (Law 24/2015, Article 68th)

The two first paragraphs from article 68th of Law 24/2015 are very similar to the two first (and only) paragraphs from articles 60th of law 11/1986. The third paragraph is a little bit vague, as it mentions elements in the claims, which are not described in the law. However, we believe that it refers to the so-called Doctrine of Equivalents , and this opinion is corroborated by the site Noticias Juridicas (Noticias Juridicas, 2015), which states:

> "Other smaller modifications consist in making explicit the reference to equivalent means in order to determine the extent of protection …" (Noticias Juridicas, 2015)

The doctrine of equivalents is applied in conjunction with the all-element rule in order to determine the extent of protection of a single claim. The new law 24/2015 tries to incorporate

the doctrine of equivalents, but it makes no clear statement of the all-element rule. Both the doctrine of equivalents and the all element rule will be further discussed in chapter 4.

3.4.2. Patent Law in Brazil

The INPI (Instituto Nacional de Propriedade Industrial, which translates in English as National Institute of Industrial Property), established by the Law 5.648, of December 11th 1970 (Brazil, 1970), is the public office from the Brazilian government that is responsible to register and grant different types of industrial property.

The main law regarding industrial property in Brazil is the Law (Brazil, 1996). In the following we discuss excerpts concerning claims and the scope of protection determined by this law. The Article 25th of the law states that:

> "The claims must be based on the descriptive report, characterizing the particularities of the (patent) request and defining, in a clear and precise way, the object matter of the protection ." (Lei Nº 9.279, de 14 de maio de 1996, Article 25th)

This article states that the claims define the object matter for which the patent protection is requested, in the Brazilian law. Additionally, it states that the claims must be based on the descriptive report section of the patent, meaning that something that has not been described in the descriptive report section of the patent cannot be claimed.

> "The extent of the protection granted by the patent will be determined by the content of the claims, interpreted having as support the descriptive report and the drawings ." (Lei Nº 9.279, de 14 de maio de 1996, Article 41st)

This article states that the extent of protection granted by the patent is determined by the claims. Also, it states that the claims should be interpreted with the help of the descriptive report section and the drawings section of the patent.

It is important to notice that patent law is common law, as stated by Nard (Nard 2010) for the US case. Therefore, claim interpretation under Brazilian law should also rely on judiciary practice and decisions, as the Law 5.648, of December 11th, 1970 (Brazil, 1970) does not provide sufficient detail for claim interpretation. The information on how patent claims are interpreted in Brazil can be found in law compendiums such as the "Patent Claim Interpretation – Global Edition", edited by Edward D. Manzo (E.D.Manzo, 2014). The PhD dissertation by R.G. Fabris (R.G.Fabris, 2012) can be another source of information on Claim interpretation under Brazilian Law. Concepts like broader and narrower coverage are not directly specified in the law, which let some questions open for research, as it will be discussed in chapter 6.

3.4.3. Patent Law in USA

The USPTO (United States Patent and Trademark Office), established by the United States Code Title 35 – Patents (USA, 2019), is the public office from the United States government that is responsible to register and grant different types of industrial property, including patents.

The main Law governing patents in the United States is the United States Code Title 35 – Patents (USA, 2019). In the following we discuss some excerpts of this law.

First, we highlight that 35 U.S.C. 112(a) (applicable to applications filed on or after September 16, 2012) provides:

> "(a) IN GENERAL.—The specification shall contain a written description of the invention, and of the manner and process of making and using it, in such full, clear, concise, and exact terms as to enable any person skilled in the art to which it pertains, or with which it is most nearly connected, to make and use the same, and shall set forth the best mode contemplated by the inventor or joint inventor of carrying out the invention". (35 U.S.C. 112 Specification, paragraph a).

Notice that what the law calls specification is the concept of descriptive section in this thesis. The previous paragraph states that the descriptive section (called specification) should clearly describe (i.e., it is a descriptive section indeed) what the invention is, how to make and use it, and should also describe the best mode of use known by the inventor. The main point here is that the specification mentioned by USA law (USA, 2019) is not a different concept compared to the description section that we mention as one of the sections of a patent.

The paragraph (b) of 35 U.S.C. 112 states that:

> "(b) CONCLUSION.—The specification shall conclude with one or more claims particularly pointing out and distinctly claiming the subject matter which the inventor or a joint inventor regards as the invention."
>
> (35 U.S.C. 112 Specification, paragraph b).

This paragraph states that the description or the descriptive report section, named here as the specification must be concluded by a claim section. The claim section should state clearly what the inventors regard as the invention. Again in US law (USA, 2019), as it was the case for Spain and Brazil, the extent of the protection is determined by the claim section.

> (d) REFERENCE IN DEPENDENT FORMS.—Subject to subsection (e), a claim in dependent form shall contain a reference to a claim previously set forth and then specify a further limitation of the subject matter claimed. A claim in dependent form shall be construed to incorporate by reference all the limitations of the claim to which it refers.
>
> (35 U.S.C. 112 Specification, paragraph d).

This paragraph has two interesting features. The first one is that it defines dependent claims and how they should be interpreted. The second one is that it refers to elements of the invention listed in the claims with the word "limitation". This is a very wise word choice as it somehow provides the legal support for the all-element rule.

3.4.4. Patent Law in Australia

The IP Australia is the public office from the Australian government that is responsible to register and concession of different types of industrial property. The main Australian Law governing patents is the Patents Act 1990 (Australia, 1990). Concerning claims, Australian Law defines that the invention is defined by the claims as stated by Division 2 – 40th Article defining the specification section of an Australian patent:

> "(2) A complete specification must:
> (a) disclose the invention in a manner which is clear enough and complete enough for the invention to be performed by a person skilled in the relevant art; and
> (aa) disclose the best method known to the applicant of performing the invention; and
> (b) where it relates to an application for a standard patent—end with a claim or claims defining the invention; and
> (c) where it relates to an application for an innovation patent—end with at least one and no more than 5 claims defining the invention.
> (3) The claim or claims must be clear and succinct and supported by matter disclosed in the specification.
> (3A) The claim or claims must not rely on references to descriptions or drawings unless absolutely necessary to define the invention.
>
> (Patents Act 1990, Division 2 – 40th Article)

The Australian Law has similarities with other cited countries, as the protected invention is defined by the claims. Additionally, the claimed invention should be supported by the specification section of the patent, meaning that what is not described in the specification cannot be claimed. Australia is currently in process of amending its law, through the Intellectual Property Laws Amendment Act 2015 (Australia, 2015).

3.4.5. Patent Law in Canada

The CIPO (Canadian Intellectual Property Office) is the public office from the Canadian government that is responsible to register and grant different types of industrial property. The main Canadian Law governing patents is the 1985 Patent Act amended in 2018 and updated online in 2019 (Canada, 2019), which states that:

> "(4) The specification must end with a claim or claims defining distinctly and in explicit terms the subject-matter of the invention for which an exclusive privilege or property is claimed." (Patent Act 1985, Article 27th , paragraph 4).

Again, the subject matter of the invention is defined by the claim section. This is the only section of the law describing what subject matter is covered by the patent.

3.5. International Cooperation Agreements

In this section we discuss international cooperation agreements in the field of patent law. Agreements discussed include European patents, the Paris Convention and the Patent Cooperation Treaty. European patents are managed by the European Patent Office (EPO, 2019), while the Paris Convention and the Patent Cooperation Treaty are administered by the World Intellectual Property Organization - WIPO (WIPO, 2019a).

3.5.1. Patent Law in Europe

The European Patent Convention (EPC) was signed on 5 October 1973, by 16 European countries. The EPC came into effect in 1977, allowing applicants to file a single patent application with the EPO that, if granted, is applicable in all the member states that they choose. Member states retain the right to enforce and revoke individual patents. Until now, a

patent granted by the EPO does not lead to a single European patent enforceable before one single court, but rather to several essentially independent national European patents that can be enforced through national courts according to different national legislations and procedures. The patent claims could be potentially different, according to national laws. This way, the EPO only facilitated application procedures; the individual country laws still defined how claims would be interpreted. However, this situation is changing, as the EPO is changing towards having European Patents that will be enforceable through a European Patent court, yet to be created. The European Parliament approved such move, but final regulations are still being discussed.

The most recent version of the European Patent Convention is the European Patent Convention, 16th edition from June 2016 (EPO, 2016). Concerning claims and the extent of protection, the European Patent Convention says:

> "(1)The extent of the protection conferred by a European patent or a European patent application shall be determined by the claims. Nevertheless, the description and drawings shall be used to interpret the claims."
>
> European Patent Convention, Article 69, Extent of protection.

3.5.2. Paris Convention

The Paris Convention (Paris Convention, 1883) is an agreement among several different countries, concerning patents. The main point of the agreement is that once a patent is applied in one member country, the inventor has 12 months to apply the patent in other member countries. The agreement does not interfere on claim evaluation and interpretation according to the law of each country. The Paris Convention is administered by WIPO (WIPO, 2019a).

3.5.3. Patent Cooperation Treaty

The PCT (Patent Cooperation Treaty) is also an agreement among several different countries, concerning patents. The PCT agreement (PCT, 1970) introduced the figure of an international search with an associated written opinion and also an international preliminary exam. The search and the preliminary exam focus on determining the novelty and the inventive activity of the invention. Claims are still judged by each country individually, according to its own national laws. Similarly to the Paris Convention, the PCT agreement does not interfere on claim evaluation and interpretation according to the law of each country. The PCT agreement offers more time to apply the patent in different countries: once a patent is applied in one member country, the inventor has 30 months to apply the patent in other member countries. The PCT agreement is administered by WIPO (WIPO, 2019a).

3.6. Contributions of this chapter

This chapter presented a review of patent law in different countries. However, patent interpretation is mainly based on the all-element rule. Next chapter will discuss this rule, due to its importance in general and for this thesis.

4. The all-element rule

4.1. About this Chapter

In this chapter, the all-element rule is discussed. It is important to say that the legal system for intellectual property is mostly based on common law, i.e. important decisions on how to interpret patent claims come from judge decisions, not from statutory law (A.L.Durham, 2018). One example of important accessory pragmatic information for patent law is the so-called all-element rule, which describes how to determine if a patent is infringed. The basic idea of the rule is that a product infringing a patent must present all elements (features) recited in a patent claim.

This chapter is organized as follows. Section 4.2 presents a small bibliographical review. Section 4.3 discusses different properties or features of objects. Different meanings that the word element can assume are highlighted in Section 4.4. The structure of a patent claim is presented in Section 4.5. The all-element rule is then discussed in Section 4.6.

4.2. Bibliographical Review

Patent claims are interpreted with the so-called all-element rule (S.-J. Wang, 2008) (R. Schechter, J. Thomas, 2007) that states that a product is covered by a patent when the product contains all the elements recited in at least one of the claims of the patent. Wang (S.-J. Wang, 2008) describes how to legally avoid patent infringement, based on claim interpretation and explicitly describes the all-elements rule. The all-element rule is also explicitly described in the work of Schechter and Thomas (R.Schechter, J.Thomas, 2007). The need for the all-elements rule arises from the fact that patent law in itself is vague, as laws are many times designed to be vague (T. Endicott, 2011) (S. Ramakrishna and A.Paschke, 2014) (S. Ramakrishna, 2013). For instance, according to Ramakrishna and Paschke (S. Ramakrishna and A.Paschke, 2014): “In

general, laws are designed to be vague. Their vagueness is to accommodate different possible scenarios under which a law can be applied". For this reason, Ramakrishna and Paschke (S. Ramakrishna and A.Paschke, 2014) (S. Ramakrishna, 2013) introduced Elementary Pragmatics (EPs) to deal with norms/precedents/guidelines as accessory information to patent law. The all-element rule is not a law, but is an important accessory rule in patent law.

4.3. Different properties of objects

Objects can present different properties. For instance, T-shirts may present different properties. Figure 4.1 illustrates a T-shirt with three physical highlighted properties that can be described using words as: folded sleeves (1), polka dots (2) and V-neck (3). Notice that each of these properties may be individually present or absent in a specific T-shirt.

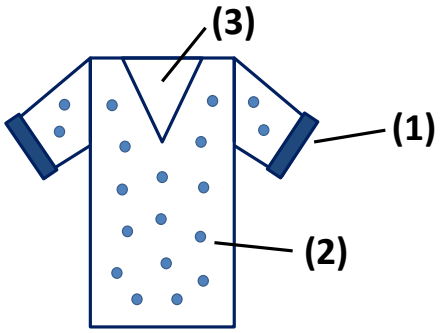


Figure 4.1: A T-shirt with folded sleeves (1), polka dots (2) and V-neck (3).

4.4. Different meanings of the word element

The previous section introduced set theory and the associated nomenclature used by the set theory community. In the remainder of the paper we will apply concepts of set theory to the interpretation of patent claims, considering the concepts from the patent law community. Unfortunately, these two communities have different concepts associated to the word element.

For this reason, we will use the names set-element (definition 4.1) and claim-element (definition 4.2) so that we avoid confusion between the two definitions of element.

Definition 4.1: A **set-element** (Set Theory Community) is a member of a set.

Example 4.1: Considering Figure 4.2, e3 is both an element of sets S1 and S2.

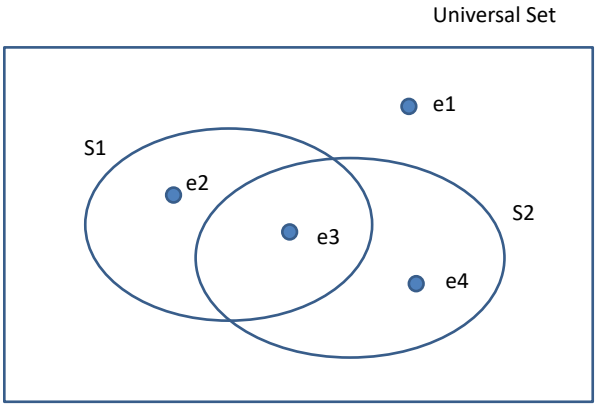


Figure 4.2: Two sets S1={e2, e3} and S2={e3, e4} with a common element e3.

Definition 4.2: A **claim-element**[1] (Patent Law Community) is a constructive property that may be present in an object.

Example 4.2: Figure 4.1 illustrates folded sleeves (1), polka dots (2) and V-neck (3) as possible claim-elements, i.e. constructive properties (definition 4.2) of T-shirts. Notice that according to Figure 4.3, the subset of T-shirts with folded sleeves is composed of four T-shirts that are set-elements (definition 4.1) of a subset.

[1] Better named as **property**, instead of element. However, the name element is well established in the patent law community.

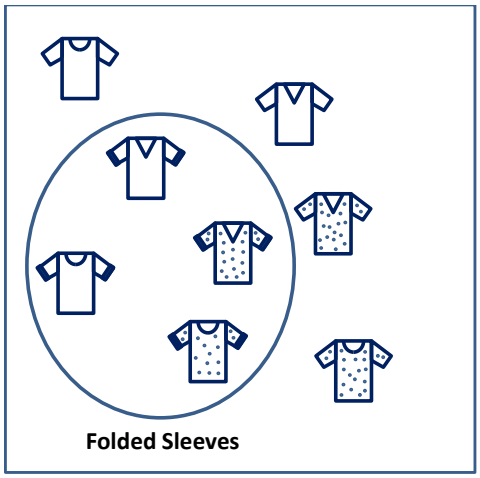


Figure4.3: The subset of T-shirts with folded sleeves.

4.5. The structure of a patent claim

The internal phrasal structure of a patent claim must follow a well-defined pattern, according to the World Intellectual Property Organization (WIPO). This structure is discussed in the WIPO Patent Drafting Manual (WIPO, 2019b). The general structure is shown in Figure 4.4(a), while an example is shown in Figure 4.4(b). The general structure of a patent claim consists of (i) a preamble, (ii) a transitional phrase (or transition) (iii) and the body of the claim, which recites one or more claim-elements.

Preamble, transition:	An apparatus, comprising:
Claim-element (#CE1);	a plurality of printed pages;
Claim-element (#CE2); and	a binding configured to hold the printed pages together; and
Claim-element (#CE3).	a cover attached to the binding.
(a) general structure	*(b) one example*

Figure 4.4: The structure of a patent claim, according to WIPO (WIPO, 2019b).

The preamble defines the nature of the invention being claimed. For instance, it might be common to have almost identical claims in a single patent where the only distinction is the preamble. It would be possible for a patent to claim very similar inventions in the form of a

method, an algorithm or a computer program, just by having claims with different preambles. From a patent drafting point of view, most patent offices worldwide require the preamble to be separated from the transition by a comma, as shown in Figure 4.4. The remainder of our discussion will be based on the properties (or claim-elements) presented in Figure 4.1, for didactic reasons. This way, we rephrased the apparatus claim from Figure 4.4(b) into a T-shirt claim with a similar structure, as shown in Figure 4.5(b). The structure of a patent according to WIPO (WIPO, 2019b) is shown both in Figure 4.4(a) and Figure 4.5(a), to emphasize that the claims in Figure 4.4(b) and in Figure 4.5(b) have the same structure.

Preamble, transition: Claim-element (#CE1); Claim-element (#CE2); and Claim-element (#CE3).	A T-shirt, comprising: folded sleeves (1); a plurality of polka dots (2); and a V-neck (3).
(a) general structure	*(b) one example*

Figure 4.5: The structure of a patent claim, according to WIPO (WIPO, 2019b) and an example using the properties illustrated in Figure 4.1.

The transitional phrase determines the relationship among the claim-elements of the body and the nature defined by the preamble. Both in the example of Figure 4.4(b) and Figure 4.5(b), the transition is the verb *comprising*. Notice that from a punctuation point of view as advised by WIPO (WIPO, 2019b), the transition is separated from the preamble by a comma and separated from the body by a colon.

The body of the claim consists of one or more claim-elements and the relationship among them. In the example of Figure 4.4, the body of the claim consists of three distinct claim-elements: CE1 (a plurality of printed pages); CE2 (a binding configured to hold the printed pages together); and CE3 (a cover attached to the binding). In the example of Figure 4.5, the body of the claim consists of the three claim-elements for T-shirts illustrated in Figure 4.1: CE1 (folded sleeves); CE2 (a plurality of polka dots); and CE3 (a V-neck). The numbers inside parenthesis can be used to the claim elements as illustrated in a patent figure similar to Figure 4.1, which

illustrates the claim elements in this paper. This is how the connection between claim-elements and patent figures is usually done.

4.6. The all-element rule

The all-element rule is used to verify patent infringement. Basically, a claim of a patent is infringed by objects that contain all elements listed in the text of the claim.

Definition 4.3: The **all-claim-elements rule** states that an object is covered by a patent when the object physically presents all the claim-elements (definition 4.2) verbally recited in one of the claims of the patent.

Several different authors point to the all-element rule. For instance Prof. Pascual Segura relies on this rule to teach patent drafting (Segura, 2019). Wang describes how to legally avoid patent infringement, based on claim interpretation and explicitly describes the all-element rule (S.-J. Wang, 2008). The all-element rule is also explicitly described in the work of Schechter and Thomas (R. Schechter and J. Thomas, 2007).

4.6.1. Prevalence of the all-element rule

One could argue that the observations made herein rely on the all-element rule, and therefore are only valid in countries where such rule applies. We agree, and still our work is useful in several countries where it applies, notably the United States of America.

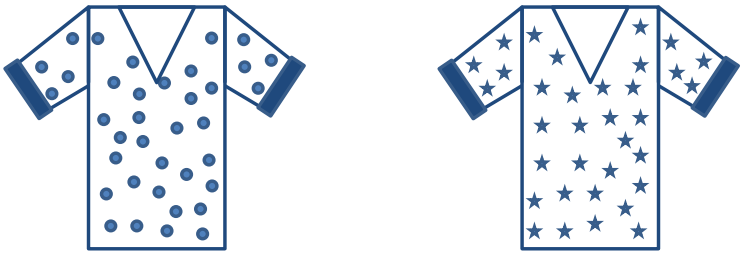
We also highlight that WIPO (World Intellectual Property Organization) makes extensive use of this rule, including in WIPO Patent Drafting Manual (WIPO, 2019b). We also know by the experience of some co-authors of this paper, that WIPO uses questions based on the all-element to test student knowledge on patent infringement and prior art.

Also, the Spanish patent law was recently modified and the new law includes a mention to claim elements that can be understood as an adoption of the all-element rule (Spain, 2015). For all these reasons, we believe that the all-element rule will be increasingly followed by European countries in the future. This way, we believe the all-element rule will be used in a larger number of national patent offices in the future, making the work presented here more relevant.

4.6.2. Doctrine of equivalents

The doctrine of equivalents says that regarding the analysis of infringement using the all-element rule, an object can infringe a patent claim if it contains elements that are either equal or equivalent to all elements listed in a claim. The Spanish law is being altered to include the doctrine of equivalents. The new Spanish law (Spain, 2015) explicitly says:

> 3. To determine the scope of protection under paragraphs 1 and 2 above shall be duly taken into account all equivalent elements to one element indicated in the claims .
>
> (Law 24/2015, Article 68th)



(a) Polka dot T-shirt *(b) Star dot T-shirt*

Figure 4.6: Two possibly equivalent T-shirts.

As an example of the doctrine of equivalents, consider the two T-shirts shown in Figure 4.6. The T-shirt from Figure 4.6(a) is covered by the claim in Figure 4.5(b). This happens because the

T-shirt in Figure 4.6(a) literally has all three elements listed in the claim: folded sleeves (1), polka dots (2) and a V-neck (3). In contrast, the T-shirt in Figure 4.6(b) does not present polka dots as an element, and in this sense it does not literally infringe the claim in Figure 4.5(b). However, under the doctrine of equivalents the star dots could be considered equivalent to the polka dots if they perform the same function on the invention. This way, a non-literal infringement could occur under the doctrine of equivalents, but only if the star dots are considered equivalent to the polka dots. In the case of non-literal infringements like these, there is always a discussion about the equivalence of the elements that can be decided for or against the equivalence in a dispute, depending on the arguments presented by both parts.

4.7. Contributions of this chapter

This chapter has presented the all-element rule for patent infringement. Next chapters will present several contributions based on the use of this rule for patent interpretation.

5. Logic aspects of the all-element rule

5.1. About this Chapter

This chapter presents contributions to logic modeling of the all-element rule. Previous works made attempts to model patents with Description Logic (N. Karam and A. Paschke, 2012) and Deontic Logic (R. Hilpinen and P. McNamara, 2013). This chapter proposes the first attempt to model the all-element rule as Description Logic (N. Karam and A. Paschke, 2012) and Deontic Logic (R. Hilpinen and P. McNamara, 2013). This modeling was already accepted and published as part of a book chapter published by Springer (S. R.N. Reis et al, 2018).

This chapter is organized as follows. Section 5.2 describes the processing of claim information with Description logic. Section 5.3 discusses the example 1 from Karam and Paschke (N. Karam and A. Paschke, 2012), while the example 2 is discussed in Section 5.4. Section 5.5 describes how to represent the all-element rule with Description Logic and Deontic Logic.

5.2. Processing claim information with Description Logic

Karam and Paschke (N. Karam and A. Paschke, 2012) proposed a Description Logic approach to model patents claims and performing differences. According the authors, “their work was motivated by an application in the context of patent applications valuation. In this context one needs to compare the claims of the patent with previous patents solving a similar problem”. This affirmation is true, but it can be more precisely described when the all-element rule is taken into account. The result section of Karam and Paschke (N. Karam and A. Paschke, 2012) is composed of two examples, which we will discuss in the following sub-sections considering patent claim structure and the all-element rule.

5.3. Discussion about example 1 from Karam and Paschke (N. Karam and A. Paschke, 2012)

The example 1 from Karam and Paschke (N. Karam and A. Paschke, 2012) discusses a comparison of a patent application against a previous patent. The patent application "is for a chair with only one leg having a seat made only of a light material", which indicates that this description is being claimed, i.e. it can be found in a claim of the application, even if the provided text in the example is not in the form of a claim. This claim is represented in Description Logic by the formula in Equation (1). The previous patent "describes a chair with three legs and having one seat made of light wood", which is represented in Description Logic by the formula in Equation (2).

$$=1\text{hasLeg} \sqcap \exists \text{hasSeat}.(\forall \text{hasMaterial}.\text{Light}) \quad (1)$$

$$=3\text{hasLeg} \sqcap \exists \text{hasSeat}.(\forall \text{hasMaterial}.(\text{Wood} \sqcap \text{Light})) \quad (2)$$

Karam and Paschke (N. Karam and A. Paschke, 2012) proposed an algorithm to compute the difference between concepts expressed in Description Logic. Their algorithm returns as answer the formula in Equation (3), which reads "at most one leg" for the difference between Equation (1) and Equation (2). We agree that the differences between the two concepts reside mainly in the number of legs presented by the chairs in the application and in the previous patent. However, we do not agree that the difference can be expressed as "at most one leg", in a way that is meaningful for patent interpretation. In fact, the expected difference would be two legs, which does not correspond to Equation (3). Unfortunately, Karam and Paschke (N. Karam and A. Paschke, 2012) do not verbalize the meaning of Equation (3), which makes difficult to check for possible typos in the equation.

≤1hasLeg (3)

The comparison between the individual elements of the patent application and the previous patent in example 1 are shown in Table 5.1. From an all-element rule standpoint, the question is whether the claimed elements in the application were already present in the previous patent. From Table 5.1, it is clear that element e2 is present in both the application and the previous patent. It is also easy to see that the previous patent has the element e3 of the application, even if it uses wood as the light material. The difference resides in element e1, concerning the number of legs, but the difference is not "at most one leg". From a patent law point of view, the following concerns can be raised. First, the examiner would probably not allow the word only in a claim as only one leg means not having more than one leg, and the form not having is not a valid form of claiming. The patent agent should use the wording exactly one leg, which is admissible. Second, any patent agent would try to use the broader formulation at least one leg while claiming, but then the previous patent would be valid prior art, as a chair with three legs has at least one leg.

Table 5.1. The comparison of the elements in the patent application and in the previous patent in example 1 from Karam and Paschke (N. Karam and A. Paschke, 2012).

Element	Element in the application	Element in the previous patent
e1	Only one leg	Three legs
e2	One seat	One seat
e3	Seat of light material	Seat of light wood

5.4. Discussion about example2 from Karam and Paschke (N. Karam and A. Paschke, 2012)

The example 2 from Karam and Paschke (N. Karam and A. Paschke, 2012) discusses a comparison between a patent application for a watch and an existing physical watch. The application is for "a watch with at least two displays that are bright", which is expressed in Description Logic by the formula in Equation (4). The existing physical watch has one display that is analogical and has one display that is not analogical, which is written in Description Logic through the formula in Equation (5). According to Karam and Paschke (N. Karam and A. Paschke, 2012), their algorithm to compute differences between formulas returns the formula in Equation (6), as answer for the difference between Equation (4) and Equation (5). The formula in Equation (6) reads "all displays are bright". We agree with the difference provided as answer in this example by Karam and Paschke (N. Karam and A. Paschke, 2012).

$$>=2\text{hasDisplay} \sqcap \forall \text{hasDisplay.Bright} \quad (4)$$

$$\exists \text{hasDisplay.Analogical} \sqcap \exists \text{hasDisplay.} \neg \text{Analogical} \quad (5)$$

$$\forall \text{hasDisplay.Bright} \quad (6)$$

Table 5.2. The comparison of the elements in the patent application and in the existing watch in example 2 from Karam and Paschke (N. Karam and A. Paschke, 2012).

Element	Element in the application	Element in the existing watch
e1	Has two or more displays	Has two displays
e2	All displays are bright	Not present

The comparison between the individual elements of the patent application and the existing physical watch in example 2 are shown in Table 5.2. From an all-element rule standpoint, the question is once again if the claimed elements in the application were already present in the

existing watch. From Table 5.2, it is clear that element e1 is present in the existing watch. However, element e2 is not present in the existing watch, so it is not a valid prior art for the patent, meaning that the patent could potentially be granted due to the novelty provided by element e2.

Notice that Karam and Paschke (N. Karam and A. Paschke, 2012) introduce an algorithm to compute the difference between two concepts expressed through Description Logic to be used in patent valuation. They also propose to use the difference algorithm to compute the difference between two concepts. However, they do not discuss whether the difference algorithm can be applied altogether with the all-element rule. In fact, Karam and Paschke (N. Karam and A. Paschke, 2012) conclude their work stating that "a direction for future work would be to investigate the decision making process based on the results returned by the difference and empirical rules derived from experts decisions". We believe that the discussion provided herein helps to work into this direction by clarifying the role of the all-element rule in experts' decision-making.

5.5. Representing the all-element rule with Description Logic and Deontic Logic

In this section, we express the all-element rule in terms of Description Logic (N. Karam and A. Paschke, 2012) and in terms of Deontic Logic (R. Hilpinen and P. McNamara, 2013). This is done in the next two subsections. The importance of representing claims in Description Logic and in Deontic Logic is justified by the existence of frameworks for automatically computing logic difference between concepts, such as the one presented in (N. Karam and A. Paschke, 2012).

5.5.1. All-element rule in Description Logic

The all-element rule takes the general form of Equation (7) when written in Description Logic. There will be one of these formulas for each claim in the patent, taking into account all the elements in the claim. Equation (7) is read in such a way that an object covered by the claim has to have all elements recited in the claim; meaning that an object that "has element e1 and has element e2 and has element en" is covered by the claim. In order for a physical object not to be covered by the claim represented by Equation (7) it must follow the conditions given by Equation (8). Equation (8) is read in such a way that an object not covered by the claim should not have all of the elements recited in the claim; meaning that an object that "either has not element e1 or has not element e2 or has not element en" is not covered by the claim. The same applies for a previous patent not describing prior art.

$$=\text{hasElement.e1} \sqcap \text{hasElement.e2} \sqcap \ldots \sqcap \text{hasElement.en} \quad (7)$$

$$=\neg\text{hasElement.e1} \sqcup \neg\text{hasElement.e2} \sqcup \ldots \sqcup \neg\text{hasElement.en} \quad (8)$$

5.5.2. All-element rule in Standard Deontic Logic

Considering Deontic Logic (R.Hilpinen and P.McNamara, 2013), we have a similar modeling as well. There are early developments by Nitta (K.Nitta et al, 1988) and Roberts (as quoted by Jones and Sergot (A.J. Jones and M. Sergot, 1992)). From our perspective, the all-element rule takes the general form of Equation (9) when written in Standard Deontic Logic. There will be one of these formulas for each claim in the patent, taking into account all the elements in the claim. Equation (9) is read in such a way that an object covered by the claim has an obligation O to have all elements recited in the claim; meaning that an object that "element e1 is obligatory and element e2 is obligatory and element en is obligatory" for an object covered by the claim. In order for a physical object to be permitted, i.e. not covered, by the claim represented by

Equation (9) it must follow the conditions given by Equation (10). Equation (10) is read in such a way that an object is permitted P (i.e., the object is not covered by the claim) when the object does not have all the elements recited in the claim; meaning that the object is permitted if "either it has not element e1 or it has not element e2 or it has not element en". The same applies for a previous patent not describing prior art.

$Oe1 \wedge Oe2 \wedge \ldots \wedge Oen$ (9)

$P(\neg e1 \vee \neg e2 \vee \ldots \vee \neg en)$ (10)

5.6. Contributions of this chapter

This chapter presented contributions to logic modeling of the all-element rule. As far as we know, this chapter proposed the first attempt to model the all-element rule as Description Logic (N. Karam and A. Paschke, 2012) and Deontic Logic (R. Hilpinen and P. McNamara, 2013). This contribution is demonstrated by the fact that the proposed modeling was already accepted and published as part of a book chapter published by Springer (S. R. N. Reis et al, 2018).

6. A semiotic understanding of patents

6.1. About this Chapter

This chapter presents the main contribution of this thesis: a semiotic approach for interpretation and understanding of patent documents. Next chapters of the thesis will present practical contribution derived from the approach proposed in this chapter. The proposed approach in this chapter was accepted for publication in the Journal for the Semiotics of Law in the form of an article entitled Semiotic Aspects in Patent Interpretation (S.R.N.Reis et al, 2019).

This chapter is organized as follows. Section 6.2 presents a brief review of semiotic aspects. Section 6.3 discusses object properties and then uses these properties to discuss how sets are defined by using words. Section 6.4 discusses the structure of patent claims. The interpretation of claims using the all-elements rule for patents is discussed in section 6.5. The hierarchical relationship among derived claims in a patent is described in section 6.6. The enumeration of different possible combinations of properties of objects is discussed in section 6.7. The coverage of claims depending on the order that properties are listed in derived claims is presented in section 6.8. After many sections focusing on the claim sub-section, the submission process is discussed in section 6.9, with emphasis on the contents of the four sub-sections (abstract, description, drawings and claims). Section 6.10 presents the analysis of real-life patent examples. The proposed semiotics approach for patent interpretation is then summarized in section 6.11. Related and future works are discussed in section 6.12. Finally, section 6.13 presents the contribution of this chapter.

6.2. Review of Semiotic Aspects

The field of semiotics studies the nature of human communication processes and therefore can be a helpful tool for legal interpretation. Indeed, a well-developed field of the semiotics of law exists (A.Wagner et al, 2005) (A.Wagner et al, 2007). In this paper, we propose to use a semiotic approach for patent interpretation based on the all-elements rule (S.-J. Wang, 2008) (R. Schechter, J. Thomas, 2007). Semiotics is a large field, and many approaches and contributions do exist. In the following, we highlight three different semiotic standpoints, which we consider in our interpretation approach.

First, in his book "A theory of semiotics", Umberto Eco (U.Eco, 1976) focuses on the semiotics of communication, defining "a communicative process as the passage of a signal (not necessarily a sign) from a source (through a transmitter, along a channel) to a destination." This idea is very present in the patent system, as a patent document is a communication of a legal right. Interestingly, a patent is a message that is divided into message sub-sections with different legal effects, as it will be discussed further in this chapter. For the moment, it is highlighted that the claim sub-section determines the coverage of a patent, interpreted with the help of the description and the drawings (two other message sub-sections). Part of our contribution comes from identifying different message sub-sections with different functions in a patent document, then using a semiotic approach to highlight which content should be communicated through which sub-section in a patent application. We discuss the interaction among the four patent sub-sections (abstract, description, drawings and claims) focusing on the valid and invalid use of these sub-sections. The proposed approach helps to understand and avoid misuse of the message sub-sections, resulting in stronger patents.

The second standpoint is that communication in Peircean semiotics is divided into Syntax, Semantics and Pragmatics (J.J.Liszka, 1996) (J.Zeman, 1977) (U.Eco, 1976b) (C.W. Morris, 1938) (J.F. Sowa, 2000) (I. Skoczeń, 2016) (S.C. Levinson, 1983) (C.K. Ogden and I.A. Richards, 1923). Syntax deals with patterns of formation of sentences and phrases from words. Semantics studies the meaning of words (signs). Pragmatics can be considered as accessory information to

a message, which facilitates the correct interpretation in a given context. In this sense, some works in legal interpretation focus on facilitating legal interpretation by providing easier links to accessory information. For instance, Ramakrishna and Paschke (S. Ramakrishna and A.Paschke, 2014) (S. Ramakrishna, 2013) introduced Elementary Pragmatics (EPs) to deal with norms/precedents/guidelines as accessory information to patent law. Also, Casanovas et al. (P.Casanovas et al, 2017) discuss the role of pragmatics in the web of online data. One example of important accessory pragmatic information for patent law is the so-called all-element rule. Patent claims are interpreted with the all-elements rule that states that a product is covered by a patent when the product contains all the elements recited in at least one of the claims of the patent. Wang (S.-J. Wang, 2008) describes how to legally avoid patent infringement, based on claim interpretation and explicitly describes the all-elements rule. The all-element rule is also explicitly described in the work of Schechter and Thomas (R. Schechter, J. Thomas, 2007). The all-elements rule is not a law, but is an important accessory rule in patent law, so it is an example of pragmatics for patent law. Pragmatics should not be confused with metapragmatics (M. Silverstein, 1993). Metapragmatics occurs when an emitter of a message explains how the message should be interpreted. In this sense, explicit metapragmatics is desirable in the description section, as the description section has the role of helping to understand the claims.

The third standpoint is the Peircean triad of interrelated concepts of interpretant, sign-vehicle, and referent. A referent is an object in the physical world, such as a (physical) chair. An example of a sign-vehicle is a word used to communicate an idea, such as the word chair in its written or spoken forms. The interpretant is the concept that the sign-vehicle invokes in the mind of a person for whom the sign is meaningful. Our contribution in this sense is to describe a claim as a sign-vehicle that can be abstracted to an interpretant by using the all-elements rule. In this sense, we introduce a novel approach to analyze claims in depth with the help of set theory (H.Parks et al, 2000) and Venn diagrams (T.D. Brainard, 2000), to visually express the all-elements rule (S.-J. Wang, 2008) (R. Schechter, J. Thomas, 2007). The work by Collins (K.M. Collins, 2010) applies the Peircean triad to patent interpretation. However, his goal is not to study how an interpretant is produced from the claims; Collins argues that software patents lack an object/referent and should not be admissible.

6.3. Defining sets and sub-sets using words expressing properties

In this section, we discuss how properties described using words can be used to define sets and subsets of a universal set. The clear understanding of set definition through properties expressed using words will be necessary later on to perform patent claim interpretation (starting from section 6.5). In the section, we will address this issue purely from a set theory standpoint, completely disregarding patents for the moment. However, we warn the reader that some words which express properties may present a more restrictive interpretation from a patent legal perspective as described in the USPTO Glossary (USPTO, 2019). In the following, we will discuss how we can define subsets of a universal set through examples that group elements according to the properties they present, using the properties illustrated in Figure 6.1 as part of the examples.

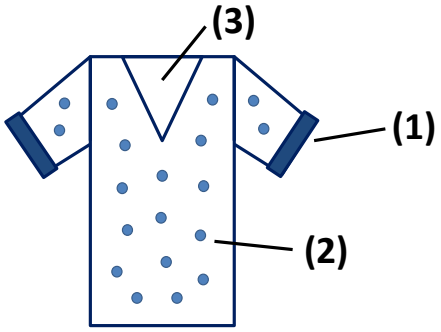


Figure 6.1: A T-shirt with folded sleeves (1), polka dots (2) and V-neck (3).

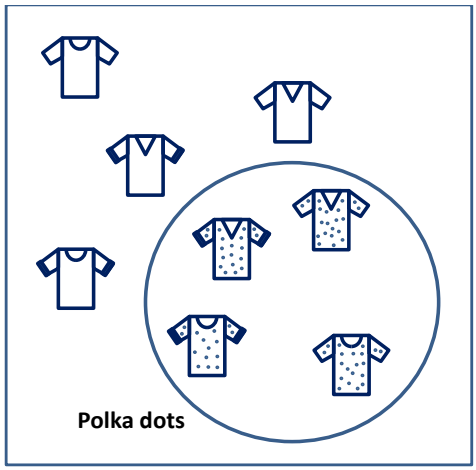


Figure 6.2: The subset of T-shirts with polka dots.

Example 6.1: Consider a set of T-shirts defined as "*a subset of all T-shirts such that member T-shirts present polka dots*." This set is represented as a Venn diagram in Fig. 6.2. Notice that it is possible to use words to determine a set by requiring that members of the set must present a given property. In this example, the property was "*polka dots*," which could be further explained by referencing Fig. 6,1 and saying "*polka dots (2)*".

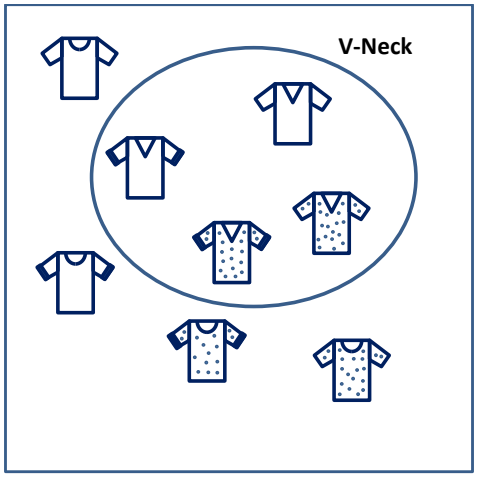


Figure 6.3: The subset of T-shirts with V-necks.

Example 6.2: Consider a set of T-shirts defined as "a subset of all T-shirts such that member T-shirts present V-neck." This set is represented as a Venn diagram in Fig. 6.3. Notice that it is

possible to use words to determine a different set from example 6.1 by requiring that members of the set must present a different property. In this example, the property was "*V-neck (3)*".

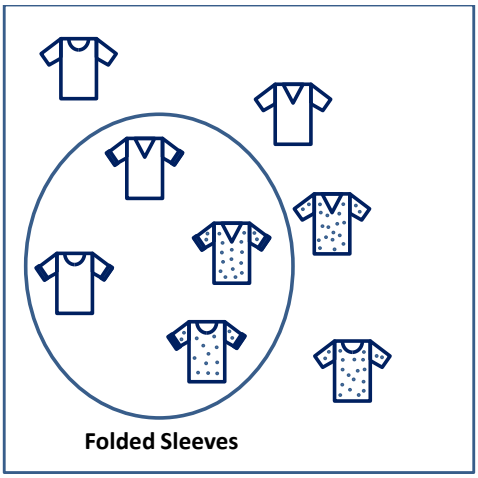
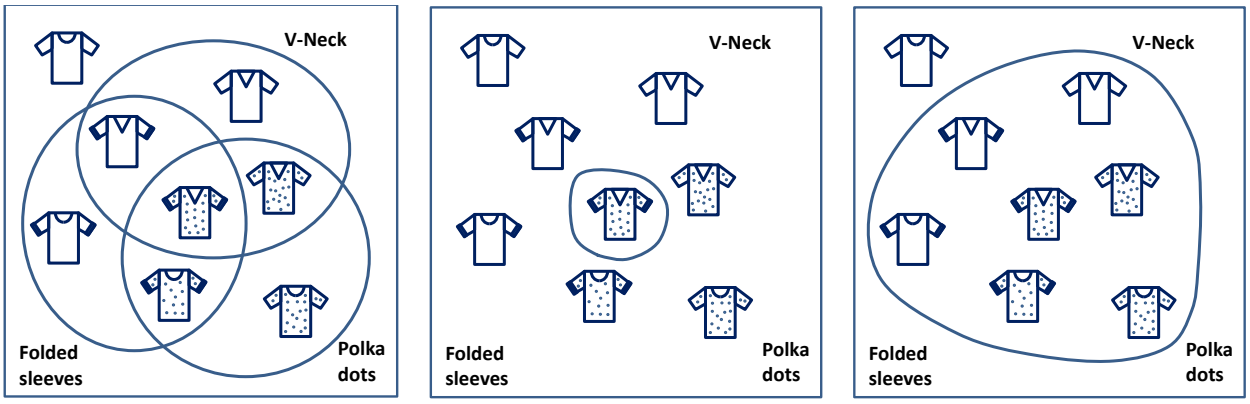


Figure 6.4: The subset of T-shirts with folded sleeves.

Example 6.3: Consider a set of T-shirts defined as "a subset of all T-shirts such that member T-shirts present folded sleeves." This set is represented as a Venn diagram in Fig. 6.4. Notice that it is possible to use words to determine a different set from examples 6.1 and 6.2 by requiring that members of the set must present a different property. In this example, the property was "*Folded sleeves (1)*".



(a) Individual sets (b) T-shirt with all 3 properties (c) T-shirts with at least 1 property

Figure 6.5: The subsets of T-shirts with polka dots, V-neck and folded sleeves.

The examples 6.1, 6.2 and 6.3 discussed sets of T-shirts defined through a single property; those are shown together in Fig. 6.5(a). In the more elaborate examples (6.4 and 6.5) described below, it is possible to define sets by composing properties.

Example 6.4: Consider a set of T-shirts defined as "*a subset of all T-shirts such that member T-shirts present polka dots (2) and present V-neck (3) and present folded sleeves (1)*". The induced set is the intersection of the sets from examples 6.1, 6.2 and 6.3 that are shown together in Fig. 6.5(a). The resulting intersection is shown in Fig. 6.5(b).

Example 6.5: Consider a set of T-shirts defined as "*a subset of all T-shirts such that member T-shirts present at least polka dots (2) or present at least V-neck (3) or present at least folded sleeves (1)*". The induced set is the union of the sets from examples 6.1, 6.2 and 6.3 that are shown together in Fig. 6.5(a). The resulting union is shown in Fig. 6.5(c).

6.4. The structure of a patent claim

The internal phrasal structure of a patent claim must follow a well-defined pattern, according to the World Intellectual Property Organization (WIPO). This structure is discussed in the WIPO Patent Drafting Manual (WIPO, 2019b). The general structure is shown in Figure 6.6(a), while a specific instance is shown in Figure 6.6(b). The general structure of a patent claim consists of (i) a preamble, (ii) a transitional phrase (or transition) (iii) and the body of the claim, which recites one or more claim-elements.

Preamble, transition:	An apparatus, comprising:
Claim-element (#CE1);	a plurality of printed pages;
Claim-element (#CE2); and	a binding configured to hold the printed pages together; and
Claim-element (#CE3).	a cover attached to the binding.
(a) general structure	*(b) one example*

Figure 6.6: The structure of a patent claim, according to WIPO (WIPO, 2019b).

The preamble defines the nature of the claimed invention. For instance, it might be common to have almost identical claims in a single patent where the only distinction is the preamble. It would be possible for a patent to claim very similar inventions in the form of a method, an algorithm or a computer program, just by having claims with different preambles. From a patent drafting point of view, most patent offices worldwide require the preamble to be separated from the transition by a comma, as shown in Figure 6.6. The remainder of our discussion will consider the properties (or claim-elements) presented in Figure 6.1, for didactic reasons. This way, we rephrased the apparatus claim from Figure 6.6(b) into a T-shirt claim with a similar structure, as shown in Figure 6.7(b). The structure of a patent according to WIPO (WIPO, 2019b) is shown both in Figure 6.6(a) and Figure 6.7(a), to emphasize that the claims in Figure 6.6(b) and in Figure 6.7(b) have the same structure.

Preamble, transition: Claim-element (#CE1); Claim-element (#CE2); and Claim-element (#CE3).	A T-shirt, comprising: folded sleeves (1); a plurality of polka dots (2); and a V-neck (3).
(a) general structure	*(b) one example*

Figure 6.7: The structure of a patent claim, according to WIPO (WIPO, 2019b) and an example using the properties illustrated in Figure 6.6.

The transitional phrase determines the relationship among the claim-elements of the body and the nature defined by the preamble. For the examples in Figure 6.6(b) and Figure 6.7(b), the transition is the verb *comprising*. Notice that from a punctuation point of view as advised by WIPO (WIPO, 2019b), the transition is separated from the preamble by a comma and separated from the body by a colon.

The body of the claim consists of one or more claim-elements and the relationship among them. In the example of Figure 6.6, the body of the claim consists of three distinct claim-elements: CE1 (a plurality of printed pages); CE2 (a binding configured to hold the printed pages together); and CE3 (a cover attached to the binding). In the example of Figure 6.7, the body of

the claim consists of the three claim-elements for T-shirts illustrated in Figure 6.1: CE1 (folded sleeves); CE2 (a plurality of polka dots); and CE3 (a V-neck). The numbers inside parenthesis can be used to the claim elements as illustrated in a patent drawing similar to Figure 6.1, which illustrates the claim elements in this chapter. The use of numbers between parenthesis is the usual way to make the connection between claim-elements and patent drawings.

6.5. Claim interpretation with the all-element rule

In the scope of this work, we focus on claim interpretation under the so-called all-element rule, in the nomenclature of the patent law community. In order to avoid confusion between the two meanings of the word element, as discussed in Section 4.3 (in Chapter 4), we will refer to the all-elements rule as the all-claim-elements rule, in this paper. This rule is presented in definition 6.1 below.

Definition 6.1: The **all-claim-elements rule** states that an object is covered by a patent when the object physically presents all the claim-elements (definition 2) verbally recited in one of the claims of the patent.

A visual interpretation of the all-claim-elements rule using a Venn Diagram is presented in Figure 6.8. The preamble defines the nature of what is being claimed. For instance, the nature of the claim in Figure 6.6(b) is "*an apparatus*," while the nature in the claim in Figure 6.7(b) is "*a T-shirt*." Notice that the word apparatus in the claim of Figure 6.6(b) is chosen because it has a broad general sense. What is claimed is defined by the nature (preamble) of the claim, restricted by the claim-elements recited in the claim. In the case of the claim in Figure 6.7(b), it has three claim-elements (CE1, CE2, and CE3). These three claim-elements restrict the nature of the claim, and the intersection among the three claim-elements gives the claimed invention. The resulting intersection is illustrated in Figure 6.8.

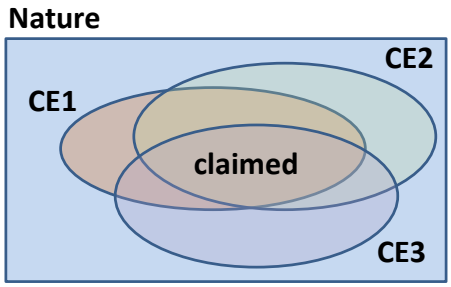


Figure 6.8: Visual Interpretation of the all-claim-elements rule.

The interpretation of a patent with the all-claim-elements rule can be made through a set of questions about the nature and the presence of the claim-elements in the object. In order to decide if the claim in Figure 6.7(b) covers an object, the questions in Figure 6.9 should be asked.

1. Is the object a *T-shirt*?
2. Does the object comprise *folded sleeves (1)*?
3. Does the object comprise *a plurality of polka dots (2)*?
4. Does the object comprise *a V-neck (3)*?

Figure 6.9: Questions to detect coverage of claim in Figure 6.7 (b) using the all-claim-elements rule.

A given object is covered by the claim in Figure 6.7(b) when the answer for each of the questions in Figure 6.9 is yes. When the answer for any of these questions is no, the object is not covered by the claim in Figure 6.7(b).

6.6. Relationship among the claims of a patent

A patent typically contains more than one claim. The reasoning for this, from a patent strategy standpoint, is that patent claims can be invalidated during patent litigation. This way,

having more than one claim makes the patent more robust during litigation. Typically, a well-written patent has more than one claim.

The claims of a patent can be of two different types: independent and dependent claims. An independent claim does not refer any other claim in the patent. A dependent claim refers to at least one of the previous claims of the patent. For example, we illustrate an independent claim and a derived claim in Figure 6.10. The claim presented in Figure 6.10(a) is an independent claim comprising two claim-elements. The derived (or dependent) claim presented recited in Figure 6.10(b) adds a third claim-element to the two claim-elements inherited through the reference to the first claim. In this sense, the claim in Figure 6.10(b) has three claim-elements: one recited in the claim and two inherited by reference. Notice that the claim in Figure 6.10(b) could be rewritten in independent format by textually reciting all the three claim-elements in the body of the claim. The claim in Figure 6.7(b) could be a possible rewriting of the claim in Figure 6.10(b) in independent form. In this sense, the claims from Figure 6.7(b) and Figure 6.10(b) have the same legal coverage, as they have the same nature and the same claim-elements.

1) A T-shirt, comprising:
folded sleeves (1); and
a plurality of polka dots (2).

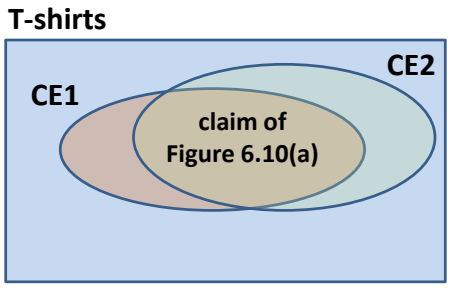
(a) an independent claim

2) A T-shirt, according to claim 1, further comprising:
a V-neck (3).

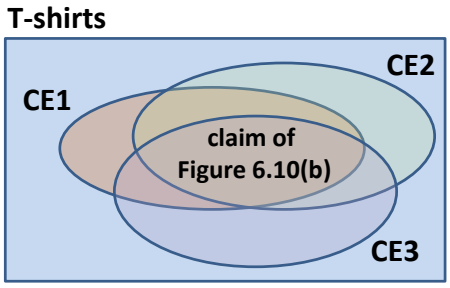
(b) a derived claim

Figure 6.10: An independent claim and a derived claim. Notice this is a synthetic example that cannot be granted due to the lack of novelty, but can be used to explain claim interpretation.

The coverage of the claims in Figure 6.10 can be discussed by using the all-claim-elements rule. This coverage is illustrated in Figure 6.11(a) for the claim in Figure 6.10(a). As shown in Figure 6.11(b), the claim in Figure 6.10(b) adds a third claim-element to the two already existing in Figure 6.10(a). The added claim-element acts as a restriction or limitation, which further limits the coverage of the claim from Figure 6.10(b), concerning the claim from Figure 6.10(a).



(a) Coverage of the claim in Figure 6.10(a)



(b) Coverage of the claim in Figure 6.10(b)

Figure 6.11: Coverage of the claims from Figure 6.10. Claim-element CE1 is "*folded sleeves (1)*"; claim-element CE2 is "*a plurality of polka dots (2)*"; and claim-element CE3 is "*a V-neck (3)*".

As a consequence of the all-claim-elements rule, as illustrated in Figure 6.11, a derived claim tends to be narrower than the claim it refers. This observation is always true when the reference is made to add new claim-elements to an existing claim.

The interpretation of a patent with the all-claim-elements rule can be made through a set of questions about the nature of the object and about the presence of the claim-elements in the object. In order to decide if an object is covered by the claim in Figure 6.10(a), the questions in Figure 6.12 should be asked.

1. Is the object a *T-shirt*?
2. Does the object comprise *folded sleeves (1)*?
3. Does the object comprise *a plurality of polka dots (2)*?

Figure 6.12: Questions to detect coverage of claim in Figure 6.10(a) using the all-claim-elements rule.

A given object is covered by the claim in Figure 6.10(a) when the answer for all the three questions in Figure 6.12 is yes. When the answer for any of these questions is no, the object is not covered by the claim in Figure 6.10(a). Concerning the claim in Figure 6.10(b), it is

equivalent to the claim in Figure 6.7(b). This way, the set of questions to detect coverage of the claim in Figure 6.10(b) is the same set of questions as shown in Figure 6.9 for the equivalent claim in Figure 6.7(b).

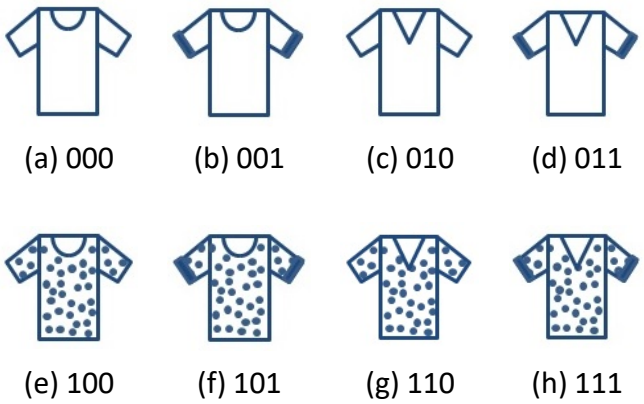
6.7. Different combinations of properties

In the previous sections, we have discussed that the properties expressed as claim-elements act as restrictions applied to a universal set. In this section, we will discuss the enumeration of different categories of objects that arise according to the combination of different properties. The properties considered in patent interpretation are of the type yes/no or present/absent, meaning that each property can assume two distinct values. This way, the properties for T-shirts illustrated in Figure 6.1 are also of the type yes/no, offering, therefore, two combinations, meaning that they have a cardinality of two. For *n* constructive properties with cardinality two, there are 2^n possible combinations. For instance, considering T-shirts having (or not) polka dots, V-necks and folded sleeves, there are eight (2^3) different combinations of properties that are possible. The eight possible combinations of properties can be considered as different categories of T-shirts and are listed in Table 6.1.

For easier reference, a binary code is also assigned to each combination in Table 6.1, representing the absence (0) or presence (1) of each constructive property. The binary codes are used as a reference to illustrate the drawings of each possible T-shirt combinations in Figure 6.13. Notice that Figure 6.13 highlights that there are eight possible categories of T-shirts according to the properties; the drawings are illustrative of each category.

Table 6.1: Possible categories of T-shirts with polka dots, V-neck and folded sleeves.

Code	Polka dots	V-Neck	Folded Sleeves
000	no	no	no
001	no	no	yes
010	no	yes	no
011	no	yes	yes
100	yes	no	no
101	yes	no	yes
110	yes	yes	no
111	yes	yes	yes



(a) 000 (b) 001 (c) 010 (d) 011

(e) 100 (f) 101 (g) 110 (h) 111

Figure 6.13: Drawings of the 8 possible T-shirt combinations.

6.8. Claim coverage and claim derivation order

In this section, we discuss how the order that claim-elements are added in a set of claims affects the final claim coverage. The order is especially important for a set of dependent claims derived from a first independent claim. We present three different examples to explain how this order affects claim coverage. In each example, we discuss a set of three claims involving the properties depicted in Table 6.1 and Figure 6.13. The difference among the examples is the order in which claim elements are added to the claims.

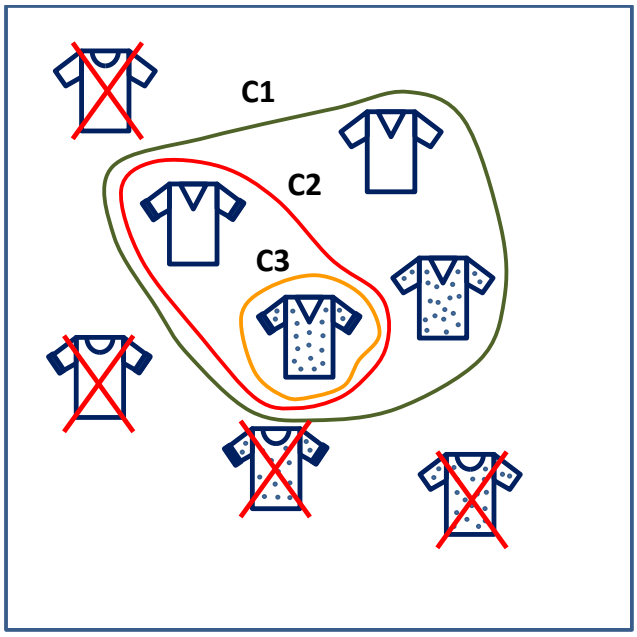


Figure 6.14: Patent interpretation corresponding to example 6.6.

Example 6.6: consider a patent having the following set of claims:

"*1. A T-shirt characterized by having V-neck.*

2. A T-shirt according to claim 1 characterized by having folded sleeves.

3. A T-shirt according to claim 2 characterized by having polka dots".

The corresponding patent interpretation for example 6.6 is shown in Figure 6.14. In this case, claim 1 (C1) requires the claim-element V-neck, which corresponds to shirts from Table 6.1 labeled with binary codes of type ´-1-´, meaning all the codes that present 1 (or yes) in the column V-neck. The symbol ´-´ represents a don´t-care and can be set to 0 or 1. This way, the code ´-1-´ corresponds to four T-shirts with code 010, 011, 110 and 111 (i.e., all codes with a 1 (yes) in the middle. These T-shirts are the ones with the value ´yes´ in the column V-neck in Table 6.1).

Claim 2 (C2) further restricts the T-shirts from claim 1 to have the claim-element folded sleeves, which results in T-shirt codes of type ´-11´. The ´-11´ code corresponds to the T-shirts with codes 011 and 111 in Table 6.1.

Claim 3 (C3) further restricts T-shirts to have polka dots, which results in the T-shirt code ´111´. Notice that every derived claim is a restriction of the coverage of the prior claims. The restriction happens because each new derived claim is adding constructive properties (definition 2) that will be required by the all-elements rule.

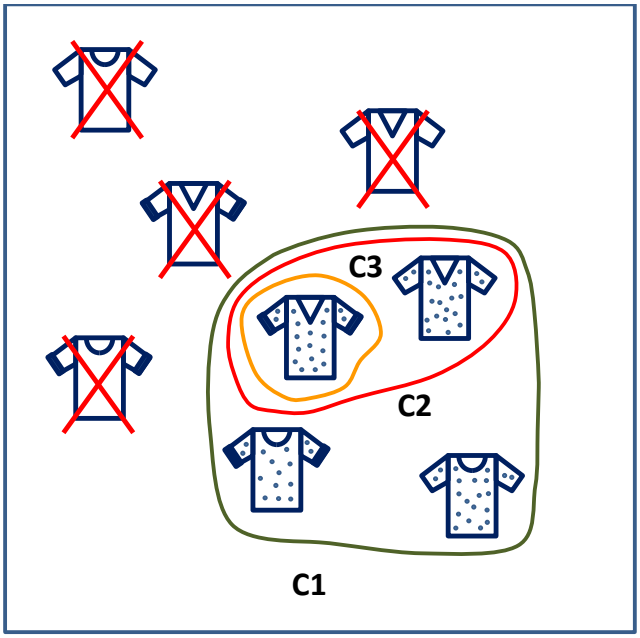


Figure 6.15: Patent interpretation corresponding to example 6.7.

Example 6.7: consider a patent having the following set of claims:

"*1. A T-shirt characterized by having polka dots.*

2. A T-shirt according to claim 1 characterized by having V-neck.

3. A T-shirt according to claim 2 characterized by having folded sleeves".

The corresponding patent interpretation for example 6.7 is shown in Figure 6.15. In this case, claim 1 (C1) requires the constructive property polka-dots, which corresponds to shirts from Table 6.1 labeled with binary codes of type ´1--´, meaning all the codes that present polka dots. The code ´1--´ corresponds to four T-shirts with code 100, 101, 110 and 111.

Claim 2 (C2) further restricts T-shirts to have V-neck, which results in T-shirt codes of type ´11-´. The code ´11-´ corresponds to codes 110 and 111.

Claim 3 (C3) further restricts T-shirts to have folded sleeves, which results in the T-shirt code ´111´. Again, as in example 6.6, every derived claim is a restriction of the coverage of the prior claims. Notice that the T-shirts with codes 111 and 110 are covered both by the claims in examples 6.6 and 6.7. Similarly, the T-shirts with codes 001 and 000 are not covered by the claims in examples 6.6 and 6.7.

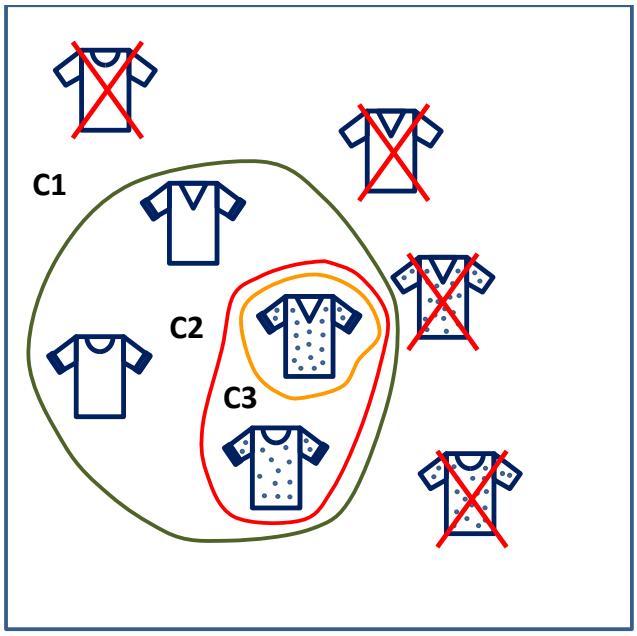


Figure 6.16: Patent interpretation corresponding to example 6.8.

Example 6.8: consider a patent having the following set of claims:

"*1. A T-shirt characterized by having folded sleeves.*

2. A T-shirt according to claim 1 characterized by having polka dots.

3. A T-shirt according to claim 2 characterized by having V-neck".

The corresponding patent interpretation is shown in Figure 6.16. In this case, claim 1 (C1) requires the constructive property folded sleeves, which corresponds to shirts from Table 6.1

labeled with binary codes of type ´--1´, meaning all the codes presenting folded sleeves. The code ´--1´ corresponds to four T-shirts with code 001, 011, 101 and 111.

Claim 2 (C2) further restricts T-shirts to have polka dots, which results in T-shirt codes of type ´1-1´. The code ´1-1´ corresponds to codes 101 and 111.

Claim 3 (C3) further restricts T-shirts to have V-neck, which results in the T-shirt code ´111´. Again, as in the examples 6.6 and 6.7, every derived claim is a restriction of the coverage of the prior claims.

By comparing the examples 6.6, 6.7 and 6.8, it is possible to see that the order in which claim-elements are added to derived claims will affect claim coverage. Indeed, the claims in the three examples have different coverages. The coverages of individual claims, for the three examples, are presented in Table 6.2. Notice that the T-shirt with code 000 is not covered by any of the examples, while the T-shirt with code 111 is covered by all the claims in all the examples. For all the other six categories of T-shirts, the coverage changes with the order in which claim elements are added.

Table 6.2: Comparative coverage of individual claims from examples 6.6, 6.7 and 6.8.

T-shirt code	Example 6.6			Example 6.7			Example 6.8		
	Claim 1	**Claim 2**	**Claim 3**	**Claim 1**	**Claim 2**	**Claim 3**	**Claim 1**	**Claim 2**	**Claim 3**
000	no	no	no	no	no	no	no	no	no
001	no	no	no	no	no	no	**covered**	no	no
010	**covered**	no	no	no	no	no	no	no	no
011	**covered**	**covered**	no	no	no	no	**covered**	no	no
100	no	no	no	**covered**	no	no	no	no	no
101	no	no	no	**covered**	no	no	**covered**	**covered**	no
110	**covered**	no	no	**covered**	**covered**	no	no	no	no
111	**covered**	**covered**	**covered**	**covered**	**covered**	**covered**	**covered**	**covered**	**covered**

6.9. Submission process

In the previous sections, we discussed how to interpret patents based on the claim section. In this section, we will resume the discussion of a patent as a document divided into four message sub-sections, as depicted in Figure 6.17. The submission process will affect more the claim sub-section, so this section has a bidirectional nature (represented in Figure 6.17 as a double arrow). The other sub-sections have a more unidirectional nature.

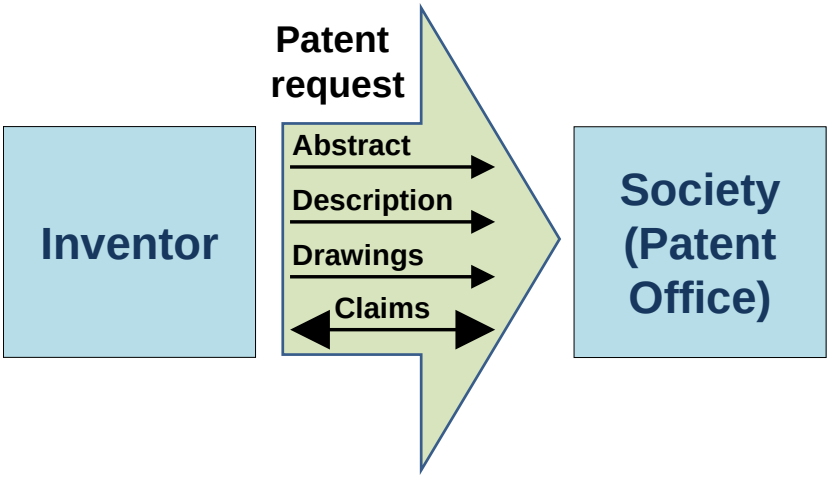


Figure 6.17: During the submission process, the claim sub-section is bidirectional by nature, while the other sub-sections are mostly unidirectional.

The claim sub-section, when the patent application is filed, is an aspiration from the inventor side. The initial writing represents the rights being requested. However, the patent examiner can grant narrower rights compared to what was initially requested. By granting claims with a narrower scope, the examiner is affecting the writing of the claims, meaning that the process is bidirectional: it starts with the initial writing made by the inventor (possibly with the help of a patent agent or attorney), and this initial writing is changed to reflect the narrower scope granted by the examiner.

The abstract, description and drawings sub-sections remain mostly unchanged in substance during the application process, except for minor and formal corrections. This way they can be considered as almost unidirectional message sub-sections. The reason that these sub-sections remain mostly unchanged is that by adding new material to the description or the drawings, the inventor may be forced to file a new patent request with the dates of the addition of the new material. The potential changes in application dates are risky because any publication (including publications by the inventor) made by the patent office can be considered prior art for the new application with modified description and drawings.

6.9.1. Contents of the sub-sections

The other important point during the submission process is that the claim sub-section will represent the granted rights. This way, claims are restricted to represent the protected objects. In this sense, some contents are not allowed in the claims and belong in other sub-sections.

The claim text is restricted to contain claim-elements, which are properties defining the invention. In this sense, several types of text are not allowed in the claim section, for instance: (a) examples of use of the invention, (b) reasons why the invention is useful, (c) reasons why the invention is economically viable, (d) benefits of using the invention, (e) comparisons of the invention with prior art. All the different type of text from items (a) to (e) above are not properties describing the invention, so they cannot be claim-elements, and they cannot be discussed in the claim sub-section; they belong in the description sub-section. In this sense, it is important to notice that the contents allowed in the claim sub-section are restricted to be claim-elements; and additionally, each claim element acts as a restriction, making the resulting claim narrower.

In order to reinforce this point, we highlight that the patent laws from USA (USA, 2019), Brazil (Brazil, 1996), and Spain (Spain, 2015) say that the substance of the invention is determined by the claims, while description and drawings provide metapragmatics to interpret

the claims. The article 41st of Brazilian law Nº 9.279 (Brazil, 1996) on patents say that[1]: "*The extent of the protection granted by the patent will be determined by the content of the claims, interpreted having as support the descriptive report and the drawings*." The article 68th of Spanish Law 24/2015 (Spain, 2015) on patents states that[2]: "*The scope of the protection conferred by the patent or patent application is determined by the claims. The description and drawings serve to interpret the claims.*" So, the description and drawings subsections provide metapragmatics to interpret the patent rights expressed in the claims. The main Law governing patents in the United States (the United States Code Title 35 – Patents (USA, 2019)) also states that the claims express "*the subject matter which the inventor or a joint inventor regards as the invention*." The fact that the invention is determined by the content of the claims is further expressed by the paragraph (b) of 35 U.S.C. 112, which states that: "*The specification shall conclude with one or more claims particularly pointing out and distinctly claiming the subject matter which the inventor or a joint inventor regards as the invention.*" Therefore, the substance of the invention is expressed in the claims, while metapragmatics is expressed in the description and drawings subsections.

6.10. Examples from a real-life patent

In this section, we apply the patent interpretation methods proposed in this thesis to examine a claim as it was submitted and how it was granted. The patent application US20110083062 (L.V. Carginini and R.D.R. Fagundes, 2011) was granted as the United States patent US8631307 (L.V. Carginini and R.D.R. Fagundes, 2014). This patent was initially submitted as a Brazilian patent application (L.V. Carginini and R.D.R. Fagundes, 2008), and the claims applied in the USA are a direct translation of the claims originally submitted in Portuguese. A claim, as submitted in the USA patent application (L.V. Carginini and R.D.R. Fagundes, 2011), is presented in Figure 6.18. Notice that the claim contains text referring to

[1] Translated from Brazilian Portuguese by the authors.
[2] Translated from Spanish by the authors.

examples of ´*means in which the technique can be employed*´. This text cannot be part of a patent claim, as it is not a characteristic or a property of the method.

#X. System, according with claim **#Y**, characterized to be used in information transmission and information reception, where information can be any kind of data,
by any means in which the technique can be employed, **as example**
optic fibers, wireless systems, radio systems, TV broadcasting, telemetry and data transmission system, breaking systems for car, train, airplanes, communications systems for satellites, rockets, memory access, missiles or spaceships.

Figure 6.18: Claim submitted in Patent Application US20110083062 (L.V. Carginini and R.D.R. Fagundes, 2011).

#X. The system according to claim **#Y**, wherein the error correcting code
is employed in a means **selected from the group consisting of**
optic fibers, wireless systems, radio systems, television broadcasting, telemetry and data transmission systems, breaking systems for cars, trains, and airplanes, communications systems for satellites, rockets, memory access, missiles, and spaceships.

Figure 6.19: Claim granted in patent US8631307 (L.V. Carginini and R.D.R. Fagundes, 2014).

The claim that was granted in the final application is presented in Figure 6.19. The text ´*as example*´ in the submitted claim was changed to ´*selected from the group consisting of*.´ Notice that this has a profound implication from a patent interpretation point of view using the all-claim-element rule. The text in Figure 6.20 is a claim-element that acts as a restriction, narrowing the scope of the claim. It is plausible that the original intention of the inventors when giving examples in the claim was to make it broader, by listing a broad range of applications. However, as claim elements are restrictions, they have instead made a large list of restrictions that narrow their claim.

employed in a means selected from the group consisting of optic fibers, wireless systems, radio systems, television broadcasting, telemetry and data transmission systems, breaking systems for cars, trains, and airplanes, communications systems for satellites, rockets, memory access, missiles, and spaceships.

Figure 6.20: A claim-element of the claim in Figure 6.19.

A system presenting all claim-elements of claim #Y, wherein the error correcting code is employed in a means selected from the group consisting of optic fibers, wireless systems, radio systems, television broadcasting, telemetry and data transmission systems, breaking systems for cars, trains, and airplanes.

Figure 6.21: Description of a system that does not infringe the claim in Figure 6.19.

Avoiding infringement of the claim in Figure 6.19 is possible by employing the error correcting code in a means selected from a group that does not consider ´*communications systems for satellites, rockets, memory access, missiles, and spaceships*.´ Indeed, such a description of a system that does not infringe the claim in Figure 6.19 is presented in Figure 6.21. Notice that the claim in Figure 6.19 is very easy to work around by avoiding the excessive restrictions listed in the claim; for instance, by excluding spaceships from consideration. The final text of the claim results then in a very narrow claim.

Another example is the pair of the patent application number US20140017753 (V. Franco Puntes et al, 2014), and the corresponding granted patent US9416373 (V. Franco Puntes et al, 2016). The texts for the applied and granted first claims are shown in Figure 6.22. Again, it is possible to see that the examiner has introduced an extra element to reduce the patent scope, due to the prior art. The added restriction is the text '*wherein the diameter of the surface-modified iron oxide nanoparticles is between 3 nm and 30 nm*'.

Initial claim in the application US20140017753 (V. Franco Puntes et al, 2014)	Granted claim in the patent US9416373 (V. Franco Puntes et al, 2016)
1. A process for the production of biogas from biodegradable material which comprises the steps of: (a) adding a biodegradable material to the reactor; (b) inoculating a microorganism;	1. A process for producing biogas from biodegradable material which comprises the steps of: (a) adding a biodegradable material to a reactor; (b) inoculating a microorganism;
(c) adding a colloidal solution of surface-modified iron oxide nanoparticles to the reactor;	(c) adding a colloidal solution of surface-modified iron oxide nanoparticles to the reactor, **wherein the diameter of the surface-modified iron oxide nanoparticles is between 3 nm and 30 nm;**
(d) providing anaerobic conditions; (e) carrying out an anaerobic digestion; (f) collecting the biogas; wherein the steps (a), (b) and (c) can be carried out in any order.	(d) providing anaerobic conditions; (e) carrying out an anaerobic digestion; (f) collecting the biogas; wherein the steps (a), (b) and (c) can be carried out in any order.

Figure 6.22: Claim submitted in Patent Application US20140017753 (V. Franco Puntes et al, 2014) and the corresponding claim granted patent US9416373 (V. Franco Puntes et al, 2016).

By avoiding the added element, it is possible to work around the patent, as illustrated in Figure 6.23. This observation means that the processes described in Figure 6.23 can be used without infringing the granted patent.

A first workaround method	A second workaround method
1. A process for the production of biogas from biodegradable material which comprises the steps of: (a) adding a biodegradable material to the reactor; (b) inoculating a microorganism;	1. A process for producing biogas from biodegradable material which comprises the steps of: (a) adding a biodegradable material to a reactor; (b) inoculating a microorganism;
(c) adding a colloidal solution of surface-modified iron oxide nanoparticles to the reactor, **wherein the diameter of the surface-modified iron oxide nanoparticles is smaller than 3 nm;**	(c) adding a colloidal solution of surface-modified iron oxide nanoparticles to the reactor, **wherein the diameter of the surface-modified iron oxide nanoparticles is larger 30 nm;**
(d) providing anaerobic conditions; (e) carrying out an anaerobic digestion; (f) collecting the biogas; wherein the steps (a), (b) and (c) can be carried out in any order.	(d) providing anaerobic conditions; (e) carrying out an anaerobic digestion; (f) collecting the biogas; wherein the steps (a), (b) and (c) can be carried out in any order.

Figure 6.23: Two workarounds for granted patent US9416373 (V. Franco Puntes et al, 2016).

6.11. Proposed semiotic approach for patent interpretation

In this section, we summarize the semiotic approach we proposed for patent interpretation. The idea is depicted in Figure 6.24. Patent interpretation consists of interpreting the sign represented by a claim, in order to extract the concept that corresponds to the granted patent rights (concept). Each claim is an individual complex sign expressing a corresponding patent right. The claim sub-section contains multiple claims expressing multiple patent rights, one for each claim. The semantics to interpret each claim as a (complex) sign is provided by the all-elements rule, extensively discussed in the previous sections. The metapragmatics necessary to help the interpretation of claims is given by the other message sub-sections of the patent: description, drawings and abstract. Metapragmatics (e.g., examples of use) is not allowed in the claims. The metapragmatics in the description sub-section can be used to define terms (lexicon) used in the claims to have a broader sense. In this sense, the description sub-section can also play a syntactic role in interpreting the claims. This way, description, and drawings play a syntactic and metapragmatic role in explaining the claims, while the all-elements rule provides semantics. When the description and drawings do not provide sufficient syntactic and metapragmatic information, the pragmatics and syntax for understanding the claims will come from the common knowledge of expert people in the field. This way, if inventors want to favor some broader interpretation of claims, they should explicitly include the necessary syntax and lexicon (e.g., words and terms definitions) and metapragmatics (e.g., examples of use and applications) in the description and drawings message sub-sections. The product (object) given as an example in Figure 6.24 is covered by the claim, as the product has all the elements listed in the claim. The product (object) given as an example in Figure 6.25 is not covered by the claim, as it has not all the elements listed in the claim, as folded sleeves (element listed in the claim) are missing in the product (object).

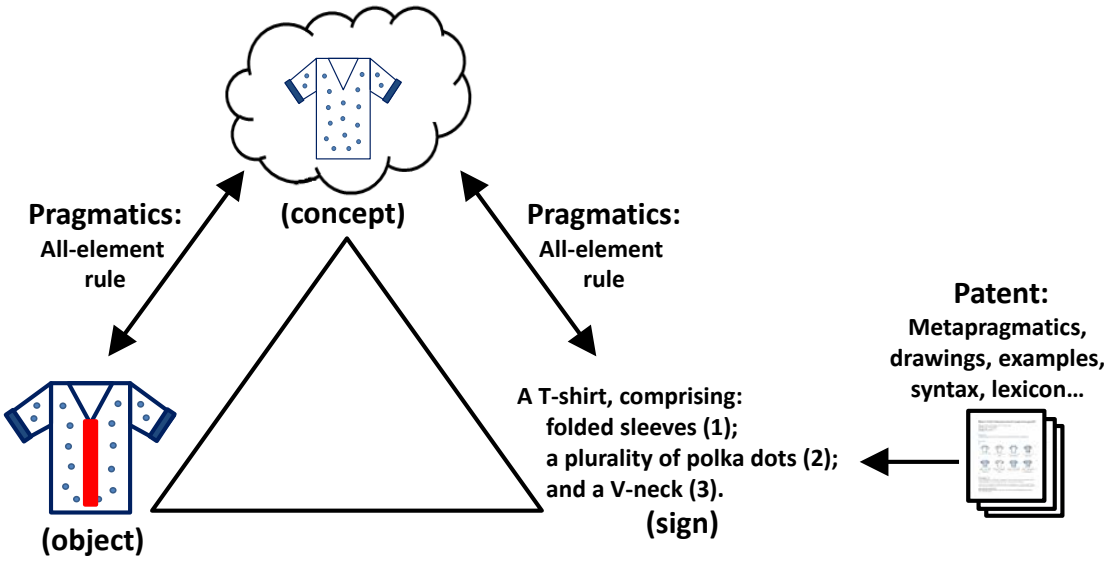


Figure 6.24: Claim interpretation based on semiotics, example of product (object) that is protected by the patent rights (concept) expressed by a claim (sign).

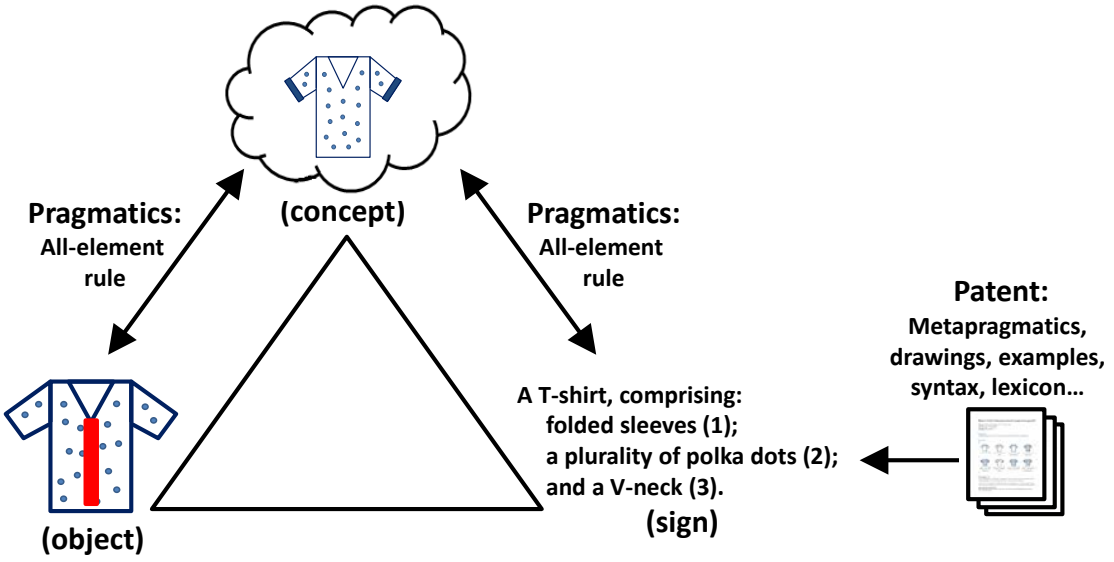


Figure 6.25: Claim interpretation based on semiotics, example of product (object) that is not protected by the patent rights (concept) expressed by a claim (sign).

6.12. Contributions of this chapter

In this chapter, we have discussed a semiotics approach to patent interpretation. This semiotics model of patent interpretation considers the all-claim-element rule, and it also considers that patents have more than one claim, providing layered protection. Sowa (J.F. Sowa, 2000) argues that a semiotic understanding produces consequences in modeling knowledge with metadata and ontologies. We think this is an interesting future line of research and we have already done some preliminary work (S.R.N.Reis et al, 2018) on modeling patent claims in ontologies. Explicitly describing the relation among claims is a contribution of our work concerning the ontology for patents proposed by Giereth et al (M. Giereth et al, 2007), which neither model individual claim elements nor model the relationship among multiple dependent claims. Our preliminary work (S.R.N.Reis et al, 2018) also makes some first steps to model claim elements and the relationships among multiple claims using description logics (N. Karam and A. Paschke, 2012) and deontic logic (A.J. Jones and M. Sergot, 1992). We believe that the semiotics discussion provided herein will provide a theoretical framework to further develop these preliminary contributions in (S.R.N.Reis et al, 2018) to exploit the relationship among ontology, metadata, and semiotics as highlighted by Sowa (J.F. Sowa, 2000).

This chapter has presented a semiotic approach for interpretation and understanding of patent documents. Next chapters of the thesis will present practical contributions derived from the approach proposed in this chapter: gamification approaches (chapter 7), patent quality metrics (chapter 8), evaluation of patents using the proposed metrics (chapter 9), knowledge modeling for patents (chapter 10) and a defense of the all-element rule (chapter 11).

7. Practical applications: gamification and sample questions

7.1. About this Chapter

This chapter discusses questions to investigate the understanding patents by the general public, by using gamification through synthetic examples. The questions are proposed to verify specific points about the semiotic understanding of patents presented in the previous chapter. In this chapter, gamification techniques are used to have some more direct questions. The proposed questions try to emulate issues that arise in real-life patents. For each presented question, it is discussed what the wrong and the right answers mean with respect to the proposed semiotic approach for patent interpretation.

The questions proposed in this chapter can have two types of application. One application is to diagnose points that are not understood by a person or a group of people. The second application is to use the questions to educate people, by exposing and correcting common misunderstandings.

This chapter is organized as follows. Section 7.2 presents an approach to gamification of patent learning by presenting a pair of a synthetic patent application and the corresponding synthetic granted patent. Section 7.3 presents questions considering the semiotic approach for patent interpretation presented in chapter 6.

7.2. Gamification through Synthetic Patent Examples

Gamification is the use of game elements in non-game contexts in order to engage people in different tasks of interest (Dicheva et al, 2015). An enabler of gamification is the creation of synthetic environments to focus the attention on the aspects to be discussed (Schultze et al, 2008). In this section we present a synthetic patent application and the corresponding synthetic granted patent.

7.2.1. A Synthetic Patent Application

A synthetic patent application is presented in appendix 1. It is based on the T-shirt examples used throughout this thesis. The claims of the patent application are similar to the ones discussed in chapter 6. However, a complete patent application has a broader context, provided by the abstract, drawings, description and claim sections viewed together as a whole. For reference, the claims in the application are presented in Fig. 7.1.

1. A T-shirt characterized by having folded sleeves.

2. A T-shirt characterized by having polka dots.

3. A T-shirt characterized by having V-neck".

Figure 7.1: Claims in the synthetic patent application of appendix 1.

7.2.2. Questions about the Synthetic Patent Application Example

The goal of the synthetic patent application presented in Annex 1 is to test and diagnose people about their knowledge about the role of each section of a patent application. One question about the coverage of the patent application is presented in Fig. 7.2.

	Covered by the patent?			Covered by the patent?	
	Yes?	No?		Yes?	No?
		**X**		**X**	

Figure 7.2: Questions about the coverage of the synthetic patent application in appendix 1.

Notice that the T-shirt on the left is not covered by the patent application. However, someone could think that it is covered, as a drawing of the T-shirt is present in the drawing section of the application. This would indicate a lack of knowledge about the role of each section, by believing that the drawings in the patent provide legal protection. As already discussed in previous chapters, the legal protection is determined by the claims. A larger set of question is presented in the appendix 2, while the answers to the proposed questions are presented in appendix 3.

7.2.3. A Synthetic Granted Patent

A synthetic granted patent is presented in appendix 4. It is also based on the T-shirt examples used throughout this thesis. The synthetic granted patent is based on the patent application of appendix 1. The main modification between the application and the granted patent is the claim section. As it happens in the case of real patents, the abstract, description and drawings remain unchanged. For reference, the claims in the synthetic granted patent are presented in Fig. 7.3. In order to see the changes, the granted claims (in Fig. 7.3) can be compared to the applied claims (in Fig. 7.1).

1. A T-shirt characterized by having folded sleeves.

2. A T-shirt according to claim 1 characterized by having polka dots.

3. A T-shirt according to claim 2 characterized by having V-neck.

Figure 7.3: Claims in the synthetic patent of appendix 3.

7.2.4. Questions about the Synthetic Granted Patent Example

Some questions about the coverage of the synthetic granted patent are presented in Fig. 7.4. These questions are made claim by claim, already inducing the idea that the claims provide

the scope of protection. By answering these questions, it is possible to test and diagnose the understanding of individual coverage of claims. A larger set of question is presented in the appendix 5. Answers to these questions are presented in appendix 6.

	Is covered by?							Is covered by?					
	Claim 1		Claim 2		Claim 3			Claim 1		Claim 2		Claim 3	
	y	n	y	n	y	n		y	n	y	n	y	n
		X		X		X		X			X		X
	X		X		X				X		X		X

Figure 7.4: Questions about the coverage of the synthetic granted patent in appendix 4.

7.3. Diagnosing Awareness about Patents

In this section a series of questions to diagnose awareness about patents is presented. The questions are indirectly based on the semiotic approach for the interpretation of patents, proposed in the previous chapter. Notice that the questions avoid direct references to the semiotic concepts used in the proposed approach for patent interpretation. The questions rather focus on the consequences of a good understanding of patents (indirectly based on the semiotic concepts), always using a gamification approach and synthetic examples to provide a context for the discussion of patents.

Considering the options below, what is the best choice for the first claim of a patent, in order for the invention claim to be broader?

- ○ a. A T-shirt characterized by having folded sleeves.
- ○ b. A T-shirt characterized by having polka dots, a V-neck and folded sleeves.
- ○ c. A T-shirt characterized by having polka dots and folded sleeves.

Figure 7.5: Question about the coverage of claims with different number of words.

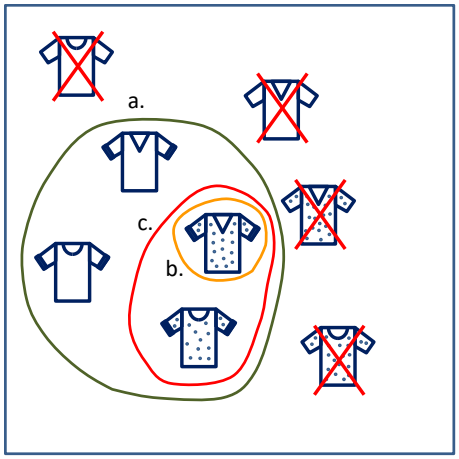


Figure 7.6: Understanding of patents needed to answer question in Figure 7.5.

7.3.1. Questions about the Number of Words in the First Claim

Increasing the number of elements in a claim adds more restrictions due to the all-element rule. This way, a claim with more words has narrower coverage, while a claim with fewer words has broader coverage. The question in Fig. 7.5 tests if a person is aware of this effect. The correct answer is given by option a.

The person answering correctly the question in Figure 7.5 has to mentally build an understanding as shown in Figure 7.6. From the standpoint of the all-element rule, this

understanding illustrates that option a is broader than option c which in turn is broader than option b. This happens accordingly the semiotic understanding of patents proposed in chapter 6. Notice that the question in Figure 7.5 does not ask directly about the approach proposed in chapter 6, but it asks about the consequences through a synthetic example.

7.3.2. Questions about the Number of Claims

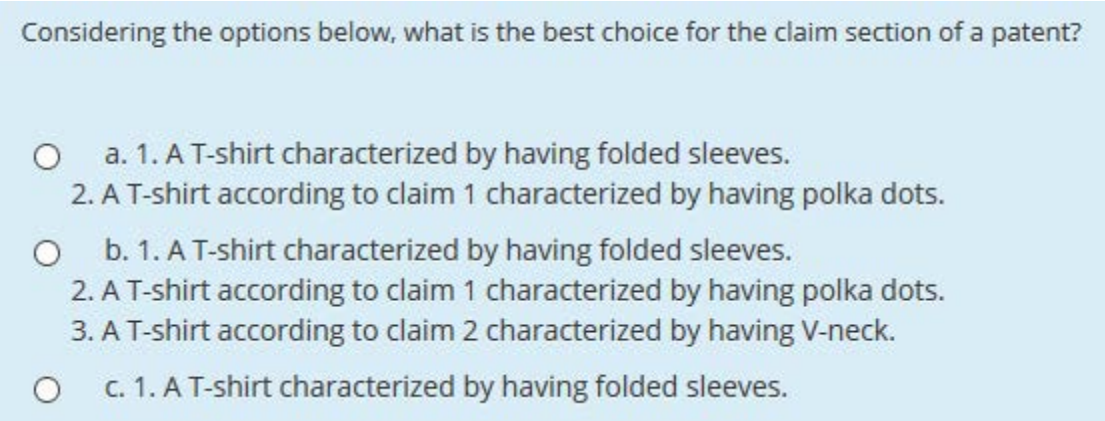
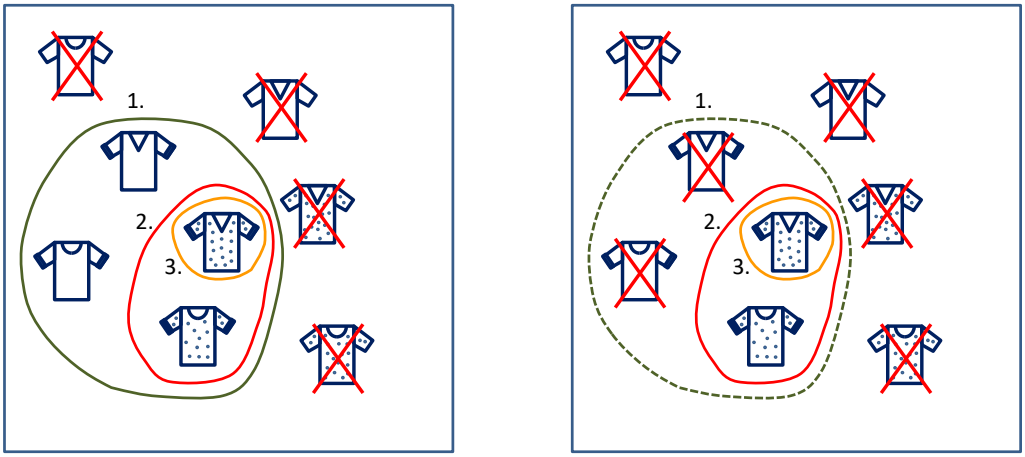


Figure 7.7: Question about the number of claims in a patent.

Increasing the number of claims in a patent adds robustness to the patent. This happens because each claim has a separate legal effect, and each claim can be individually invalidated in litigation. This way, a patent with more claims is more robust. Having more claims allow some of the (narrower) claims not to be invalidated even if some (broader) claims are invalidated. The question in Fig. 7.7 tests if a person is aware of this effect. The correct answer is given by option b, as it has a set of three claims, presenting therefore more claims compared to the other options in the question.

The fact that a patent has three claims provides a more complete protection, as each claim is a granted right in itself. For instance, as shown in Figure 7.8, claim 2 and 3 can still be valid, even when claim 1 is invalidated. However, there are situations where all the three claims can

be invalidated. For instance, as shown in Figure 7.9, if claim 3 is considered invalid, then claims 1 and 2 are also invalid. This happens because the T-shirts protected by claim 3 are also protected by claims 1 and 2. Therefore, if the T-shirts covered by claim 3 cannot be granted as a patent right, then claims 1 and 2 should not be granted, as claims 1 and 2 also cover the T-shirt for which no protection should be issued.



(a) All three original claims (b) Claim 1 invalid, claims 2 and 3 valid

Figure 7.8: Claims 2 and 3 can still be valid, even if claim 1 is invalid.

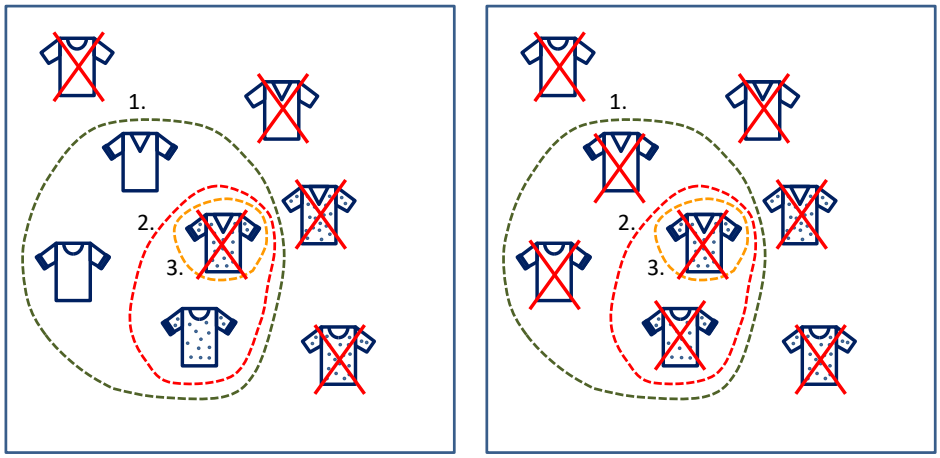


Figure 7.9: If claim 3 is invalid, then claims 1 and 2 are also invalid.

7.3.3. Questions about References to Figures in the Claims

Considering the options below, what is the best choice to refer to the drawings of the patent in the claims?

- ○ a. Write the claim as "A T-shirt characterized by having folded sleeves (1)" and indicate the folded sleeves in the drawing just with the label (1).
- ○ b. Write the claim as "A T-shirt characterized by having folded sleeves, as shown in Figure 3."
- ○ c. Write the claim as "A T-shirt characterized by having folded sleeves, as shown in Figure 3." and indicate the folded sleeves in the drawing.
- ○ d. Write the claim as "A T-shirt characterized by having folded sleeves (1) as shown in Figure 3." and indicate the folded sleeves in the drawing with the label "folded sleeves (1)".
- ○ e. Write the claim as "A T-shirt characterized by having folded sleeves (1)" and indicate the folded sleeves in the drawing with the label "folded sleeves (1)".

Figure 7.10: Question about the references to figures in the claims of a patent.

References to figures are necessary and should be made in a very specific way. The question in Figure 7.10 tests about the awareness on how references to figures should be made. The correct answer is given in option a. Notice that a good patent drawing makes only numeric references to features, as illustrated in Figure 7.11.

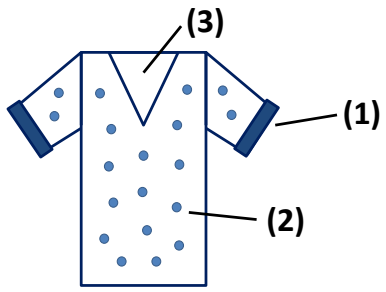


Figure 7.11: An example of a good patent drawing.

The options b, c and d in Figure 7.10 are not good as they make reference to the drawings with the text "*as shown in Figure 3*" and this is not allowed in the claims. The option e in Figure 7.10 is not good because it would add text to the Figures, which can make difficult to translate the patent to apply in different countries with different languages. This would require the figures to be redrawn with translated labels. Notice that the drawing in Figure 7.11 does not require translation.

7.3.4. Questions about Narrow Terms

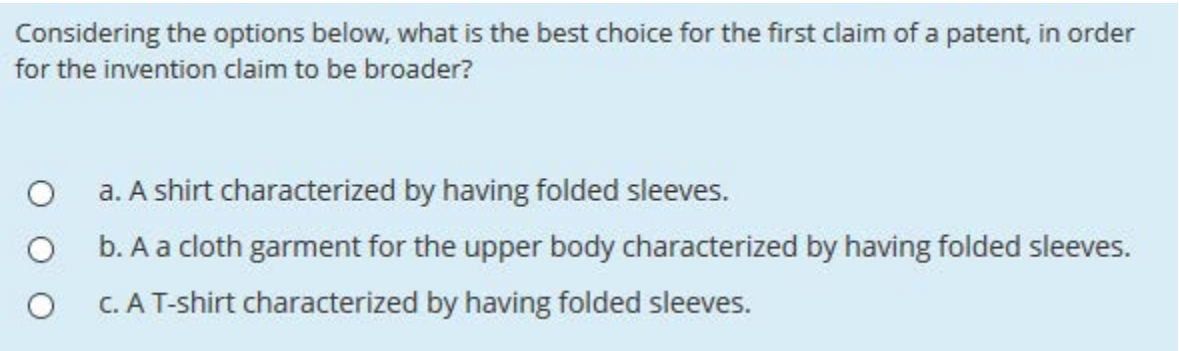


Figure 7.12: Question about the use of narrow or broad terms in the claim.

The use of broader terms to define the nature or the elements in a claim makes the claim itself broader. This way, a claim with narrower terms has narrower coverage, while a claim with broader terms has broader coverage. The question in Fig. 7.12 tests if a person is aware of this effect. The correct answer is given by option b. Notice that there is an apparent contradiction with using fewer words, but using more words is a good trade-off if the use of broader terms require increasing (a little) the number of words.

The use of broader terms makes the claimed invention broader. This is especially true for the nature of the invention, as it was made in the options of the question in Figure 7.12. In order to answer correctly the question in Figure 7.12, a person has to mentally build an

understanding like the one shown in Figure 7.13. Figure 7.13 illustrates that some of the claim natures can be broader than others. It is always good to choose the broadest possible nature, in order to add value to the patent.

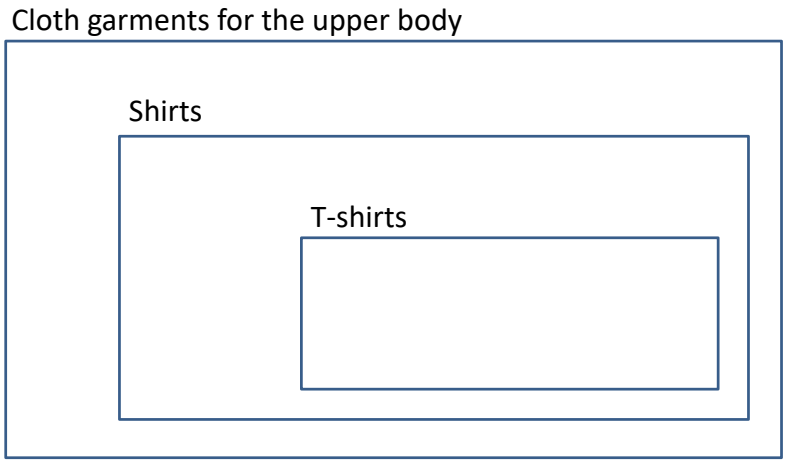


Figure 7.13: Question about the use of narrow or broad terms in the claim.

7.3.5. Questions about Claim Matter not Supported by Description

Only matter that is supported in the description can be claimed. This means that something that does not appear in the description cannot be introduced directly in a claim. Also, if something has already been described in the description, it does not need to be described again in the claims, just mentioned. The question in Fig. 7.14 tests if a person is aware of this effect. The correct answer is given by option c, as it describes the composition in the description section and mentions it in the claim. Further derived claims could mention the composition. The options a and b add details about the elastic fabric in the claims, these are restrictions that make the claims narrower. The option b is worst, as the details are provided only in the claim and are not provided in the description section.

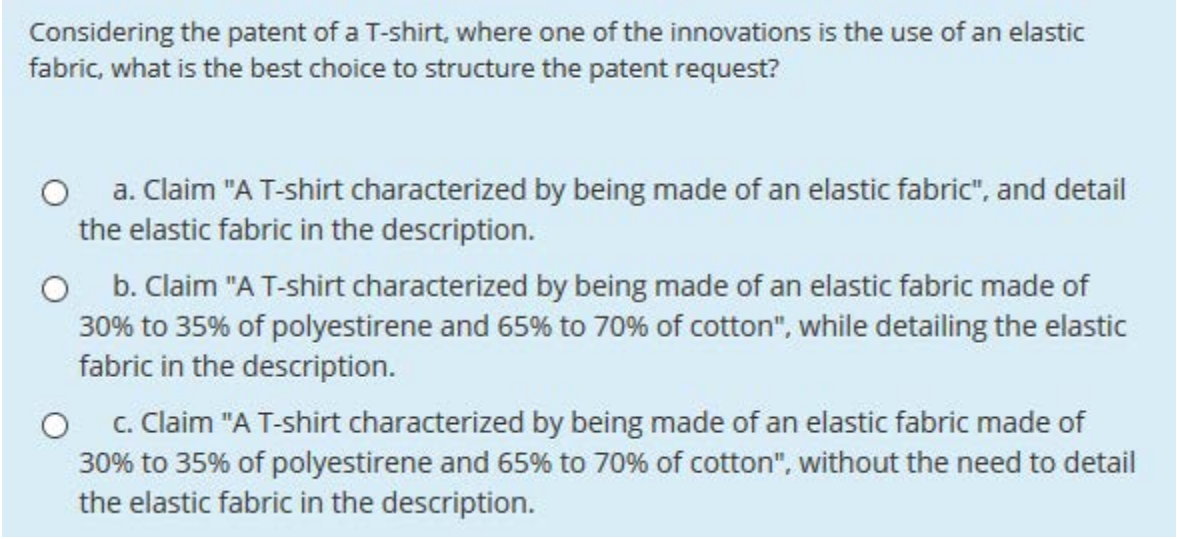


Figure 7.14: Question about the description support for the claim matter.

7.3.6. Questions about Use of Examples in the Claims

Examples are not allowed in the claims, only in the description section of a patent. Using examples in the claims is contamination by metapragmatics. The question in Fig. 7.15 is designed to test if a person is aware that examples are not allowed in the claims. The correct answer is given by option c. All the other options have examples in the claims, which can be perceived by the use of the words "*for instance*".

7.3.7. Questions about Definition of Terms in the Claims

The definition of terms is not allowed in the claims, only in the description section. Using definition in the claims is contamination of the text with metapragmatics. The question in Fig. 7.16 tests if a person is aware of this effect. The correct answer is given by option c. The other options have definitions in the claims, which can be detected by the wording "*defined as*" in the claims.

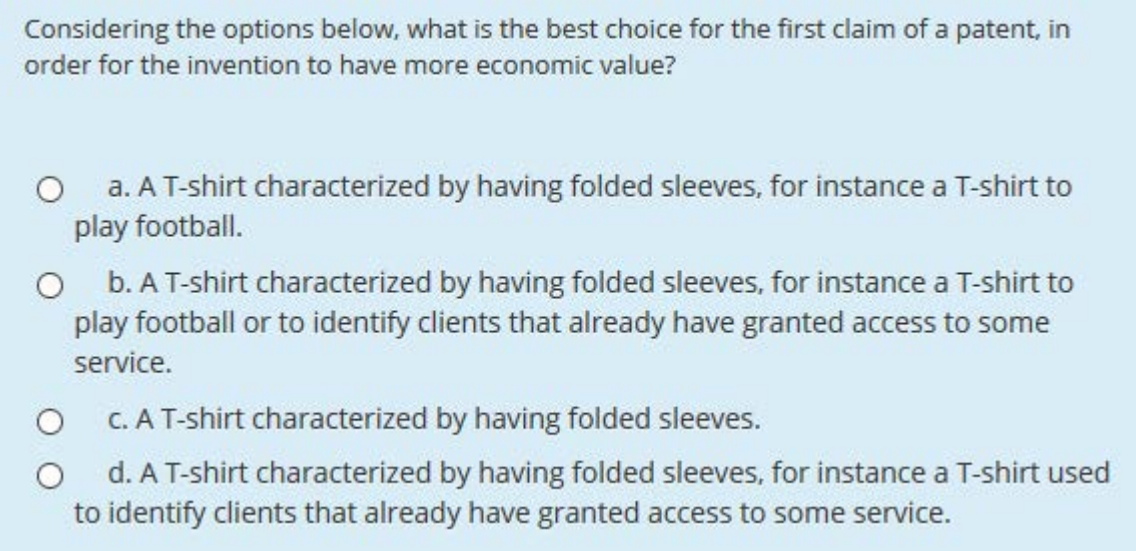


Figure 7.15: Question about the use of examples in the claim.

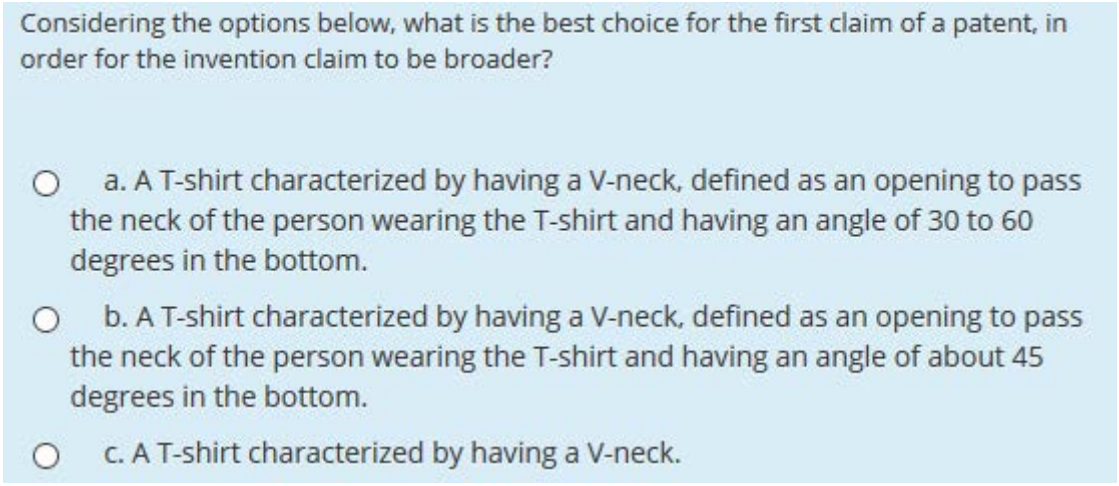


Figure 7.16: Questions about including the definition of terms in the claims.

7.4. Contributions of this chapter

This chapter has presented questions to diagnose the understanding of patents considering (indirectly) the semiotic approach for patent interpretation presented in chapter 6. Notice that

the proposed questions do not make direct reference to the semiotic concepts, but rather investigate awareness about the consequences of the proposed interpretation approach.

By using the type of questions proposed in this chapter, it is possible to evaluate knowledge about the main aspects concerning patent interpretation. The contribution of this chapter is to introduce these questions that can be applied to diagnose awareness and to educate people about patent interpretation. The introduced synthetic patent application and the corresponding synthetic granted patent allow using gamification approaches for diagnosing patent awareness and educating people about the main aspects involved in patent interpretation.

8. Practical Applications: Proposed Metrics to Evaluate Patent Quality

8.1. About this Chapter

This chapter proposes metrics for evaluating the quality of patents. These metrics are derived from the semiotics approach for patent interpretation presented in chapter 6.

This chapter is organized as follows. In section 8.2, a panorama of intellectual property from engineering journals is presented. This panorama has the goal to show the need for patent quality metrics. Section 8.3 discusses the main writing weaknesses in patents. Metrics to evaluate patents are proposed in section 8.4, where it is also discussed how each metric is able to detect some form of weakness in the writing of the patent.

8.2. A Panorama of Intellectual Property from Engineering Journals

In this section we review several articles on intellectual property published in computer engineering and computer science journals. This review aims to discover which concerns the community of computer engineering and computer science historically has, when considering intellectual property. These fields are the main focus area intended for this thesis, especially because it is the technical area of my co-advisors.

One of the concerns is the cost of patenting. Teska (Teska, 2008) states that:

> "patent attorneys charge between US $7000 and $15 000 to prepare and file a patent application". (Teska, 2008)

Loebner (Loebner, 2006) proposes that inventors prepare patent applications themselves, in order to reduce costs. However, the position defended in the article has some imprecisions,

for instance it seems that Loebner considers having the patent granted as a sufficient criteria of success. This is evidenced by the following statement:

> "I have been told that no one should apply for a patent without the help of a lawyer and that any inventor who does so is foolishly risking making a mistake that could cost him or her dearly. But I have six patents under my belt, and I wrote them and applied for all of them myself". (Loebner, 2006)

What Loebner is saying (in one of the most reputed engineering journals) is that as he got the patents granted, he has made no mistake and achieved patent success. However, having a patent granted does not mean success, as observed by Lemley (Lemley, 2001):

> "How much time and money should the Patent and Trademark Office spend deciding whether to issue a patent? To judge by recent criticism of the office from academics, industry leaders, and the press, the answer is "a lot more than it does now." The PTO has come under attack of late for failing to do a serious job of examining patents, thus allowing bad patents to slip through the system." (Lemley, 2001)

Lemley clearly warns that bad patents slip through the system. More than warning about this, Lemley also states that this situation makes sense from an economic point of view for the society:

> "The essential insight of this Essay stems from the little acknowledged fact that the overwhelming majority of patents are never litigated or even licensed. Because so few patents are ever asserted against a competitor, it is much cheaper for society to make detailed validity determinations in those few cases than to invest additional resources

examining patents that will never be heard from again. In short, the PTO doesn't do a very detailed job of examining patents, but we probably don't want it to." (Lemley, 2001)

So, according to Lemley, getting a patent granted by the patent office cannot be considered the only criteria of success. Still considering costs, Teska (Teska, 2009) makes an analysis of what he calls strategic patenting. The basic idea is to use a budget to construct a portfolio of patents covering distinct aspects of a product. In order to make a more focused discussion, Teska presents a table describing a hypothetical portfolio, which is reproduced here in Table 8.1. Although Teska presents an extensive discussion about patent strategy, the reproduction of Table 8.1 in the scope of the current work has the purpose to highlight that the cost of patents can vary from application from application. For instance, the patent described in line number 1 in Table 8.1 was granted with a cost of US$ 12 328; while the patent described in line number 2 in Table 8.1 has not been granted yet and has already costed US$ 16 291. Additionally, the expected costs to pursue and maintain the patent in the US and outside the US are also higher. This way, it is possible to conclude that patenting costs can vary among applications and that a higher cost does not guarantee a better result in terms of having the patent granted and issued.

Table 8.1: Table of three hypothetical patents extracted from Teska (Teska, 2009) discussion on strategic patenting.

line #	Patent No.	Status	Covers	Cost to date	Cost to pursue/maintain (US$)	
					U.S.	Non-U.S.
1	7214229	Issued	Overall functionality	$12 328	$8 265	$30 298
2	60/250936	Pending	User interface	$16 291	$15 391	$60 351
3	60/635891	Pending	Next-generation functionality	$8 641	$18 250	$60 451

According to Teska (Teska, 2009), the cost for a small business to obtain a patent in USA is around 10.000 dollars. Extending the patents to nine other countries will add a total cost ranging from $ 160.000 to $360.000 dollars. This makes the cost per patent vary in between

$17.700 to $40.000 dollars. Costs are given in dollars of the year 2002 in the original Government Accountability Office report (GAO, 2003), which is not cited by Teska.

> "A 2002 report by the U.S. Government Accountability Office, supplemented in 2003, estimated that getting a single patent in the United States and maintaining it for 20 years would cost a small business about US $10 000, and that extending that same patent to nine other countries would add between $160 000 and $360 000." (Teska, 2009)

Considering the high costs involved in obtaining a patent, Teska (Teska, 2009) advises to consider the "quality" of the patents. Only the patents with sufficient "strength" and "broadest coverage" should be pursued.

> "Also, consider the quality of the patent. Only a small fraction of all patents provide any real return on investment. Therefore, you must analyze the strength of the patent you are likely to obtain—which may well not be as broad in its coverage as the patent you have in the United States—and check your analysis with an expert." (Teska, 2009)

The terms quality, strength and broad coverage are used generically and they not specifically defined by Teska in his work. Fortunately, other authors discuss what makes the quality of a patent, so that we can discuss these terms in further detail. The main observation by Teska (Teska 2009) is that patent quality is related to patent value and the capacity to provide return of investment. Patent value is associated to patent quality and especially to the coverage provided by the patent. The portion of a patent that legally determines what the patent covers is the claim section. According to Osenga (Osenga, 2006):

> "It begins with a collection of words—a single sentence that can be worth thousands, or even millions, of dollars, or may instead be worth little more than the paper on which it is written; a sentence that can secure one company's financial future or spell another company's ruin. It all begins with the patent claim, a single sentence given the extraordinary function of designating the metes and bounds of an invention, providing notice to the public to advance technology, and providing notice to competitors to avoid trespass. The value of the sentence, whether financial or functional, often turns on the definition or construction given to the terms that comprise it. And yet, claim construction—the process of giving the claim meaning through defining its terms—is largely an unsettled and uncertain area of patent law." (Osenga, 2006)

The works of Rackman (Rackman, 1978), Emma (Emma, 2005) and Corcoran (Corcoran, 2015) discuss the importance of well written claims and the corresponding impact in the economic value of patents. Wang (Wang, 2008) discusses how to avoid infringement of specific patent claims. The interpretation of patent claims was extensively discussed in chapter 6. Next sections will discuss patent strength and propose quality metrics for patents.

8.2.1. Overview of the engineering view

As an overview of the engineering review, it must be noted that the notion that obtaining a patent seems to be the criteria of success. There is no discussion about the quality of patents, or what makes a patent weak or strong. In the following section, the main possible weaknesses of patents are discussed. After that, metrics are proposed to evaluate patent quality, in relation with the main weaknesses presented.

8.3. Possible Weaknesses in Patents

In this section, possible weaknesses in patents are discussed. Six different types of weaknesses are described in the next sub-sections. The idea of this section is to discuss possible weak points in patents, in order to later on propose metrics that highlight the occurrence of these weak points.

8.3.1. Too many elements in the first claim

Considering the all-element rule, a claim only covers products that present all claim-elements listed in the claim. As a consequence, claims with too many elements are easy to avoid possible claim infringement. This way, a first claim with too many claim-elements is a weak claim that can be easily avoided.

8.3.2. Too few claims

Each claim is an independent intellectual property right. In this sense, several claims in the same patent can be understood as a set of successive fences (or layers of defense) protecting an intellectual property right. Obviously, having more successive layers of protection provides a better protection. In most countries, the first ten claims are analyzed without paying extra fees. This way, it would make no sense to submit a patent without at least ten claims.

8.3.3. Claims that do not reference drawings

Claims must be supported by the description and drawings sections of the patent. As already pointed out in chapter 6, the description and drawings provide the metapragmatics

necessary to support and understand the claims. The use of references to the drawings in the claims helps to reinforce the understanding of the claims. Not using references to the drawings in the claims can be considered a weakness in patents, as not making these references to the drawings is to abdicate of the metapragmatics that the drawings provide to clarify the meaning of the claims.

8.3.4. Use of narrow terms as elements or as claim nature

Weak claims are associated with a narrow coverage. A narrow coverage occurs by using narrow terms in the claims. One example of word extensively used in patents to enlarge the scope of coverage is the word *apparatus*. This word is frequently used to define a broader nature for the claims.

8.3.5. Claim matter not supported by description

In order to claim an invention it must be disclosed. That means that the patent should teach the knowledgeable reader how to reproduce the invention. Claiming something that is not supported by a detailed description contemplating reproducibility is ground for rejecting the claim and the patent. This way, a patent with claims not supported by the description section are weak patents to the point of possibly not being granted.

8.3.6. Use of examples in the claim

Another weakness in patents is the use of examples in the claims. Examples do not describe what the example is or is not, in the sense that examples do not describe the characteristics of the invention. The claims are restricted to describe what the characteristics of the invention

are. In other words, the claims are restricted to list the essential elements of the invention. Claims containing examples are not admissible. Examples belong in the description section, not in the claims. This way, a patent (application) with claims comprising examples is a weak patent (application) as it contains claims that cannot be granted.

8.3.7. Definition of terms and concepts in the claims

Very similar to the use of examples in the claims described in the previous section, yet another weakness in patents is the definition of terms and concepts in the claims. The definition of terms and concepts in the claims do not describe what the example is or is not, in the sense that the definition of terms and concepts do not describe the characteristics of the invention. The claims are restricted to describe what are the characteristics of the invention are. In other words, the claims are restricted to list the essential elements of the invention. Claims containing the definition of terms and concepts inside the claim text are not a good strategy. The definition of terms and concepts in the claims belong in the description section, not in the claims. This way, a patent (application) with claims comprising the definition of terms and concepts in the claims is a weak patent (application) as it contains claims that could rely on the definition of terms and concepts in the description section.

8.4. Metrics to evaluate Patents

In this section, metrics to evaluate the quality of patents are proposed. Five different metrics are proposed in the next sub-sections. This section also discusses how to estimate the proposed metrics and what is evaluated by each specific metric.

8.4.1. Number of words in each claim

The first proposed metric is the number of words in each claim. In the following, the definition of the metric is provided and different aspects of this metric are discussed.

Definition 8.1: The **number of words in each claim** is defined as the number of words in the body of each claim (i.e. the words after the explicit or implicit "characterized by"), considering the words inherited from previous claims in the case of derived claims.

This metric can be evaluated to obtain an objective number, but the evaluation is still subjective to a certain degree. Figure 8.1 shows an example to discuss how to evaluate the metric. The example is taken from the synthetic patent from Appendix 3. Table 8.2 and Table 8.3 illustrate two different possible word counts for the example in Figure 8.1.

1. A T-shirt characterized by having folded sleeves.

2. A T-shirt according to claim 1 characterized by having polka dots.

3. A T-shirt according to claim 2 characterized by having V-neck.

Figure 8.1: Claims in the synthetic patent of appendix 3.

Looking at Table 8.2, the words considered for the first claim are "*having folded sleeves*", which results in a word count of 3, as shown in the table. The six words considered for claim 2 are "*having folded sleeves, having polka dots*", which considers the words inherited form claim 1, as claim 2 is derived (through the use of the words according to) from claim 1. This way, the number of words considered for claim 2 is 6, as shown in Table 8.2. Similarly, the number of words considered for claim 3 is 8.

Table 8.2: A first possible word count for the claims in Fig. 8.1.

Claim	Text considered	Number of words
Claim 1	having folded sleeves.	3
Claim 2	having folded sleeves, having polka dots.	6
Claim 3	having folded sleeves, having polka dots, having V-neck.	8

Looking at Table 8.3, the words considered for the first claim are again “having folded sleeves”, which results in a word count of 3, as shown in the table. However, the number of words for claim 2 is five and the number of words for claim 3 is six. It is possible to notice that the word count for derived claims (claims 2 and 3) is different when Table 8.2 is compared to Table 8.3. For this reason, the final number of words obtained for derived claims can have slight variations if redundant words are removed, making the final numbers for the metric slightly subjective. However, the relative order among derived claims is still maintained.

Table 8.3: A second possible word count for the claims in Fig. 8.1.

Claim	Text considered	Number of words
Claim 1	having folded sleeves.	3
Claim 2	having folded sleeves, polka dots.	5
Claim 3	having folded sleeves, polka dots, V-neck.	6

In order to understand how the metric is related to patent quality, it is necessary to interpret the metric. As discussed in chapter 6, according to the pragmatics provided by the all-element rule, all the elements in the claim are restrictions to the scope of the claimed invention, making it less general, with a reduced coverage. The idea behind this metric is the assumption that the more words a claim has, the more the claim is restricted by reciting different elements. As a reference, for the patents analyzed in this thesis, granted to UAB and

UFRGS by the USPTO, the smallest number of words is 22 and the largest is 250 (as it is presented in the next chapter).

8.4.2. Number of Claims: total, independent and derived

The second proposed metric is the number of claims (total, independent and derived) in the patent. In the following, the definition of the metric is given and different aspects of this metric are discussed.

Definition 8.2: The **number of claims (of a certain type)** in a patent is defined as the quantity of claims (of that type) in the patent being considered. Possible types of claims for this metric are total, independent and derived.

This metric can be evaluated to obtain an objective number. Figure 8.2 shows an example to discuss how to evaluate the metric.

1. A T-shirt characterized by having folded sleeves.

2. A T-shirt according to claim 1 characterized by having polka dots.

3. A T-shirt characterized by having V-neck.

Figure 8.2: A set of claims to discuss the number of claims as a metric.

The type of claims for the example in figure 8.2 is shown in Table 8.4. From the table, it is possible to see that the total number of claims is three, the number of independent claims is two (claims 1 and 3) and the number of derived claims is one (claim 2 is derived from claim 1).

Table 8.4: types of claims for the example in Figure 8.2.

Claim	Claim Text	Type
Claim 1	A T-shirt characterized by having folded sleeves.	Independent
Claim 2	A T-shirt *according to claim 1* characterized by having polka dots.	Derived (from claim 1)
Claim 3	A T-shirt characterized by having V-neck.	Independent

In order to understand how the number of claims is related to patent quality, it is useful to make the mental image of a claim as a wall (or fence) protecting the intellectual property. So the question is how many walls (claims) are necessary to protect the (intellectual) property? One possible answer is related to the number of claims that are admitted free of extra charges in a given country. For instance, in Brazil a patent examination includes ten claims without extra charges. This way, it does not seem wise to submit a Brazilian patent with less than the 10 claims that are free of extra charges. Before adding extra claims (beyond 10 in Brazil), it would be wise to reflect on the value added and the cost incurred to add extra claims. Similarly, the number of free claims in US is twenty while in Spain there is not a specific limit for free claims, which can potentially lead to abuses.

8.4.3. Number of references to drawings in each claim

The third proposed metric is the number of references to drawings in each claim. In the following, the definition of the metric is provided and different aspects of this metric are discussed.

Definition 8.3: The **number of references to drawings in each claim** is defined as the number of references to drawings in the body of each claim (i.e. the words after the explicit or implicit “characterized by”), considering the text inherited from previous claims in the case of derived claims.

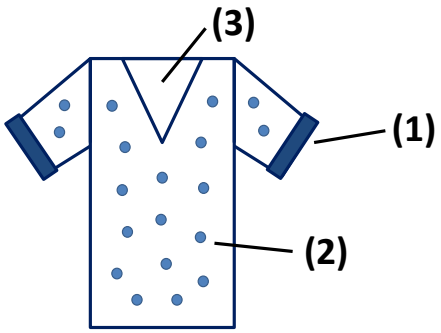


Figure 8.3: Example of a drawing illustrating a T-shirt with folded sleeves (1), polka dots (2) and V-neck (3).

In order to understand how the metric is computed, consider the claims in Table 8.5 that refer the T-shirt drawing presented in Fig. 8.3. Claim 1 has only one drawing reference, to folded sleeves (1). Claim 2 has two drawing references, one to folded sleeves (1) inherited from claim 1 and one to polka dots (2) directly in the text of the claim. Claim 3 has only one drawing reference, to V-neck (3). Claim 4 has three distinct drawing references. The first drawing reference in claim 4 is a reference to folded sleeves (1), inherited from claim 1 through claim 2. The second drawing reference in claim 4 is a reference to polka dots (2), inherited directly from claim 2. The third drawing reference in claim 4 is a reference to V-neck (3), directly in the text of the claim.

Table 8.5: a set of claims making references to the drawing in Figure 8.3.

Claim	Claim Text	Drawing References
Claim 1	A T-shirt having folded sleeves (1).	1
Claim 2	A T-shirt according to claim 1 having polka dots (2).	2
Claim 3	A T-shirt having V-neck (3).	1
Claim 4	A T-shirt according to claim 2 having V-neck (3).	3

Table 8.6: a set of claims making references to the drawing in Figure 8.3, with independent claims incorporating the text.

Claim	Claim Text	Drawing References
Claim 1	A T-shirt having folded sleeves (1).	1
Claim 2	A T-shirt having folded sleeves (1) and polka dots (2).	2
Claim 3	A T-shirt having V-neck (3).	1
Claim 4	A T-shirt having folded sleeves (1), polka dots (2) and V-neck (3).	3

In order to clarify the drawing references that happen by inheritance in derived claims, Table 8.6 presents the claims from Table 8.5 with derived claims written in the form of independent claims by incorporating the text from previous claims. From the rewritten claims presented in Table 8.6, the number of drawing references is straightforward.

In order to understand how the number of drawing references is related to patent quality, it is necessary to interpret the metric. As discussed previously, the use of references to the drawings in the claims helps to reinforce the understanding of the claims. Not using references to the drawings in the claims can be considered a weakness in patents, as not making these references to the drawings is to abdicate of the metapragmatics that the drawings provide to clarify the meaning of the claims.

8.4.4. Broadness of the claim nature

The fourth proposed metric is an index to measure the broadness of the claim nature. In the following, the definition of the metric is provided and different aspects of this metric are discussed.

Definition 8.4: The index to measure the **broadness of the claim nature**, as a metric proposed herein, is defined as a number between 0 and 5 that expresses how broad is the

nature of the claim. The number is assigned such that a higher number represents a broader claim nature (compared to lower numbers).

This metric cannot be evaluated to obtain an objective number; the evaluation will be therefore subjective. Figure 8.4 shows a possible taxonomy of clothing terms illustrating that the word garment is broader than the term T-shirt. This happens because garments include shirts, dresses and overalls, while T-shirts are a specific type of shirts. Figure 8.5 shows the claims from Fig. 8.1 rewritten with "a garment" as the nature instead of "a T-shirt" as the nature. Simply using the word garment as the nature in the claims makes the claims in Figure 8.5 more general than the claims in Figure 8.1, as now the claims can cover dresses, overalls and other garments, besides T-shirts.

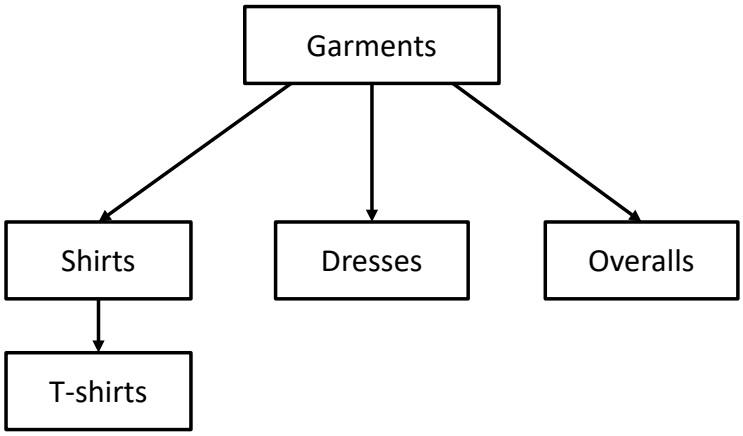


Figure 8.4: A taxonomy of clothing items.

1. A garment characterized by having folded sleeves.

2. A garment according to claim 1 characterized by having polka dots.

3. A garment according to claim 2 characterized by having V-neck.

Figure 8.5: The claims from Fig. 8.1 rewritten with "*a garment*" as the nature instead of "*a T-shirt*" as the nature.

As it was discussed previously, the broadness of the claim nature (definition 8.4) is a subjective metric. In this sense, it will depend on the person that evaluates the metric. Table 8.7 illustrates several alternative different claim natures and evaluates the metric for each nature. A justification is provided for each evaluation. From the justifications in Table 8.7, it is possible to see how the relative broadness of claim natures can be evaluated by using the proposed metric.

Table 8.7: evaluation of the metric for the broadness of the claim nature (definition 8.4) for some alternative claim natures.

Nature	Evaluation	Justification
Short sleeve T-shirt	1	Restriction of a T-shirt to have short sleeves.
T-shirt	2	T-shirt, a type of shirt that acts as a restriction.
Polo shirt	2	Polo shirt, a type of shirt that acts as a restriction.
Shirt	3	All types of shirts.
Cloth garment for the upper body	4	Includes garments that are not shirts, but restricted to cloth and for the upper body.
Garment	5	All types of garments.

8.4.5. Description Support for Claim Matter

The fifth proposed metric is an index to measure the support for claim matter provided in the description. In the following, the definition of the metric is provided and different aspects of this metric are discussed.

Definition 8.5: The index to measure **description support for claim matter**, as a metric proposed herein, is defined as a number between 0 and 5 that expresses how well the description section supports the matter claimed by each claim. The number is attributed such

that higher numbers represent better support of the claim matter by the description section of the patent.

Table 8.8: evaluation of the metric for the description support for claim matter (definition 8.5) for some alternative sets of claims.

ID	Evaluation	Claims
ID1	0	1. A garment characterized by having long sleeves. 2. A garment according to claim 1 characterized by having stripes. 3. A garment according to claim 2 characterized by having turtleneck.
ID2	2	1. A garment characterized by having sleeves brought into a compact form by bending and laying parts together. 2. A garment according to claim 1 characterized by having a pattern consisting of an array of large filled circles of the same size. 3. A garment according to claim 2 characterized by having V-shaped opening for the neckline.
ID3	3	1. A garment characterized by having sleeves (1) brought into a compact form by bending and laying parts together. 2. A garment according to claim 1 characterized by having a pattern consisting of an array of large filled circles of the same size (2). 3. A garment according to claim 2 characterized by having V-shaped opening for the neckline (3).
ID4	4	1. A garment characterized by having folded sleeves. 2. A garment according to claim 1 characterized by having polka dots. 3. A garment according to claim 2 characterized by having V-neck.
ID5	5	1. A garment characterized by having folded sleeves (1). 2. A garment according to claim 1 characterized by having polka dots (2). 3. A garment according to claim 2 characterized by having V-neck (3).

As it was discussed previously, the description support for claim matter (definition 8.5) is a subjective metric. In this sense, it will depend on the person that evaluates the metric. Table 8.8 illustrates several sets of claims for which the description support for the claims was evaluated. The first column (labeled ID), presents the identification code (ID1 to ID5) of the set of claims, so that it is possible to refer to each set of claims in the text. The second column (labeled evaluation) presents the evaluation attributed to the metric. The third column,

presents each set of claims. Notice that the metric to be evaluated is the support given by the description section. For doing so, it is necessary to have a description section to compare against the claims. For the evaluation presented in Table 8.8, the description section of the synthetic patent in appendix 2 is considered. In the following we discuss the evaluation of the five sets of claims in Table 8.8.

The first set of claims (ID1) is evaluated to zero, as the description does not mention long sleeves, stripes or turtleneck. These words appear only in the claim, which is obviously not supported by the description.

The second set of claims (ID2) is evaluated to two, as the description section mentions folded sleeves, polka dots and V-neck. However, in the claims, more vague descriptions of these terms appear for the first time instead of the terms defined in the description section. This way, it is not immediately clear that "*sleeves brought into a compact form by bending and laying parts together*" are in fact folded sleeves. The same is true for the wording "*a pattern consisting of an array of large filled circles of the same size*", meaning polka dots and the wording "*V-shaped opening for the neckline*", meaning V-neck. The third set of claims (ID3) is evaluated to three, as it has the same wording and consequently the same problems as the second set (ID2), but the claims are better supported by the description through the references to the figures.

The fourth set of claims (ID4) is evaluated to four, as the description explicitly mentions folded sleeves, polka dots and V-neck. These words are used in the claim, which is obviously well supported by the description. However, the claims do not refer to the drawings, so the evaluation is not the highest grade. Finally, the fifth set of claims (ID5) is evaluated to the maximum grade of five, as the claims have the same wording than the fourth set of claims (ID4), but it is improved by the references to the figures.

8.4.6. Absence of Metapragmatics in the Claims

The sixth proposed metric is an index to measure the absence of metapragmatics in the claims. In the following, the definition of the metric is provided and different aspects of this metric are discussed.

Definition 8.6: The index to measure the **absence of metapragmatics in the claims**, as a metric proposed herein, is defined as a number between 0 and 5 that expresses how well the claim describes the substance of the invention, without including metapragmatics. The number is attributed such that higher numbers represent that the claims are free from metapragmatics, while low numbers represent that the claims are contaminated with metapragmatics.

As it was discussed previously, the absence of metapragmatics in the claims (definition 8.6) is a subjective metric. In this sense, it will depend on the person that evaluates the metric. Table 8.9 illustrates several sets of claims for which the absence of metapragmatics in the claims was evaluated. In the following we discuss the evaluation of the five sets of claims in Table 8.9.

The first set of claims (ID1) is evaluated to zero, as the claims are contaminated with definitions and examples (that belong in the description section). The second set of claims (ID2) is evaluated to one, as the claims are contaminated only with examples. The third set of claims (ID3) is evaluated to three, as the examples were rephrased as a claim element (that restricts the claim). Claims containing examples receive a low evaluation as they cannot be granted and will not be allowed by the examiner. The fourth set of claims (ID4) is evaluated to four, as the claims are contaminated only with definitions, which can be allowed by some examiners. The fifth set of claims (ID5) receives maximum grade, as it is free from metapragmatics.

Table 8.9: evaluation of the metric for the absence of metapragmatics in the claims (definition 8.6) for some alternative sets of claims.

ID	Evaluation	Claims
ID1	0	1. A garment characterized by having folded sleeves, where folded sleeves **are defined** as sleeves brought into a compact form by bending and laying parts together, where the garment can be used **for instance** to play different sports such as volleyball or basketball or football, **etc**. 2. A garment according to claim 1 characterized by having polka dots, where polka dots **are defined** as a pattern consisting of an array of large filled circles of the same size. 3. A garment according to claim 2 characterized by having V-neck, where V-neck **is defined** as a V-shaped opening for the neckline.
ID2	1	1. A garment characterized by having folded sleeves, where the garment can be used **for instance** to play different sports such as volleyball or basketball or football, **etc**. 2. A garment according to claim 1 characterized by having polka dots. 3. A garment according to claim 2 characterized by having V-neck.
ID3	3	1. A garment characterized by having folded sleeves, where the garment is used to play a sport chosen from a group comprising volleyball and basketball and football. 2. A garment according to claim 1 characterized by having polka dots. 3. A garment according to claim 2 characterized by having V-neck.
ID4	4	1. A garment characterized by having folded sleeves, where folded sleeves **are defined** as sleeves brought into a compact form by bending and laying parts together. 2. A garment according to claim 1 characterized by having polka dots, where polka dots **are defined** as a pattern consisting of an array of large filled circles of the same size. 3. A garment according to claim 2 characterized by having V-neck, where V-neck **is defined** as a V-shaped opening for the neckline.
ID5	5	1. A garment characterized by having folded sleeves. 2. A garment according to claim 1 characterized by having polka dots. 3. A garment according to claim 2 characterized by having V-neck.

8.5. Contributions of this chapter

This chapter presented a set of metrics to evaluate the quality of patents. The metrics were based in the semiotic approach to patent interpretation presented in chapter 6. The metrics were illustrated with synthetic examples proposed for gamification in chapter 7. Next chapter will evaluate the proposed metrics on real life patents granted to UAB and UFRGS.

9. Practical Applications: Evaluating Patents with Proposed Metrics

9.1. About this Chapter

In the previous chapter, several metrics to evaluate patent quality were proposed. In this chapter, the proposed metrics are applied to evaluate practical examples of patents. The examples chosen are patents applied and granted by UAB and UFRGS at the United States Patent Office. This choice was done to limit the evaluated patents to a manageable number. The goal of this chapter is to demonstrate the applicability of the proposed quality metrics to real life examples of patents.

9.2. UAB Patents and applications

The UAB patents chosen for the analysis are the ones in USPTO that have “Universitat Autonoma de Barcelona” as assignee. That means the patents that are owned or at least co-owned by UAB.

A search in the USPTO returns sixteen different granted patents with UAB as assignee. These patents are listed in Table 9.1. The table is organized in three columns. The first column, labeled ID, presents an identifier to refer to the patent in the text. The second column presents the number of the granted patent; this number can be used to search the patent in the USPTO. The third column presents the title of the patent. In the following two subsections, two patents are evaluated in detail, the ones labeled UAB13 and UAB11 in Table 9.1. In section 9.4, a general panorama for all sixteen UAB patents is presented in comparison to UFRGS patents.

Table 9.1. Patents granted to UAB in the United States.

ID	Patent	Title
UAB1	8685413	Heterologous protection against Pasteurella multocida provided by P. multocida fur cells and the outer-membrane protein extracts thereof
UAB2	8906642	Methods and compositions for the treatment and diagnosis of haemorrhagic conversion
UAB3	9226518	Salmonella bacteriophage compositions and uses thereof
UAB4	6137029	PEPCK-insulin gene construct and transgenic mouse
UAB5	9192190	Continuous system and procedure of sterilization and physical stabilization of pumpable fluids by means of an ultra-high pressure homogenization
UAB6	6432676	Chimeric gene using the gene or cDNA of insulin, specially for the gene therapy of diabetes
UAB7	10156565	Peptide, magnetic peptide and method for detecting celiac disease
UAB8	6379959	Metalocarboxypeptidase inhibitors and derived molecules used as antitumor agents
UAB9	9678032	Chemometric analysis of chemical agents using electrochemical detection and classification techniques
UAB10	9744247	Functionalized liposomes useful for the delivery of bioactive compounds
UAB11	9416373	Biogas production
UAB12	8999994	Derivatives of propargylamine having neuroprotective capacity for the treatment of Alzheimer's and Parkinson's diseases
UAB13	7573734	Magnetoelectric device and method for writing non-volatile information into said magnetoelectric device
UAB14	9199007	Use of gelled PRP (platelet gel) for volumetric breast reconstruction
UAB15	9580468	Methods and reagents for efficient and targeted delivery of therapeutic molecules to CXCR4 cells
UAB16	9492509	Apotransferrin for the treatment of brain stroke

9.2.1. United States Patent 7573734 - Magnetoelectric device

In this section the patent labeled UAB13 in Table 9.1 is analyzed. The patent number is 7573734, and the complete title is “Magnetoelectric device and method for writing non-volatile information into said magnetoelectric device”. The corresponding patent application is numbered 20090016097 and it has the same title as the granted patent. The first claim of the patent application is shown in Figure 9.1.

> 1. A device comprising at least a first ferromagnetic layer (202) and an element (204) exchange-bias coupled to this layer in at least one place through an interface (208), for controlling the magnetic state of the ferromagnetic layer (202) in the coupling place with an electrical field applied at least on the element, the element comprising a material with clamped antiferromagnetic and ferroelectric characteristics.

Figure 9.1: Claim submitted in Patent Application US20090016097 (J.F.I. Grino et al, 2009a).

The first claim in the granted patent is shown in Figure 9.2. The granted claim is exactly the same as the claim in the patent application. This indicates a good initial writing of the patent, as the first claim was granted as applied.

> 1. A device comprising at least a first ferromagnetic layer (202) and an element (204) exchange-bias coupled to this layer in at least one place through an interface (208), for controlling the magnetic state of the ferromagnetic layer (202) in the coupling place with an electrical field applied at least on the element, the element comprising a material with clamped antiferromagnetic and ferroelectric characteristics.

Figure 9.2: Claim as granted in Patent US7573734 (J.F.I. Grino et al, 2009b).

Table 9.2: Evaluation of the proposed metrics for patent US7573734 (J.F.I. Grino et al, 2009b).

Metric	Evaluation
Number of words in the first claim of the application	61
Number of words in the first claim of the granted patent	61
Number of claims (total, independent and derived) in the application	16 - 2 - 14
Number of claims (total, independent and derived) in the granted patent	16 - 2 - 14
Number of references to drawings in the first claim	4
Broadness of the claim nature	5
Support for claim matter provided in the description	5
Absence of metapragmatics in the claims	5

The evaluations of the proposed metrics for the patent are presented in Table 9.2. The number of words is presented only for the first claim that has 61 words. This is a low number of words[1], indicating that the invention was well claimed without adding too many restrictive elements. The number of claims is 16 for both the patent application and the granted patent.

[1] Compared to the 88.2 average number of words in the first claim for the granted UAB patents studied in this work.

There are two independent claims in the patent and in the application. Claim 1 is an independent claim with a device nature; it has seven derived claims. Claim 9 is an independent claim with a method nature; it has seven derived claims. The claims have references to drawings, for instance, claim 1 has four references to drawings, as shown in Figure 9.2. The nature of the claims are very broad (device for eight claims and method for eight claims), so the broadness is evaluated to five. The claims are well supported by the description and free from metapragmatics, so the last two metrics in Table 9.2 also evaluate to five.

9.2.2. United States Patent 9416373 - Biogas production

In this section the patent labeled UAB11 in Table 9.1 is analyzed. The patent number is 9416373, and the complete title is “Biogas Production”. The corresponding patent application is numbered 20140017753 and it has the same title as the granted patent. The first claim of the patent application is shown in Figure 9.3.

> 1. A process for the production of biogas from biodegradable material which comprises the steps of: (a) adding a biodegradable material to the reactor; (b) inoculating a microorganisms; (c) adding a colloidal solution of surface-modified iron oxide nanoparticles to the reactor; (d) providing anaerobic conditions; (e) carrying out an anaerobic digestion; (f) collecting the biogas; wherein the steps (a), (b) and (c) can be carried out in any order.

Figure 9.3: Claim submitted in Patent Application US20140017753 (V.Franco Puntes et al, 2014).

The first claim in the granted patent is shown in Figure 9.4. The granted claim has modifications compared to the claim in the patent application. The differences are highlighted in Figure 9.5.

1. A process for producing biogas from biodegradable material which comprises the steps of: (a) adding a biodegradable material to a reactor; (b) inoculating a microorganism; (c) adding a colloidal solution of surface-modified iron oxide nanoparticles to the reactor, wherein the diameter of the surface-modified iron oxide nanoparticles is between 3 nm and 30 nm; (d) providing anaerobic conditions; (e) carrying out an anaerobic digestion; (f) collecting the biogas; wherein the steps (a), (b) and (c) can be carried out in any order.

Figure 9.4: Claim granted in Patent 9416373 (V. Franco Puntes et al, 2016).

The first three differences are due to corrections in the English language. The definite article "the" should be used only for elements already mentioned in the claim. The production and the reactor were not mentioned before, so the definite article "the" is removed in the granted claim. The fourth difference is the addition of a new element "*wherein the diameter of the surface-modified iron oxide nanoparticles is between 3 nm and 30 nm*". This element was added due to prior art, and it makes the invention novel. This means that according to the examiner, this element is necessary to make the claimed invention new with respect to prior art.

1. A process for ~~the production of~~producing biogas from biodegradable material which comprises the steps of: (a) adding a biodegradable material to ~~the~~a reactor; (b) inoculating a ~~microorganisms~~microorganism; (c) adding a colloidal solution of surface-modified iron oxide nanoparticles to the reactor, wherein the diameter of the surface-modified iron oxide nanoparticles is between 3 nm and 30 nm; (d) providing anaerobic conditions; (e) carrying out an anaerobic digestion; (f) collecting the biogas; wherein the steps (a), (b) and (c) can be carried out in any order.

Figure 9.5: Differences between claim submitted in Patent Application US20140017753 (V.Franco Puntes et al, 2014) and claim granted in patent US9416373 (V.Franco Puntes et al, 2016).

The evaluations of the proposed metrics for the patent are presented in Table 9.3. The number of words is presented only for the first claim that has 66 words for the application and 80 words for the granted patent. This is a low number of words[2], indicating that the invention was well claimed without adding too many restrictive elements. The number of claims is 19 for the patent application and 18 for the granted patent. There are two independent claims in the patent and in the application.

Considering the application US20140017753 (V. Franco Puntes et al, 2014), claim 1 is an independent claim with a process nature; it has twelve derived claims. Claim 8 is an independent claim with a method nature; it has five derived claims. So, the total number of claims is nineteen, with two independent claims and seventeen derived claims. Considering the granted patent US9416373 (V. Franco Puntes et al, 2016), claim 1 is an independent claim with a process nature; it has twelve derived claims. Claim 8 is an independent claim with a method nature; it has four derived claims. So, the total number of claims is eighteen, with two independent claims and sixteen derived claims.

Table 9.3: Evaluation of the proposed metrics for patent US9416373 (V. Franco Puntes et al, 2016).

Metric	Evaluation
Number of words in the first claim of the application	66
Number of words in the first claim of the granted patent	80
Number of claims (total, independent and derived) in the application	19 - 2 - 17
Number of claims (total, independent and derived) in the granted patent	18 - 2 - 16
Number of references to drawings in the first claim	0
Broadness of the claim nature	5
Support for claim matter provided in the description	4
Absence of metapragmatics in the claims	5

[2] Compared to the 88.2 average number of words in the first claim for the granted UAB patents studied in this work.

The claims have no references to drawings. For instance, claim 1 has no references to drawings, as shown in Figure 9.3 and Figure 9.4. This way, the number of references to drawings in the first claim is zero, as shown in Table 9.3.

The natures of the claims are very broad (process for thirteen claims and method for six or five claims). This way, the broadness of the claim nature is evaluated to five.

The claims are well supported by the description but have no reference to drawings, so the support for claim matter provided in the description is evaluated to 4, due to the lack of references to drawings. The claims are free from metapragmatics, so the absence of metapragmatics in the claims is evaluated to five in Table 9.3.

9.3. UFRGS Patents and applications

The UFRGS patents chosen for the analysis are the ones in USPTO that have “Universidade Federal do Rio Grande do Sul” as assignee. That means the patents that are owned or at least co-owned by UFRGS.

A search in the USPTO returns 19 different granted patents with UFRGS as assignee. These patents are listed in Table 9.4. The table is organized in three columns. The first column, labeled ID, presents an identifier to refer to the patent in the text. The second column presents the number of the granted patent; this number can be used to search the patent in the USPTO. The third column presents the title of the patent. In the following two subsections two patents are evaluated in detail, the ones labeled UFRGS8 and UFRGS18 in Table 9.4. In section 9.4, a general panorama for all nineteen UFRGS patents is presented in comparison to the sixteen UAB patents.

Table 9.4. Patents granted to UFRGS in the United States.

ID	Patent	Title
UFRGS1	9695254	Metallocene catalyst supported by hybrid supporting means, process for producing same, polymerization process for producing an ethylene homopolymer or copolymer with broad or bimodal molar mass distribution, use of the supported metallocene catalyst and ethylene polymer with broad or bimodal molar mass distribution
UFRGS2	9700054	Active and intelligent additive, polymer and article
UFRGS3	9988465	Metallocene catalyst supported by hybrid supporting means, process for producing same, polymerization process for producing an ethylene homopolymer or copolymer with broad or bimodal molar mass distribution, use of the supported metallocene catalyst and ethylene polymer with broad or bimodal molar mass distribution
UFRGS4	9994648	Metallocene catalyst supported by hybrid supporting means, process for producing same, polymerization process for producing an ethylene homopolymer or copolymer with broad or bimodal molar mass distribution, use of the supported metallocene catalyst and ethylene polymer with broad or bimodal molar mass distribution
UFRGS5	10144817	Active and intelligent additive, polymer and article
UFRGS6	9181143	Process for the production of olefins and use thereof
UFRGS7	10030130	Polystyrene and polylactic acid blends
UFRGS8	8730817	Methods and apparatus to determine network link weights
UFRGS9	9868677	Process for obtaining a formulation with fertilizing and phytoprotective capability, a formulation with fertilizing and phytoprotective capability, use of a formulation with fertilizing and phytoprotective capability
UFRGS10	8993775	Chromium and nickel catalysts for oligomerization reactions and process for obtaining alpha-olefins using said catalysts
UFRGS11	9782360	Fluorinated CBD compounds, compositions and uses thereof
UFRGS12	10016350	Nanoparticle system comprising oil and UV filter
UFRGS13	9687554	Finasteride and minoxidil polymeric nanoparticle its process of preparation, aqueous suspension containing the same, pharmaceutical composition, and its use
UFRGS14	9968533	Nanoparticle system comprising oil and UV filter
UFRGS15	9895302	Finasteride polymeric nanoparticle, aqueous suspension containing the same, composition for the treatment of alopecia, process of preparation of said composition, and its use
UFRGS16	8568788	Nanoparticulated anesthetic composition for topic use
UFRGS17	9580838	Process for producing polymeric structures that have activated surfaces and activated polymeric structures
UFRGS18	9063111	Hybrid chemical sensor, and, sensitive polymeric composition
UFRGS19	9447019	Fluorinated CBD compounds, compositions and uses thereof

9.3.1. United States Patent 8730817 - Methods and apparatus to determine network link weights

In this section the patent labeled UFRGS8 in Table 9.4 is analyzed. The patent number is US8730817, and the complete title is “Methods and apparatus to determine network link

weights". The corresponding patent application is numbered US20120140636 and it has the same title as the granted patent. The first claim of the patent application is shown in Figure 9.6.

The first claim in the granted patent is shown in Figure 9.7. The granted claim has modifications compared to the claim in the patent application. The differences are highlighted in Figure 9.8.

1. A method to determine link weights for routing in a communication network, the method comprising: iteratively updating a plurality of vectors using a genetic algorithm, the vectors including a plurality of individual values decodable into possible link weights; and decoding a first one of the vectors updated using the genetic algorithm into a first plurality of link weights providing a possible routing of a load through the communication network, the load to be split among a plurality of paths having respective path lengths determined from the plurality of link weights, at least two of the paths having different path lengths.

Figure 9.6: Claim submitted in Patent Application US20120140636 (M.G.C. Resende et al, 2012).

1. A method to determine link weights in a communication network, the method comprising: iteratively updating a plurality of vectors using a genetic algorithm, the vectors including a plurality of individual values decodable into possible link weights; and decoding a first one of the vectors updated using the genetic algorithm into a first plurality of link weights providing communication network, the load to be split among a plurality of paths having respective path lengths determined from the first plurality of link weights, at least two of the paths having different path lengths, wherein iteratively updating the plurality of vectors further comprises: partitioning the plurality of vectors into a first group of vectors and a second group of vectors based on routing costs associated with the vectors; and randomly combining a first subset of the first group of vectors and a second subset of the second group of vectors based on a crossover probability.

Figure 9.7: Claim granted in Patent US8730817 (M.G.C. Resende et al, 2014).

The first difference is a correction to remove the text "*for routing*" because it is associated to metapragmatics, which is not admissible. That means that the claimed nature is "*a method to determine link weights in a communication network*". The fact that the link weights are "*for routing*" expresses finality, and finality (in the sense of purpose or use) is not material to the invention, but is rather metapragmatics.

The second difference is the removal of the optional element "*a possible routing of a load through*". This change was made as optional elements are conflicting with the idea of mandatory elements under the all-element rule.

The third difference is the addition of the word "*first*" before "*plurality of link weights*", as the prior mention was made with the word "*first*" as a qualifier. This makes clear that the mention refers to the "*first plurality of link weights*" mentioned before in the claim and not to a second plurality of link weights.

The fourth difference is the addition of a new element "*wherein iteratively updating the plurality of vectors further comprises: partitioning the plurality of vectors into a first group of vectors and a second group of vectors based on routing costs associated with the vectors; and randomly combining a first subset of the first group of vectors and a second subset of the second group of vectors based on a crossover probability*". This element was added due to prior art, and it makes the invention novel. This means that according to the examiner, this element is necessary to make the claimed invention new with respect to prior art.

1. A method to determine link weights ~~for routing~~ in a communication network, the method comprising: iteratively updating a plurality of vectors using a genetic algorithm, the vectors including a plurality of individual values decodable into possible link weights; and decoding a first one of the vectors updated using the genetic algorithm into a first plurality of link weights providing ~~a possible routing of a load through the~~ communication network, the load to be split among a plurality of paths having respective path lengths determined from the first plurality of link weights, at least two of the paths having different path lengths, wherein iteratively updating the plurality of vectors further comprises: partitioning the plurality of vectors into a first group of vectors and a second group of vectors based on routing costs associated with the vectors; and randomly combining a first subset of the first group of vectors and a second subset of the second group of vectors based on a crossover probability.

Figure 9.8: Differences between claim submitted in Patent Application US20120140636 (M.G.C. Resende et al, 2012) and claim granted in patent US8730817 (M.G.C. Resende et al, 2014).

Table 9.5: Evaluation of the proposed metrics for patent US8730817 (M.G.C. Resende et al, 2014).

Metric	Evaluation
Number of words in the first claim of the application	88
Number of words in the first claim of the granted patent	142
Number of claims (total, independent and derived) in the application	20 - 3 - 17
Number of claims (total, independent and derived) in the granted patent	18 - 3 - 15
Number of references to drawings in the first claim	0
Broadness of the claim nature	5
Support for claim matter provided in the description	4
Absence of metapragmatics in the claims	3.5

The evaluations of the proposed metrics for the patent are presented in Table 9.5. The number of words is presented only for the first claim that has 88 words for the application and 142 words for the granted patent. The application had a low number of words[3], indicating that

[3] Compared to the 146.9 average number of words in the first claim for the granted UFRGS patents studied in this work.

the invention was initially well claimed without adding too many restrictive elements. However, the number of word was substantially increased to 142 in the granted claim. The number of claims is 20 for the patent application and 18 for the granted patent. There are three independent claims in the patent and in the application.

Considering the application US20120140636 (M.G.C. Resende et al, 2012), claim 1 is an independent claim with a nature given as "*a method to determine link weights for routing in a communication network*"; this claim has seven derived claims. Claim 9 is an independent claim with a nature given as "*a tangible article of manufacture storing machine readable instructions*"; it has five derived claims. Claim 15 is an independent claim with a nature given as "*an apparatus to determine link weights for routing in a communication network*"; it has five derived claims. So, the total number of claims is twenty, with three independent claims and seventeen derived claims.

Considering the granted patent US8730817 (M.G.C. Resende et al, 2014), claim 1 is an independent claim with a nature given as "*a method to determine link weights in a communication network*"; this claim has six derived claims. Claim 8 is an independent claim with a nature given as "*a tangible machine readable medium comprising machine readable instructions*"; it has four derived claims. Claim 13 is an independent claim with a nature given as "an apparatus to determine link weights for routing in a communication network"; it has five derived claims.

The claims have no references to drawings. For instance, claim 1 has no references to drawings, as shown in Figure 9.6 and Figure 9.7. This way, the number of references to drawings in the first claim is zero, as shown in Table 9.5.

The natures of the claims are very broad (method, machine readable medium and apparatus). This way, the broadness of the claim nature is evaluated to 5.

The claims are well supported by the description but have no reference to drawings, so the support for claim matter provided in the description is evaluated to 4, due to the lack of references to drawings.

The submitted claims contained some metapragmatics, related to the text "*for routing*", expressing purpose, that was removed from the granted claim. The added element in claim 1 (the fourth difference in Figure 9.8, leading to 142 words) is also related to metapragmatics, as the added element somehow describes a genetic algorithm. If a better and more scoped definition of genetic algorithm was provided in the description, it would be possible for the claim just to refer to it. So, the absence of metapragmatics in the claims is evaluated to 3.5 in Table 9.5.

9.3.2. United States Patent 9063111 - Hybrid chemical sensor, and, sensitive polymeric composition

In this section the patent labeled UFRGS18 in Table 9.4 is analyzed. The patent number is US9063111, and the complete title is "Hybrid chemical sensor, and, sensitive polymeric composition". The corresponding patent application is numbered US20120009687 and it has the same title as the granted patent. The first claim of the patent application is shown in Figure 9.9.

> 1. A hybrid chemical sensor comprising a sensitive compound encapsulated by a hybrid capsule obtained by sol-gel reaction, said hybrid capsule using siliceous and/or titanium alkoxides, wherein at least one of said alcoxides is substituted with one or more alkyl chains.

Figure 9.9: Claim submitted in Patent Application US20120009687 (E.M. Acevedo et al, 2012).

The first claim in the granted patent is shown in Figure 9.10. The granted claim has four distinct modifications compared to the claim in the patent application. These four differences are highlighted in Figure 9.11.

1. A hybrid chemical sensor comprising a sensitive compound completely dispersed within a polyolefin matrix and encapsulated by a hybrid capsule obtained by sol-gel reaction, said hybrid capsule using siliceous alkoxides or titanium alkoxides, wherein at least one of said alkoxides is substituted with one or more alkyl chains, wherein the hybrid chemical sensor responds to the presence of amine and/or amide and/or oxide-reducing compounds, and/or vapor thereof by color change after being dispersed through the polyolefin matrix, and wherein the hybrid chemical sensor is incorporated into the polyolefin matrix by extrusion and without any loss in chemical characteristics during polyolefin processing, and is used as an indicator of conditions in a particular environment in contact with said hybrid chemical sensor.

Figure 9.10: Claim granted in Patent US9063111 (E.M. Acevedo et al, 2015).

The first difference is the addition of the element "*completely dispersed within a polyolefin matrix and*". This addition of an element makes the claim more restrictive and will be considered essential for novelty of the invention.

The second difference is a clarification meaning that "*siliceous and/or titanium alkoxides*" in the applied claim means "*siliceous alkoxides or titanium alkoxides*". This change does not add restrictions, but it clarifies that the claim refers to "*siliceous alkoxides*", with the word "*siliceous*" being an adjective used to refer to a specific type of "*alkoxides*".

The third difference is a correction from the word "*alcoxides*" (Portuguese word using the letter c) to the word "*alkoxides*" (English word using the letter k). This was probably a translation typo, as the original text was probably in Portuguese.

The fourth difference is the addition of a new element "*wherein the hybrid chemical sensor responds to the presence of amine and/or amide and/or oxide-reducing compounds, and/or vapor thereof by color change after being dispersed through the polyolefin matrix, and wherein the hybrid chemical sensor is incorporated into the polyolefin matrix by extrusion and without any loss in chemical characteristics during polyolefin processing, and is used as an indicator of conditions in a particular environment in contact with said hybrid chemical sensor*". This

element was added due to prior art, and it makes the invention novel. This means that according to the examiner, this element is necessary to make the claimed invention new with respect to prior art.

1. A hybrid chemical sensor comprising a sensitive compound completely dispersed within a polyolefin matrix and encapsulated by a hybrid capsule obtained by sol-gel reaction, said hybrid capsule using siliceous ~~and/or~~alkoxides or titanium alkoxides, wherein at least one of said ~~alcoxides~~alkoxides is substituted with one or more alkyl chains, wherein the hybrid chemical sensor responds to the presence of amine and/or amide and/or oxide-reducing compounds, and/or vapor thereof by color change after being dispersed through the polyolefin matrix, and wherein the hybrid chemical sensor is incorporated into the polyolefin matrix by extrusion and without any loss in chemical characteristics during polyolefin processing, and is used as an indicator of conditions in a particular environment in contact with said hybrid chemical sensor.

Figure 9.11: Differences between claim submitted in Patent Application US20120009687 (E.M. Acevedo et al, 2012) and claim granted in patent US9063111 (E.M. Acevedo et al, 2015).

Table 9.6: Evaluation of the proposed metrics for patent US9063111 (E.M. Acevedo et al, 2015).

Metric	Evaluation
Number of words in the first claim of the application	36
Number of words in the first claim of the granted patent	116
Number of claims (total, independent and derived) in the application	10 - 1 - 9
Number of claims (total, independent and derived) in the granted patent	5 - 1 - 4
Number of references to drawings in the first claim	0
Broadness of the claim nature	4
Support for claim matter provided in the description	4
Absence of metapragmatics in the claims	5

The evaluations of the proposed metrics for the patent are presented in Table 9.6. The number of words is presented only for the first claim that has 36 words for the application and

116 words for the granted patent. The application had a low number of words[4], indicating that the invention was initially well claimed without adding too many restrictive elements. However, the number of word was substantially increased to 116 in the granted claim. The number of claims is 10 for the patent application and only 5 for the granted patent. There is only one independent claim in the application as well as in the granted patent.

Considering the application US20120009687 (E.M. Acevedo et al, 2012), claim 1 is an independent claim with a nature given as "*a hybrid chemical sensor*"; it has nine derived claims. Claim 8 has a change in nature, reciting "*a sensitive polymeric composition comprising the hybrid chemical sensor as defined in claim 1*". Claim 8 has two derived claims. So, the total number of claims is ten, with one independent claim and nine derived claims. Considering the granted patent US9063111 (E.M. Acevedo et al, 2015), claim 1 is an independent claim with a nature again given as "*a hybrid chemical sensor*". Claim 1 in the granted patent has only four derived claims. The claims with the nature "*a sensitive polymeric composition"* were not granted. The total number of claims in the granted patent is only five, with just one independent claim and four derived claims.

The claims have no references to drawings. For instance, claim 1 has no references to drawings, as shown in Figure 9.9 and Figure 9.10. This way, the number of references to drawings in the first claim is zero, as shown in Table 9.6.

The natures used for the claims are not as broad as they could be. The used nature was "*a hybrid chemical sensor*", where the more broad natures such as "*a chemical sensor*" or even "*a sensor*" could have been used. This way, the broadness of the claim nature is evaluated to four.

The claims are well supported by the description but have no reference to drawings, so the support for claim matter provided in the description is evaluated to 4, due to the lack of references to drawings. The claims are free from metapragmatics, so the absence of metapragmatics in the claims is evaluated to five in Table 9.6.

[4] Compared to the 146.9 average number of words in the first claim for the granted UFRGS patents studied in this work.

9.4. General Panorama for UAB and UFRGS Patents at USPTO

This section presents a general panorama for all the sixteen UAB patents, compared to the nineteen UFRGS patents. The metrics computed for UAB patents are presented in Table 9.8, while the metrics computed for UFRGS patents are presented in Table 9.9. Patents are presented one per line. Table 9.7 describes the labels that were used to identify the metrics shown in the columns of Tables 9.8 and 9.9.

Table 9.7. Labels for the metrics evaluated for patents granted to UAB and UFRGS.

NWFC-AP	Number of words in the first claim of the application of the patent.
NWFC-GP	Number of words in the first claim of the granted patent.
NCAP (T-I-D)	Number of claims in the application of the patent (total, independent and dependent).
NCGP (T-I-D)	Number of claims in the granted patent.
NRD	Number of references to drawings.
BCN	Broadness of claim nature.
SCM	Support for the claim matter in the description section.
AMC	Absence of metapragmatics.

A first comment refers to the number of words in the first claim for patents from UAB and from UFRGS. There is a general tendency of patents from UAB to have fewer words in the first claim compared to UFRGS patents. In fact, the average number of words in the first claim for UAB patents is 88.2 words, while the same average for UFRGS patents is 146.9. This observation has to be taken with some reservation due to the small number of patents analyzed, but it could indicate that UAB patents are generally better written than UFRGS patents according to this metric. A similar tendency happens with the number of claims in the patents. It seems that UAB was more effective in obtaining patents with a larger number of claims compared to patents granted to UFRGS (that have in general fewer claims, compared to UAB patents).

Table 9.8. Evaluation of metrics for patents granted to UAB in the United States.

ID	NWFC-AP	NWFC-GP	NCAP (T-I-D)	NCGP (T-I-D)	NRD	BCN	SCM	AMC
UAB1	31	113	19-2-17	19-3-16	0	3	5	3
UAB2	76	100	3-0-3	7-1-6	0	2	5	5
UAB3	29	34	14-1-13	13-2-11	0	3	5	5
UAB4	NA	22	NA	13-2-11	0	5	5	5
UAB5	151	154	7-2-5	7-2-5	0	2	5	5
UAB6	NA	50	NA	9-1-8	0	4	5	5
UAB7	56	146	27-2-25	12-1-11	1	3	5	5
UAB8	NA	53	NA	13-2-11	3	3	5	5
UAB9	124	124	44-4-40	15-1-14	0	4	5	4
UAB10	70	78	22-1-21	19-1-18	0	5	5	5
UAB11	66	80	19-2-17	18-2-16	0	5	4	5
UAB12	84	90	18-1-17	13-1-12	1	4	5	5
UAB13	61	61	16-2-14	16-2-14	4	5	5	5
UAB14	48	91	25-2-23	23-2-21	0	4	5	5
UAB15	49	148	21-2-19	9-1-8	0	5	5	4
UAB16	17	67	12-1-11	10-1-9	0	3	5	5

Table 9.9. Evaluation of metrics for patents granted to UFRGS in the United States.

ID	NWFC-AP	NWFC-GP	NCAP (T-I-D)	NCGP (T-I-D)	NRD	BCN	SCM	AMC
UFRGS1	151	177	22-1-21	6-1-5	0	2	5	5
UFRGS2	79	179	13-1-12	5-1-4	0	3	5	5
UFRGS3	199	225	11-1-10	11-1-10	0	2	5	5
UFRGS4	174	193	2-1-1	4-1-3	0	2	5	5
UFRGS5	171	179	16-2-14	7-1-6	0	4	5	5
UFRGS6	168	168	17-1-16	13-1-12	0	4	5	4
UFRGS7	59	97	21-1-20	21-1-20	0	2	5	5
UFRGS8	88	142	20-3-17	18-3-15	0	5	4	3.5
UFRGS9	53	72	21-2-19	17-2-15	0	2	5	5
UFRGS10	197	184	20-2-18	21-2-19	1	2	5	5
UFRGS11	249	250	14-1-13	14-1-13	1	4	5	5
UFRGS12	36	48	6-1-5	6-1-5	0	5	5	5
UFRGS13	76	89	26-1-25	16-1-15	0	4	5	5
UFRGS14	7	194	57-1-56	3-1-2	0	4	3	4
UFRGS15	77	66	27-1-26	6-2-4	0	4	5	5
UFRGS16	32	78	12-2-10	4-1-3	0	3	5	5
UFRGS17	58	130	1-1-0	22-1-21	0	4	5	5
UFRGS18	36	116	10-1-9	5-1-4	0	4	4	5
UFRGS19	249	204	19-1-18	10-1-9	1	4	5	4

The patent UAB13 has a large number of references to drawings in the claims (J.F.I. Grino et al, 2009a) (J.F.I. Grino et al, 2009b). This possibly helped the patent to be granted as requested (no changes in the first claim), due to a good support provided by the drawings. Not many patents make effective use of the drawings section, referencing drawings in the claims.

The patent UFRGS14 was applied with a claim with only seven words (A.R. Pohlmann et al, 2011). This can be considered abusive due to resulting in an application claim that is too broad due to the lack of restrictions (elements) in the claim. Indeed, the first claim on the granted patent has 194 words (A.R. Pohlmann et al, 2018a).

It is normal for the number of words in the first claim to be increased from the application to the granted patent. However, some patents from UFRGS present a behavior contrary to this norm, in the sense that the first claim in the granted patent has fewer words than the patent application. This is the case for patents UFRGS10 (C.J.O. DeLazaro et al, 2012) (C.J.O. DeLazaro et al, 2015), UFRGS15 (A.R. Pohlmann et al, 2015) (A.R. Pohlmann et al, 2018b) and UFRGS19 (R.Mechoulam, et al, 2015) (R. Mechoulam, et al, 2016).

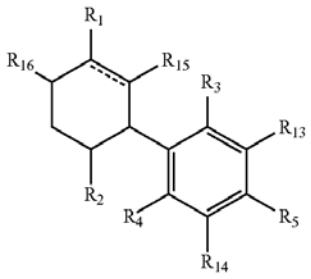
In the case of patents UFRGS10 (C.J.O. DeLazaro et al, 2012) (C.J.O. DeLazaro et al, 2015) and UFRGS19 (R. Mechoulam, et al, 2015) (R. Mechoulam, et al, 2016), the claims make references to drawings, and the granted patent was restricted by making reference to a more restrictive drawing. The drawings from patent UFRGS19 (R.Mechoulam, et al, 2015) (R. Mechoulam, et al, 2016) are shown in Figure 9.11. Notice that the drawing in the granted patent shown in Figure 9.11(b) is more restrictive has it is restricted to have a bond with an atom of Fluor (F) in a specific position of the molecule. In fact, the claims in Figure 9.11 are a special type of claims called Markush claims that use optional elements. In the case of the chemical shown in Figure 9.11(a), there is more flexibility (broadness) provided by nine different positions (R_1, R_2, R_3, R_4, R_5, R_{13}, R_{14}, R_{15} and R_{16}) to be optionally filled with chemical compounds. In the originally applied claim, the positions labeled R_{13}, R_{14}, R_{15} and R_{16} were optional positions for an atom of the chemical element Fluor (F), as the original claim has the text: "*provided that at least one of R_{13}, R_{14}, R_{15} and R_{16} is F*". However, in the granted claim shown in Figure 9.11(b) the position of the Fluor (F) atom is fixed to position R_{13}, which is an

important restriction with respect to the originally submitted claim. This way, even if the originally submitted claim had more words the granted claim is more restricted due to the chemical element Fluor (F) being restricted to position R_{13}. This means that the number of words as a metric has to be taken with care especially for claims with embedded drawings, which happens in chemistry patents where drawings of the chemical structures are embedded as part of the claim. Chemistry patents frequently use claims with a closed group of alternative elements known as Markush claims (P.Segura, 2019). In this particular case, when one of the alternative elements of a Markush claim is fixed to one of the options, the patent could be less general with fewer words.

1-48. (canceled)

49. A compound having the general formula (I):

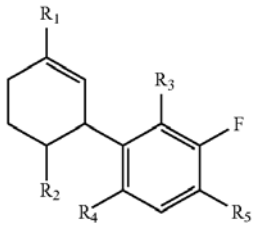
(I)



(a) Patent application

1. A compound having the general formula (V):

(V)



(b) Granted Patent

Figure 9.11: Drawings for the patent UFRGS19 (R.Mechoulam, et al, 2015) (R. Mechoulam, et al, 2016).

In the case of patent UFRGS15 (A.R. Pohlmann et al, 2015) (A.R. Pohlmann et al, 2018b), there are no references to drawings. However, the granted claim with 66 words is narrower than the applied claim with 77 words because the granted claim uses much narrower claim elements. One example of this is the element "*(c) at least one lipophilic low HLB surfactant*" in the applied claim (A.R. Pohlmann et al, 2015) that becomes "*(c) sorbitan monostearate*" in the

granted claim (A.R. Pohlmann et al, 2018b). Notice that "*(c) sorbitan monostearate*" is much more restrictive and narrow element because it is a very specific chemical compound.

9.5. Contributions of this chapter

This chapter applied the metrics previously proposed in chapter 8 to evaluate patents from UAB and from UFRGS at the US Patent Office. The chapter demonstrates how the metrics can be evaluated for real life examples of patents. Also, the metrics were effectively used to establish a panorama of the USPTO patent portfolios from UAB and UFRGS. Next chapter will discuss knowledge representation for patents, based on the proposed semiotic approach considering the all-element rule, which is the center of this thesis.

10. Knowledge representation of patents

10.1. About this Chapter

This chapter presents contributions to knowledge modeling for patents. A brief review of existing approaches for knowledge modeling for patents is presented. Then a contribution to the knowledge modeling for the claim section of a patent is presented. Finally, the proposed model is discussed by using, as a real life example, the patent by Amazon (the online bookstore and company) known as the One-Click Patent (P. Hartman et al, 1999).

10.2. Patent ontologies and claims

Several approaches have been proposed for ontological modeling in the patent domain (M. Giereth et al, 2007) (N. Karam and A. Paschke, 2012) (V.-W. Soo et al, 2006) (M. Bermudez-Edo et al, 2013) (C.V. Trappey et al, 2014) (S.-S. Lim et al, 2004) (N. Ghoula et al, 2007) (L. Zhi and H. Wang, 2009) (K.H. Law et al, 2015) (A.J.C. Trappey et al, 2013) (A.P.T. Hsu et al, 2015) (C.Nédellec et al, 2010) (M. Li et al, 2011) (F.Wang et al, 2014) (J.Calvert and P.B.Joly, 2011) (Z.Li and D.Tate, 2013) (Z.Dongsheng and L.Chen, 2007). However, none of these approaches discusses the structure of the claims in detail. Additionally, the relationship among the individual claims belonging to a set of claims is not discussed in these previous publications either.

In the following we discuss some extensions of our view to the two most relevant approaches we found for ontological patent information representation. Giereth et al carried out a broad ontological approach for patent knowledge based on web semantics (OWL) (M.Giereth et al, 2007). Karam and Paschke set a Description Logic approach to model patents claims and using an algorithm to compute differences between statements made in Description

Logic (N. Karam and A. Paschke, 2012). Both approaches can benefit from the proposed knowledge modeling of patent claim structure and the all-element rule proposed in this thesis.

10.3. Representing patent claim information with WEB semantics

Giereth et al (M.Giereth et al, 2007) is based on web semantics (OWL) including (i) patent metadata, (ii) patent classification (according classifications proposed by patent offices), (iii) patent internal structure, and (iv) patent drawings.

As previously discussed, Figure 10.1 reproduces the model for patent internal structure proposed by Giereth et al (M.Giereth et al, 2007). Notice that their proposed model for internal structure only makes reference to a single Claim as part of its textual content (TextualIPContent, in Figure 10.1).

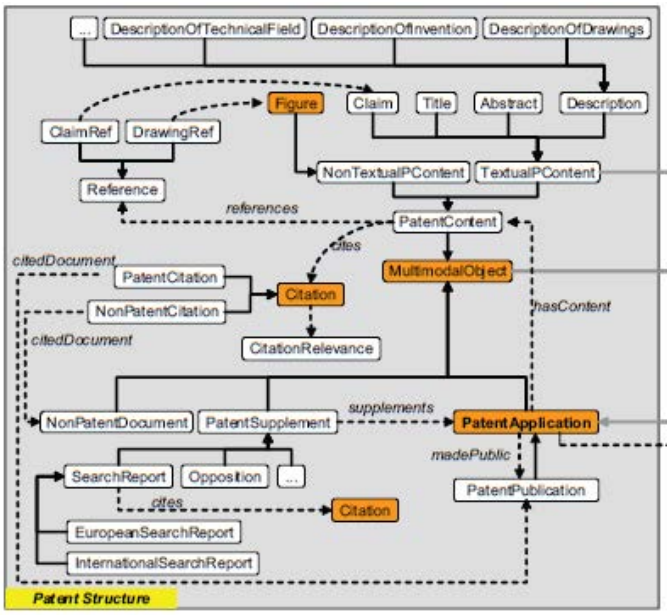


Figure 10.1: Major patent upper level concepts and relations for patent structure as proposed by Giereth et al (M.Giereth et al, 2007). The figure presented here is a verbatim partial reproduction of Figure 2 from (M.Giereth et al, 2007).

10.4. Proposed Approach for Knowledge Modeling of Patent Claims

We propose to have a more detailed model that includes a list of independent claims. Each dependent claim would be linked to the claim it refers to (i.e., the parent claim), possibly through a dependence tree. For each claim, the structure composed of preamble (nature), transitional phrase (or transition), and the body of the claim would be stored. The claim would contain a list of all of its elements. The suggested xml markers are shown in Table 10.1.

Table 10.1: Proposed xml markers for patent claim content storage.

xml marker	Role in claim description
<claims> </claims>	Claim section
<claim> </claim>	Individual claim
<parent> </parent>	Parent Claim
<preamble> </preamble>	Preamble
<transition> </transition>	Transition
<elements> </elements>	Element section
<element> </element>	Individual element

10.5. A practical example

As a practical example we examine the claims in the United States Patent 5960411, also known as the One-Click Patent by Amazon (P. Hartman et al, 1999). The first five claims of the patent are reproduced in Table 10.2. The nature of all claims is a method. The first claim is an independent claim; the four other claims are derived directly from claim 1 by adding an extra element. The way the claims are derived results in the Venn diagram presented in Figure 10.2. From now on, the labels C1 to C5 will be used to refer to the claims shown in the Table 10.2.

Table 10.2: The first five claims in United States Patent 5960411 (P. Hartman et al, 1999).

ID	Claim text
C1	A method of placing an order for an item comprising: under control of a client system, displaying information identifying the item; and in response to only a single action being performed, sending a request to order the item along with an identifier of a purchaser of the item to a server system; under control of a single-action ordering component of the server system, receiving the request; retrieving additional information previously stored for the purchaser identified by the identifier in the received request; and generating an order to purchase the requested item for the purchaser identified by the identifier in the received request using the retrieved additional information; and fulfilling the generated order to complete purchase of the item whereby the item is ordered without using a shopping cart ordering model.
C2	The method of claim 1 wherein the displaying of information includes displaying information indicating the single action.
C3	The method of claim 1 wherein the single action is clicking a button.
C4	The method of claim 1 wherein the single action is speaking of a sound.
C5	The method of claim 1 wherein a user of the client system does not need to explicitly identify themselves when placing an order.

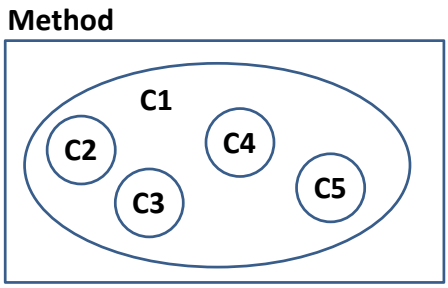


Figure 10.2: Relationship among the first five claims in United States Patent 5960411 (P.Hartman et al, 1999) represented as a Venn diagram, without considering intersections among C2, C3, C4 and C5.

```
<claims>
  <claim #1>
     <preamble>A method of placing an order for an item </preamble>
     <transition> comprising: </transition>
        <elements>
           <element>under control of a client system,</element>
           <element>displaying information identifying the item; and </element>
            <element>in response to only a single action being performed, sending a request to
               order the item along with an identifier of a purchaser of the item to a
                server system; </element>
             <element>under control of a single-action ordering component
                   of the server system, receiving the request; </element>
             <element>retrieving additional information previously stored for the purchaser
                   identified by the identifier in the received request; and</element>
             <element>generating an order to purchase the requested item for the purchaser identified
                   by the identifier in the received request using the retrieved additional
                   information; and</element>
             <element>fulfilling the generated order to complete purchase of the item</element>
             <element>whereby the item is ordered without using a shopping cart ordering
                   model. </element>
        </elements>
  </claim>
  <claim #2> <parent> #1 </parent>
    <preamble>The method of claim 1 </preamble>
    <transition>wherein </transition>
    <elements>
          <element> the displaying of information includes displaying information indicating
                the single action. </element>
    </elements>
   </claim>
  <claim #3> <parent> #1 </parent>
    <preamble>The method of claim 1</preamble>
    <transition>wherein </transition>
    <elements> <element>the single action is clicking a button. </element></elements>
  </claim>
  <claim #4> <parent> #1 </parent>
    <preamble>The method of claim 1</preamble>
    <transition>wherein </transition>
    <elements> <element> the single action is speaking of a sound. </element> </elements>
  </claim>
  <claim #5> <parent> #1 </parent>
    <preamble>The method of claim 1 </preamble>
    <transition>wherein</transition>
    <elements>
       <element>a user of the client system does not need to explicitly identify themselves
            when placing an order. </element> </elements>
  </claim>
</claims>
```

Figure 10.3. Proposed xml markers for patent claim content storage used in a practical example.

Notice that the first claim can be considered as composed of eight distinct elements. Figure 10.3 highlights these eight elements by using the proposed xml markers listed in table 10.1. Figure 10.3 also provides the markup for all the tags presented in Table 10.1, highlighting the

hierarchy of the information. The fact that all the claim elements are explicitly indicated allows for a more easy application of the all-element rule, including visualization of claim hierarchy, as presented in Figure 10.2.

In fact, the visualization in Figure 10.2 is a simplified version that ignores the intersections among the coverages of claims C2 to C5. Figure 10.4 corrects the visualization from Figure 10.2, by visually representing the intersections. In order to better explain Figure 10.4, additional details are presented in Figure 10.5, by labeling the seventeen distinct regions of the figure with different binary codes.

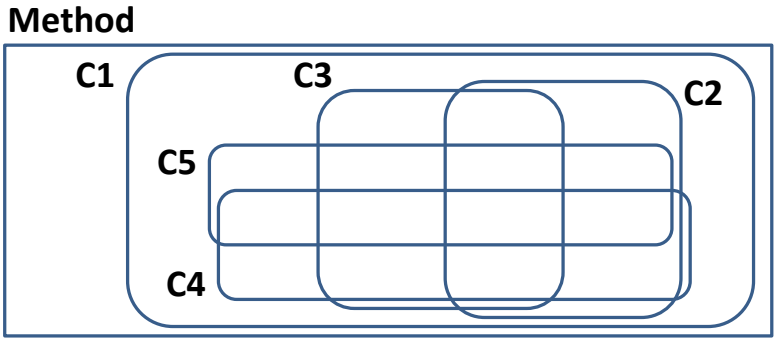


Figure 10.4: Relationship among the first five claims in United States Patent 5960411 (P. Hartman et al, 1999) represented as a Venn diagram, considering intersections among C2, C3, C4 and C5.

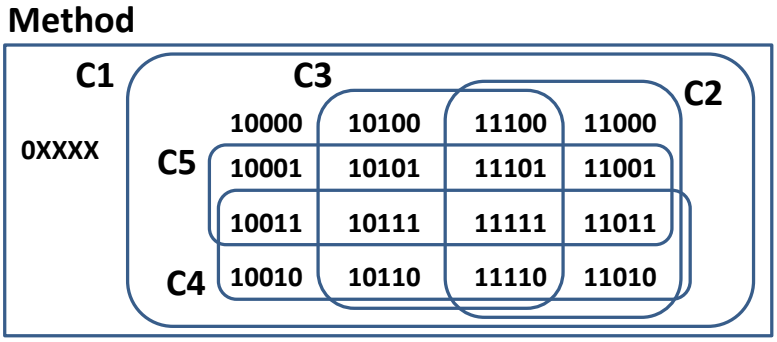


Figure 10.5: Rewriting of figure 10.4 using binary codes to illustrate seventeen distinct regions of intersection among claims C1, C2, C3, C4 and C5.

<elements>
<element>under control of a client system,</element>
<element>displaying information identifying the item; and </element>
<element>in response to only a single action being performed, sending a request to order the item along with an identifier of a purchaser of the item to a server system; </element>
<element>under control of a single-action ordering component of the server system, receiving the request; </element>
<element>retrieving additional information previously stored for the purchaser identified by the identifier in the received request; and</element>
<element>generating an order to purchase the requested item for the purchaser identified by the identifier in the received request using the retrieved additional information; and</element>
<element>fulfilling the generated order to complete purchase of the item</element>
<element>whereby the item is ordered without using a shopping cart ordering model. </element>
</elements>

Figure 10.6: The elements listed in the first claim (C1) of United States Patent 5960411 (P. Hartman et al, 1999).

<element> the displaying of information includes displaying information indicating the single action. </element>

Figure 10.7: The element listed in the second claim (C2) of United States Patent 5960411 (P.Hartman et al, 1999).

<elements> <element>the single action is clicking a button. </element></elements>

Figure 10.8: The element listed in the third claim (C3) of United States Patent 5960411 (P. Hartman et al, 1999).

<elements> <element> the single action is speaking of a sound. </element> </elements>

Figure 10.9: The element listed in the fourth claim (C4) of United States Patent 5960411 (P. Hartman et al, 1999).

<element>a user of the client system does not need to explicitly identify themselves when placing an order. </element> </elements>

Figure 10.10: The element listed in the fifth claim (C5) of United States Patent 5960411 (P. Hartman et al, 1999).

These binary codes refer to the presence or absence of the elements recited in each of the five claims. For convenience, the elements of each claim are presented above. The binary codes are listed in Table 10.3.

Table 10.3: The binary codes used in figure 10.5.

The method contains the elements listed in Claim					Claims that cover the method
C1	**C2**	**C3**	**C4**	**C5**	
0	X	X	X	X	None
1	0	0	0	0	C1
1	0	0	0	1	C1,C5
1	0	0	1	0	C1,C4
1	0	0	1	1	C1,C4,C5
1	0	1	0	0	C1,C3
1	0	1	0	1	C1,C3,C5
1	0	1	1	0	C1,C3,C4
1	0	1	1	1	C1,C3,C4,C5
1	1	0	0	0	C1,C2
1	1	0	0	1	C1,C2,C5
1	1	0	1	0	C1,C2,C4
1	1	0	1	1	C1,C2,C4,C5
1	1	1	0	0	C1,C2,C3
1	1	1	0	1	C1,C2,C3,C5
1	1	1	1	0	C1,C2,C3,C4
1	1	1	1	1	C1,C2,C3,C4,C5

Table 10.3 illustrates the possible combinations of the elements listed in Claims C1 to C5. There are seventeen distinct combinations listed in the Table. The digit 1 in each column indicates that the method has the elements listed in the claim. The digit 0 in each column indicates that the method has not the elements listed in the claim. The coverages of claims C1 to C5 are illustrated from Figure 10.11 to Figure 10.15. The brief explanation of the codes covered by each claim is made in the captions of the figures, for readability.

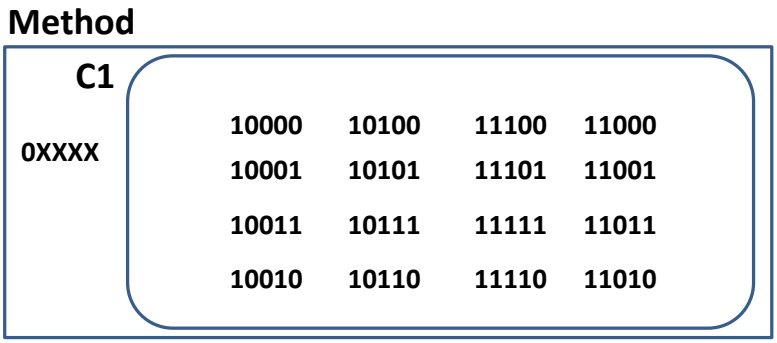


Figure 10.11: Codes from Table 10.3 that are covered by claim 1; sixteen different methods that start by digit 1, meaning that the method has the elements from claim 1.

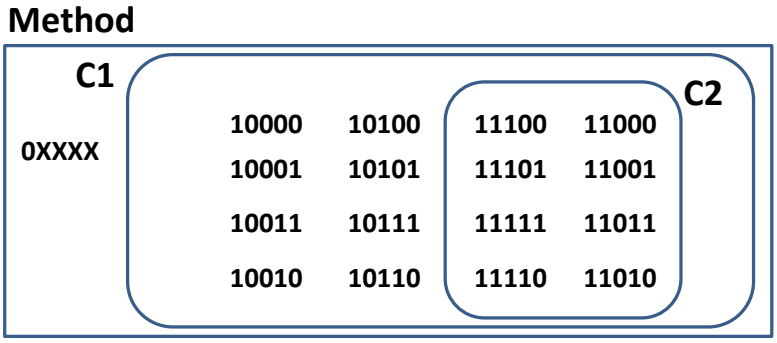


Figure 10.12: Codes from Table 10.3 that are covered by claim 2; eight different methods that start by digit 1, meaning that the method has the elements from claim 1. The second digit is also 1, meaning that the method has the elements from claim 2.

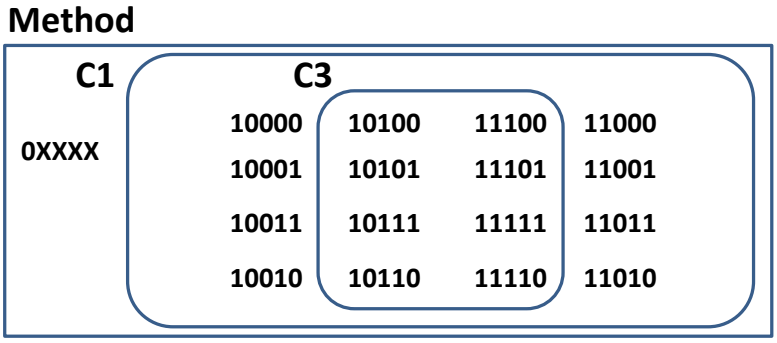


Figure 10.13: Codes from Table 10.3 that are covered by claim 3; eight different methods that start by digit 1, meaning that the method has the elements from claim 1. The third digit is also 1, meaning that the method has the elements from claim 3.

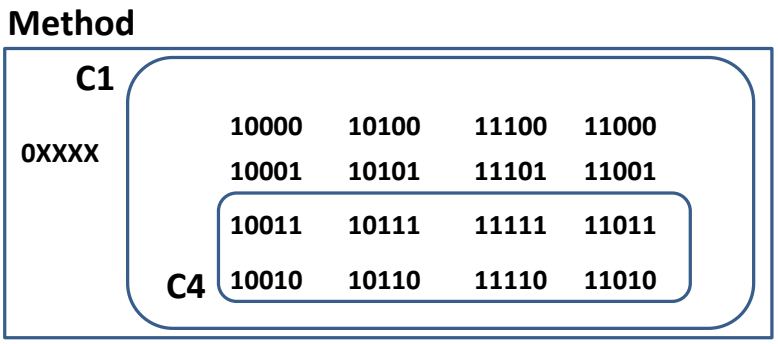


Figure 10.14: Codes from Table 10.3 that are covered by claim 4; eight different methods that start by digit 1, meaning that the method has the elements from claim 1. The fourth digit is also 1, meaning that the method has the elements from claim 4.

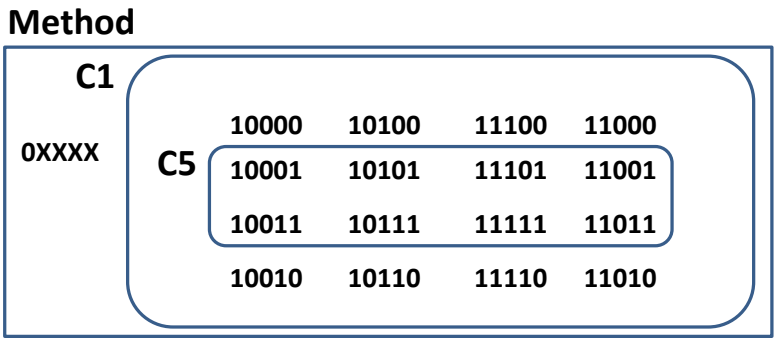


Figure 10.15: Codes from Table 10.3 that are covered by claim 5; eight different methods that start by digit 1, meaning that the method has the elements from claim 1. The fifth (and last) digit is also 1, meaning that the method has the elements from claim 5.

An example of a single code for a method is presented in Figure 10.16. The figure illustrates that the method with binary code 10110 is covered by claims C1, C3 and C4. Figure 10.17 illustrates the elements present and not present in a method with binary code 10110, according to Table 10.3. Basically, the method with code 10110 lacks the elements listed in claims C2 and C5. In figure 10.17 the elements from claims C2 and C5 appear crossed out to indicate they are not present in the method.

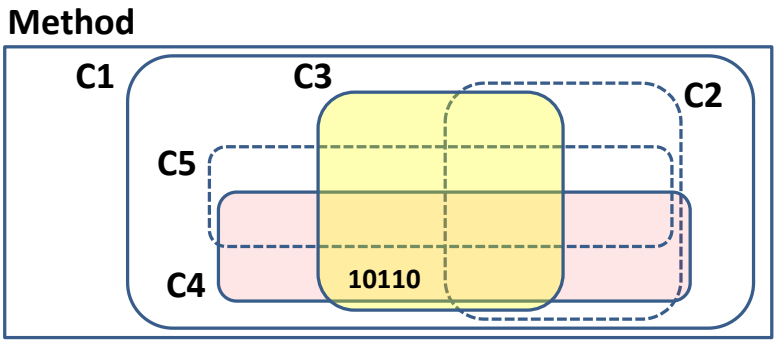


Figure 10.16: The method with binary code 10110 is covered by claims C1, C3 and C4.

<element>under control of a client system,**</element>**
<element>displaying information identifying the item; and **</element>**
<element>in response to only a single action being performed, sending a request to order the item along with an identifier of a purchaser of the item to a server system; **</element>**
<element>under control of a single-action ordering component of the server system, receiving the request; **</element>**
<element>retrieving additional information previously stored for the purchaser identified by the identifier in the received request; and**</element>**
<element>generating an order to purchase the requested item for the purchaser identified by the identifier in the received request using the retrieved additional information; and**</element>**
<element>fulfilling the generated order to complete purchase of the item**</element>**
<element>whereby the item is ordered without using a shopping cart ordering model. **</element>**
~~**<element>** the displaying of information includes displaying information indicating the single action. **</element>**~~
<elements> <element>the single action is clicking a button. **</element></elements>**
<elements> <element> the single action is speaking of a sound. **</element> </elements>**
~~**<element>**a user of the client system does not need to explicitly identify themselves when placing an order. **</element> </elements>**~~

Figure 10.17: Elements present and not present in an object with binary code 10110, according to Table 10.3.

The listing of elements present or absent in a method can be easily made with the help of a computer program. This is specially the case if claims are modeled with the xml tags proposed in this chapter. Figure 10.17 illustrates what would be crossed out of the claims to produce a description of the method with binary code 10110. A computer program would do that with the help of the xml tags. However the results could be shown in a way that they are more readable by humans. Table 10.4 shows the crossing out of elements without the xml tags. The final result, by removing the crossed out text is shown in Figure 10.18.

Table 10.4: The claims from Table 10.2 with elements crossed out to represent the method with binary code 10110.

1.	A method of placing an order for an item comprising: under control of a client system, displaying information identifying the item; and in response to only a single action being performed, sending a request to order the item along with an identifier of a purchaser of the item to a server system; under control of a single-action ordering component of the server system, receiving the request; retrieving additional information previously stored for the purchaser identified by the identifier in the received request; and generating an order to purchase the requested item for the purchaser identified by the identifier in the received request using the retrieved additional information; and fulfilling the generated order to complete purchase of the item whereby the item is ordered without using a shopping cart ordering model.
~~2.~~	~~The method of claim 1 wherein the displaying of information includes displaying information indicating the single action.~~
3.	~~The method of claim 1~~ wherein the single action is clicking a button.
4.	~~The method of claim 1~~ wherein the single action is speaking of a sound.
~~5.~~	~~The method of claim 1 wherein a user of the client system does not need to explicitly identify themselves when placing an order.~~

A method of placing an order for an item comprising:
under control of a client system,
displaying information identifying the item; and
in response to only a single action being performed, sending a request to order the item along with an identifier of a purchaser of the item to a server system;
under control of a single-action ordering component of the server system,
receiving the request;
retrieving additional information previously stored for the purchaser identified by the identifier in the received request; and
generating an order to purchase the requested item for the purchaser identified by the identifier in the received request using the retrieved additional information; and
fulfilling the generated order to complete purchase of the item
whereby the item is ordered without using a shopping cart ordering model,
wherein the single action is clicking a button or speaking of a sound.

Figure 10.18: The human readable text of the method with code 10110.

10.6. Contributions of this chapter

This chapter introduced a novel approach for knowledge modeling of patents. The proposed approach uses xml tags to label individual elements and associate them to the claims where these elements were listed. Additionally, binary codes can be used to indicate all the possible combinations among the existing elements. These combinations may be or not be covered by the claims and this can be verified by using the all-element rule, possibly by using a computer program. Although the text with the xml tags is not easy to read by humans, computer programs can manipulate internally the model and output readable versions of texts being claimed or describing possible objects. The importance of the contribution in this chapter is that it is the first patent knowledge modeling approach focused on the claim section, which determines patent coverage.

11. A Defense of the All-Element-Rule

11.1. About this Chapter

This thesis is strongly based in the all-element rule. This chapter makes a defense of the rule, before the final conclusion presented in the next chapter.

11.2. On the Validity of the All-Element Rule

Consider the claim with three elements in Figure 11.1. According to the all element rule, the claim in figure 11.1 would cover only T-shirts with all three elements. Figure 11.2 illustrates graphically the coverage of the claim. Only the T-shirt with all three elements is covered.

1. A T-shirt characterized by having folded sleeves, polka dots and a V-neck.

Figure 11.1: A claim with 3 elements.

In order to understand the value of the all-element rule, let us suppose for a moment that the all-element rule is not valid. For instance, let us consider that the claim in Figure 11.1 covers one additional T-shirt, as shown in Figure 11.3. In fact, the subset of T-shirts shown in Figure 11.3 corresponds to the T-shirts with both folded sleeves and a V-neck, but with or without polka dots. In practice, this means that the "polka dots" element was removed from the claim in Figure 11.1, which can be then rewritten as shown in Figure 11.4. Notice that if a claim has to have a coverage interpretation like the one shown in Figure 11.3, then the rewritten claim in Figure 11.4 reflects better the coverage in Figure 11.3.

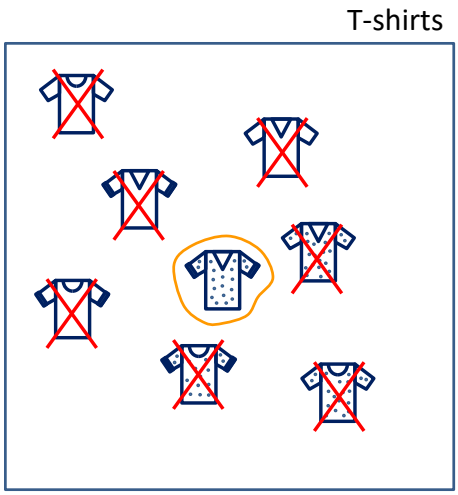


Figure 11.2: According to the all-element rule interpretation, only the T-shirt with all the three elements cited the claim in Figure 11.1 are covered by that claim.

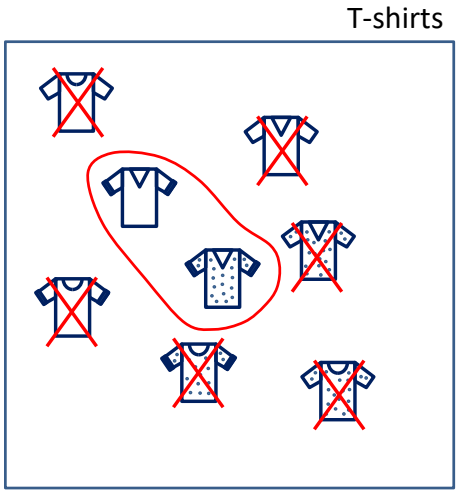


Figure 11.3: T-shirts with only two out of the three elements (folded sleeves and a V-neck) cited by the claim in Figure 11.1. In this interpretation polka dots are disregarded.

1. A T-shirt characterized by having folded sleeves~~, polka dots~~ and a V-neck.

Figure 11.4: Claim from Figure 11.2 rewritten with only two elements, polka dots were made optional (i.e. deleted from the original claim with three elements).

Further stretching our discussion about the validity of the all-element rule, it is important to highlight that the difference between the interpretation of the claim in Figure 11.1 according to the all-element rule (shown in Figure 11.2) and the different interpretation in Figure 11.3 is that one element was dropped from the claim, i.e. this is an interpretation without all-elements. And an interpretation of coverage without all elements is an interpretation that does not follow the all element rule. Following this line of thought, an interpretation that does not follow the all-element rule can make interpretations of the claims by removing elements. And if one element can be removed from the interpretation, then other additional elements can be removed from the claim. This can lead to a complete impossibility to interpret patent claims, as it is discussed in the following.

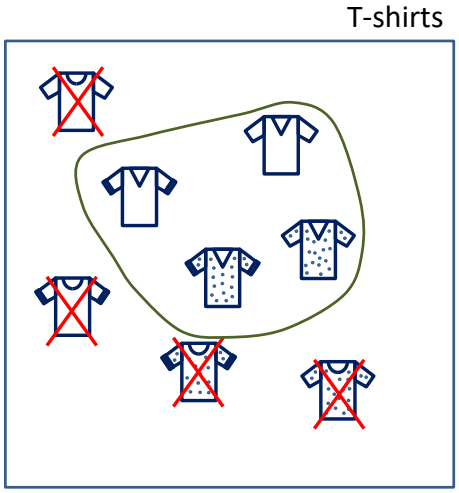


Figure 11.5: T-shirts with only one out of the three elements (a V-neck) cited by the claim in Figure 11.1. In this interpretation folded sleeves and polka dots are disregarded.

1. A T-shirt characterized by having ~~folded sleeves, polka dots and~~ a V-neck.

Figure 11.6: Claim from Figure 11.2 rewritten with only one element, folded sleeves and polka dots were made optional (i.e. deleted from the original claim with three elements).

So, if the all-element rule is not followed, elements can be disregarded in the interpretation. Figure 11.5 shows an interpretation that disregards two elements: both folded

sleeves and polka dots are disregarded as elements. However, the interpretation in Figure 11.5 is much better described by the text from illustrated in Figure 11.6.

1. A T-shirt ~~characterized by having folded sleeves, polka dots and a V-neck~~.

Figure 11.7: A purely abstract claim without any cited elements.

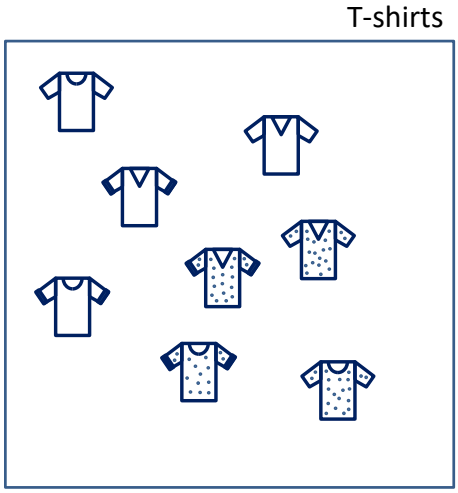


Figure 11.8: The purely abstract claim in Figure 11.7 covers all T-shirts, not a sub-set of T-shirts.

In extremis, if the all-element rule is not valid, it is possible to argue that all elements could be deleted from the claim. Figure 11.7 describes this extreme case, by rewriting the claim in Figure 11.2 as a purely abstract claim, i.e. a claim without any element. A purely abstract has only a nature (a T-shirt, in this case) and it covers all the objects that have that nature. Figure 11.8 illustrates this situation: all T-shirts are covered, not only a subset.

11.3. Contributions of this Chapter

This chapter has explained the logic behind the all-element rule. If one element in the claim can be disregarded, then more elements, possibly all, can be also disregarded. So, if the

all element rule is considered invalid, the consequence is that people could argue that all-elements should be disregarded. Disregarding all the elements of a claim potentially leads to a purely abstract claim that has only a nature and no elements. This purely abstract claim covers all the objects with the claimed nature, and is possibly too broad to be granted. The argument presented to justify the all-element rule in this chapter is based on the semiotic approach for patent interpretation introduced in chapter 6.

12. Conclusion

The work presented in this thesis made a deep analysis on how patents are interpreted to determine the scope of the invention covered by the patent. This study involved aspects of law, linguistics, semiotics and knowledge modeling and visualization. These multidisciplinary aspects were jointly considered in the patent interpretation methodology proposed in this thesis. As a result, the proposed approach is interdisciplinary, i.e. it interrelates the different disciplines to provide a basis for the proposed approach.

The proposed approach for patent interpretation is based on the field of semiotics, considering the all-element rule. The different roles that each patent sub-section play in patent interpretation are also considered. The relationship among the different claims of a patent was visually explained using set theory and Venn diagrams.

The methodology for patents interpretation is based on the all-element rule. This rule is used by WIPO (World Intellectual Property Organization), by the United States, and by the new Spanish law for patents. This new Spanish Law mentions elements and the doctrine of equivalents. This indicates that the all-element rule will be used by an increasing number of countries.

The core of the thesis proposal is presented in Chapter 6. This chapter presents the semiotic approach for patent interpretation considering the all-element rule. This chapter forms the main part of an article published by the International Journal for the Semiotics of Law.

A first practical application of the theoretical framework proposed in this thesis is the gamification of the concepts. As the contribution of the thesis in chapter 6 proposes a theoretical framework for patent interpretation, chapter 7 presents a gamification approach to understand patent interpretation. For this goal, a synthetic patent application and a synthetic granted patent were proposed (appendixes 1 to 6), together with associated questions that can be used for teaching and assessing student understanding.

A second practical application is the proposition of metrics to evaluate patent quality. Chapter 8 presents the main defects a patent can present in the writing and proposes metrics to evaluate patent quality. The chapter makes extensive use of synthetic examples similar to the ones used in the gamification presented in chapter 7.

A third practical application is the evaluation of real life patent applications with the proposed metrics. This evaluation was done in Chapter 9, by evaluating two sets of combined patent applications and granted patents. The two sets are the granted patents (and the corresponding associated patent applications) for Universitat Autonoma de Barcelona (UAB) and Universidade Federal do Rio Grande do Sul (UFRGS) at the United States Patent and Trademark Office (USPTO).

A fourth practical application is the proposition of approaches to model patent knowledge, especially regarding the claims, as presented in Chapter 10. This contribution is important, as patent interpretation is based on claims and claim elements. Prior approaches to patent knowledge modeling neglected claim modeling. In this sense, this is an important contribution of this thesis, as it is the first proposal to model patent knowledge considering the claims in more detail. This contribution was accepted for AICOL conference and later on published in a book containing a selection of AICOL papers published by Springer.

Finally, the proposed semiotic approach for patent interpretation was used to justify the importance of the all-element rule. Not considering all claim elements (i.e. selectively disregarding claim elements) can be used to argue that all elements can be disregarded, leading to purely abstract claims that are too broad. This way, the logic behind the all-element rule is that no element cited in the claim should be disregarded.

The work of this thesis is not closed in itself and it opens the way for many other works. For instance, the contributions in Chapters 7, 8 and 9 are not yet published, and all of them could be worked as journal papers. Beyond that, there are several possible ways to continue the work proposed in this thesis:

- Extend the gamification techniques and apply them in teaching and knowledge assessment.
- Propose new metrics to complement the metrics proposed herein.
- Propose algorithms or programmable approaches to evaluate the proposed metrics automatically.
- Evaluate the proposed metrics for a larger number of patens, possibly using automatic evaluation using computer programs.

In summary, this work proposed a sound foundation for patent interpretation based on the all-element rule. Many contributions, both theoretical and practical were presented. The work is not closed in itself, but it opens the way for several future works based on the contributions presented herein.

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14. Appendix 1: a Synthetic Patent Application

Patent Application[1] LP-AP204772849 filed to KLPTO[2].

Title: T-shirts with V-necks, folded sleeves and polka-dots
Inventors: Peter, Paul and Mary
Application Date: 23/04/2015
Publication Date: 24/09/2015

Abstract

This patent presents the invention of T-shirts having V-necks, folded sleeves and polka-dots.

Drawings

Figure 1: Prior art.

Figure 2: T-shirt with V-Neck.

Figure 3: T-shirt with folded sleeves.

Figure 4: T-shirt with polka-dots.

Figure 5: T shirt with folded sleeves and polka-dots.

Figure 6: T-shirt with V-Neck and folded sleeves.

Figure 7: T-shirt with V-neck and polka-dots.

Figure 8: T-shirt with V-neck, folded sleeves and polka-dots.

[1] This is a patent application. The patent is being examined by elfs and perhaps it will be granted by Santa Claus in Christmas eve.
[2] KLPTO is the Kingdom of Lapony Patent and Trademark Office.

Description

T-shirts have existed for a long while. One example of prior art existing T-shirt is presented in Figure 1. One knowledgeable in the art would appreciate that a T-shirt is a type of clothing.

T-shirts can be made better by adding extra features. One extra feature is a V-neck, displayed in Figure 2, which has two advantages over prior art. A shirt with a V-neck has a first advantage of making it easier to wear the T-shirt, as it is easier to pass the head through the V-Neck. A shirt with a V-neck has a second advantage of making it easier to wear a tie with the T-shirt, as the V-Neck provides additional space for the tie. A second additional feature is the use of folded sleeves. A T-shirt with folded sleeves is shown in Figure 3. Folded sleeves provide the functionality of added strength, making it more difficult for the T-shirt to suffer deformities. A third additional feature is the use of polka-dots. A T-shirt with polka-dots is shown in Figure 4. Polka-dots provide the functionality of camouflage, making it more difficult to see eventual defects on the T-shirt.

Notice that the features can be combined. In this sense, different combinations are illustrated in Figures 5, 6, 7 and 8. Figure 5 presents a T shirt with folded sleeves and polka-dots. Figure 6 presents a T-shirt with V-Neck and folded sleeves. Figure 7 presents a T-shirt with V-neck and polka-dots. Figure 8 presents a T-shirt with V-neck, folded sleeves and polka-dots.

Claims

1. A T-shirt characterized by having folded sleeves

2. A T-shirt characterized by having polka dots

3. A T-shirt characterized by having V-neck

15. Appendix 2: Questions about the Synthetic Patent Application

Name:

	Covered by the patent?			Covered by the patent?	
	Yes?	No?		Yes?	No?
					
					
					
					
					

16. Appendix 3: Answers for Questions about the Synthetic Patent Application

Name:

	Covered by the patent?			Covered by the patent?	
	Yes?	No?		Yes?	No?
					
					
					
					
					

17. Appendix 4: a Synthetic Granted Patent

Patent LP204772849 granted by the kingdom of Lapony[3].

Title: T-shirts with V-necks, folded sleeves and polka-dots
Inventors: Peter, Paul and Mary
Application Date: 23/04/2015
Issue Date: 24/12/2015

Abstract

This patent presents the invention of T-shirts having V-necks, folded sleeves and polka-dots.

Drawings

Figure 1: Prior art.

Figure 2: T-shirt with V-Neck.

Figure 3: T-shirt with folded sleeves.

Figure 4: T-shirt with polka-dots.

Figure 5: T shirt with folded sleeves and polka-dots.

Figure 6: T-shirt with V-Neck and folded sleeves.

Figure 7: T-shirt with V-neck and polka-dots.

Figure 8: T-shirt with V-neck, folded sleeves and polka-dots.

Description

T-shirts have existed for a long while. One example of prior art existing T-shirt is presented in Figure 1. One knowledgeable in the art would appreciate that a T-shirt is a type of clothing.

[3] This patent was issued only for effect in this exercise. The patent was examined by elfs and granted by Santa Claus in Christmas eve.

T-shirts can be made better by adding extra features. One extra feature is a V-neck, displayed in Figure 2, which has two advantages over prior art. A shirt with a V-neck has a first advantage of making it easier to wear the T-shirt, as it is easier to pass the head through the V-Neck. A shirt with a V-neck has a second advantage of making it easier to wear a tie with the T-shirt, as the V-Neck provides additional space for the tie. A second additional feature is the use of folded sleeves. A T-shirt with folded sleeves is shown in Figure 3. Folded sleeves provide the functionality of added strength, making it more difficult for the T-shirt to suffer deformities. A third additional feature is the use of polka-dots. A T-shirt with polka-dots is shown in Figure 4. Polka-dots provide the functionality of camouflage, making it more difficult to see eventual defects on the T-shirt.

Notice that the features can be combined. In this sense, different combinations are illustrated in Figures 5, 6, 7 and 8. Figure 5 presents a T shirt with folded sleeves and polka-dots. Figure 6 presents a T-shirt with V-Neck and folded sleeves. Figure 7 presents a T-shirt with V-neck and polka-dots. Figure 8 presents a T-shirt with V-neck, folded sleeves and polka-dots.

Claims

1. A T-shirt characterized by having folded sleeves

2. A T-shirt according to claim 1 characterized by having polka dots

3. A T-shirt according to claim 2 characterized by having V-neck

18. Appendix 5: Questions about the Synthetic Granted Patent

Name:

	Is covered by?							Is covered by?					
	Claim 1		Claim 2		Claim 3			Claim 1		Claim 2		Claim 3	
	y	n	y	n	y	n		y	n	y	n	y	n
													
													
													
													
													

19. Appendix 6: Answers for Questions about the Synthetic Granted Patent

Name:

	Is covered by?							Is covered by?					
	Claim 1		Claim 2		Claim 3			Claim 1		Claim 2		Claim 3	
	y	n	y	n	y	n		y	n	y	n	y	n
													
													
													
													
													

20. Appendix 7: Patent Applications from UAB

a. United States Patent Application 20090016097 - Magnetoelectric device

1. A device comprising at least a first ferromagnetic layer (202) and an element (204) exchange-bias coupled to this layer in at least one place through an interface (208), for controlling the magnetic state of the ferromagnetic layer (202) in the coupling place with an electrical field applied at least on the element, the element comprising a material with clamped antiferromagnetic and ferroelectric characteristics.

2. The device according to claim 1, wherein the material with clamped antiferromagnetic and ferroelectric characteristics comprises hexagonal YMnO3 oxide or any R1MnO3 oxides with hexagonal structure wherein R1 is any element from Ho to Lu, Y or Sc, or orthorhombic structure TbMnO3 or BiFeO3.

3. The device according to claim 1, wherein the first ferromagnetic layer (202) is included in an AMR sensor or in a GMR or MTJ-like heterostructure with a second ferromagnetic layer separated from the first ferromagnetic layer by an intermediate layer.

4. The device according to claim 1, wherein it comprises two suitable metallic electrodes (210,212) for applying an electric field E at least across the element.

5. The device according to claim 2, wherein the first ferromagnetic layer (202) is forming the ferromagnetic layer of an AMR sensor or the ferromagnetic layer of a GMR or MTJ-like heterostructure with a second ferromagnetic layer separated from the first ferromagnetic layer by an intermediate layer.

6. The device according to claim 2, wherein it comprises two suitable metallic electrodes (210,212) for applying an electric field E at least across the element.

7. The device according to claim 3, wherein it comprises two suitable metallic electrodes (210,212) for applying an electric field E at least across the element.

8. The device according to claim 5, wherein it comprises two suitable metallic electrodes (210,212) for applying an electric field E at least across the element.

9. A method for writing non-volatile information by application of an electric field into a device comprising at least a first ferromagnetic layer (202) and an element (204) exchange-bias coupled to this layer in at least one place through an interface (208), for controlling the magnetic state of the ferromagnetic layer (202) in the coupling place with an electrical field applied at least on the element, the element comprising a material with clamped antiferromagnetic and ferroelectric characteristics, the method comprising the following steps: a. heating of the device under the presence of a magnetic field, b. cooling of the device under the presence of a magnetic field without applying any electric field by exploiting the intrinsic electric anisotropy of a ferroelectric material, c. writing information by application of an electric field at least on the element after the cooling in order to modify the magnetic state of the first layer.

10. The method according with claim 9, wherein the material with clamped antiferromagnetic and ferroelectric characteristics comprises hexagonal YMnO3 oxide or any R1MnO3 oxides with hexagonal structure wherein R1 is any element from Ho to Lu, Y or Sc, or orthorhombic structure TbMnO3 or BiFeO3.

11. The method according to claim 9, wherein the first ferromagnetic layer (202) is forming the ferromagnetic layer of an AMR sensor or the ferromagnetic layer of a GMR or MTJ-like heterostructure with a second ferromagnetic layer separated from the first ferromagnetic layer by an intermediate layer.

12. The method according to claim 9, wherein it comprises two suitable metallic electrodes (210,212) for applying an electric field E at least across the element.

13. The method according to claim 10, wherein the first ferromagnetic layer (202) is forming the ferromagnetic layer of an AMR sensor or the ferromagnetic layer of a GMR or MTJ-like

heterostructure with a second ferromagnetic layer separated from the first ferromagnetic layer by an intermediate layer.

14. The method according to claim 10, wherein the device comprises two suitable metallic electrodes (210,212) for applying the electric field E at least across the element.

15. The method according to claim 11, wherein the device comprises two suitable metallic electrodes (210,212) for applying the electric field E at least across the element.

16. The method according to claim 13, wherein the device comprises two suitable metallic electrodes (210,212) for applying the electric field E at least across the element.

b. United States Patent Application 20140017753 - BIOGAS PRODUCTION

1. A process for the production of biogas from biodegradable material which comprises the steps of: (a) adding a biodegradable material to the reactor; (b) inoculating a microorganisms; (c) adding a colloidal solution of surface-modified iron oxide nanoparticles to the reactor; (d) providing anaerobic conditions; (e) carrying out an anaerobic digestion; (f) collecting the biogas; wherein the steps (a), (b) and (c) can be carried out in any order.

2. The process according to claim 1, wherein the iron oxide nanoparticles are Fe3O4 nanoparticles.

3. The process according to claim 1, wherein the process is carried out at a temperature between 30° C. and 70° C.

4. The process according to claim 1, wherein the microorganism is a mesophilic bacterium.

5. The process according to claim 2, wherein the diameter of the iron oxide nanoparticles is between 5 nm and 30 nm.

6. The process according to claim 2, wherein the surface of the iron oxide nanoparticles is hydroxylated or coated with serum proteins.

7. The process according to claim 2, wherein the concentration of the iron oxide nanoparticles is between 0.5 and 1 mg/ml.

8. A method for biogas production in anaerobic conditions and in the presence of iron ions in a biomass medium, the method adding iron oxide nanoparticles capable of supplying iron ions to the medium and collecting biogas.

9. The method according to claim 8, wherein the iron oxide nanoparticles are surface modified.

10. The method according to any of the claim 8, wherein the iron oxide nanoparticles are Fe3O4 nanoparticles.

11. The method according to claim 9, wherein the diameters of the iron oxide nanoparticles are between about 5 nm to about 30 nm.

12. The method according to claim 9, wherein the iron oxide nanoparticles are hydroxylated or coated with serum proteins.

13. The method according to claim 9, wherein the iron oxide nanoparticles are between about 0.5 to about 1 mg/ml.

14. The process according to claim 2, wherein the process is carried out at a temperature between 30° C. and 70° C.

15. The process according to claim 2, wherein the microorganism is a mesophilic bacterium.

16. The process according to claim 3, wherein the diameter of the iron oxide nanoparticles is between 5 nm and 30 nm.

17. The process according to claim 3, wherein the surface of the iron oxide nanoparticles is hydroxylated or coated with serum proteins.

18. The process according to claim 3, wherein the concentration of the iron oxide nanoparticles is between 0.5 and 1 mg/ml.

19. The process according to claim 3, wherein the microorganism is a mesophilic bacterium.

21. Appendix 8: Granted Patents from UAB

a. United States Patent 7573734 - Magnetoelectric device

1. A device comprising at least a first ferromagnetic layer (202) and an element (204) exchange-bias coupled to this layer in at least one place through an interface (208), for controlling the magnetic state of the ferromagnetic layer (202) in the coupling place with an electrical field applied at least on the element, the element comprising a material with clamped antiferromagnetic and ferroelectric characteristics.

2. The device according to claim 1, wherein the material with clamped antiferromagnetic and ferroelectric characteristics comprises: hexagonal YMnO3 oxide; any R1MnO3 oxides with hexagonal structure wherein R1 is any element from Ho to Lu, Y or Sc; orthorhombic structure TbMnO3; or BiFeO3.

3. The device according to claim 1, wherein the first ferromagnetic layer (202) is included in anisotropic magnetoresistance (AMR) sensor or in a Giant Magnetoresistance(GMR) or Magnetic Tunnel Junctions(MTJ)-like heterostructure with a second ferromagnetic layer separated from the first ferromagnetic layer by an intermediate layer.

4. The device according to claim 1, wherein the device comprises two suitable metallic electrodes (210,212) for applying an electric field E at least across the element.

5. The device according to claim 2, wherein the first ferromagnetic layer (202) is forming the ferromagnetic layer of an AMR sensor or the ferromagnetic layer of a GMR or MTJ-like heterostructure with a second ferromagnetic layer separated from the first ferromagnetic layer by an intermediate layer.

6. The device according to claim 2, wherein the device comprises two suitable metallic electrodes (210,212) for applying an electric field E at least across the element.

7. The device according to claim 3, wherein the device comprises two suitable metallic electrodes (210,212) for applying an electric field E at least across the element.

8. The device according to claim 5, wherein the device comprises two suitable metallic electrodes (210,212) for applying an electric field E at least across the element.

9. A method for writing non-volatile information by application of an electric field into a device comprising at least a first ferromagnetic layer (202) and an element (204) exchange-bias coupled to this layer in at least one place through an interface (208), for controlling the magnetic state of the ferromagnetic layer (202) in the coupling place with an electrical field applied at least on the element, the element comprising a material with clamped antiferromagnetic and ferroelectric characteristics, the method comprising the following steps: a. heating of the device under the presence of a magnetic field, b. cooling of the device under the presence of a magnetic field without applying any electric field by exploiting the intrinsic electric anisotropy of a ferroelectric material, c. writing information by application of an electric field at least on the element after the cooling in order to modify the magnetic state of the first layer.

10. The method according with claim 9, wherein the material with clamped antiferromagnetic and ferroelectric characteristics comprises: hexagonal $YMnO_3$ oxide; any $R1MnO_3$ oxides with hexagonal structure wherein R1 is any element from Ho to Lu, Y or Sc; orthorhombic structure $TbMnO_3$; or $BiFeO_3$.

11. The method according to claim 9, wherein the first ferromagnetic layer (202) is forming the ferromagnetic layer of an AMR sensor or the ferromagnetic layer of a GMR or MTJ-like heterostructure with a second ferromagnetic layer separated from the first ferromagnetic layer by an intermediate layer.

12. The method according to claim 9, wherein the device comprises two suitable metallic electrodes (210,212) for applying an electric field E at least across the element.

13. The method according to claim 10, wherein the first ferromagnetic layer (202) is forming the ferromagnetic layer of an AMR sensor or the ferromagnetic layer of a GMR or MTJ-like

heterostructure with a second ferromagnetic layer separated from the first ferromagnetic layer by an intermediate layer.

14. The method according to claim 10, wherein the device comprises two suitable metallic electrodes (210,212) for applying the electric field E at least across the element.

15. The method according to claim 11, wherein the device comprises two suitable metallic electrodes (210,212) for applying the electric field E at least across the element.

16. The method according to claim 13, wherein the device comprises two suitable metallic electrodes (210,212) for applying the electric field E at least across the element.

b. United States Patent 9416373 - Biogas production

1. A process for producing biogas from biodegradable material which comprises the steps of: (a) adding a biodegradable material to a reactor; (b) inoculating a microorganism; (c) adding a colloidal solution of surface-modified iron oxide nanoparticles to the reactor, wherein the diameter of the surface-modified iron oxide nanoparticles is between 3 nm and 30 nm; (d) providing anaerobic conditions; (e) carrying out an anaerobic digestion; (f) collecting the biogas; wherein the steps (a), (b) and (c) can be carried out in any order.

2. The process according to claim 1, wherein the surface-modified iron oxide nanoparticles are Fe3O4 nanoparticles.

3. The process according to claim 1, wherein the process is carried out at a temperature between 30° C. and 70° C.

4. The process according to claim 1, wherein the microorganism is a mesophilic bacterium.

5. The process according to claim 2, wherein the diameter of the surface-modified iron oxide nanoparticles is between 3 nm and 20 nm.

6. The process according to claim 2, the surface-modified iron oxide nanoparticles having surfaces, wherein the surfaces of the surface-modified iron oxide nanoparticles are hydroxylated or coated with serum proteins.

7. The process according to claim 2, wherein the surface-modified iron oxide nanoparticles are in a concentration between 0.5 and 1 mg/ml.

8. A method for biogas production in anaerobic conditions and in the presence of iron ions in a biomass medium, the method comprising the steps of: a) inoculating the biomass medium with a microorganism for anaerobic digestion; b) adding surface-modified iron oxide nanoparticles capable of supplying iron ions to the biomass medium, wherein the diameters of the surface modified iron oxide nanoparticles are between 3 nm and 30 nm; and c) collecting biogas.

9. The method according to any of the claim 8, wherein the surface-modified iron oxide nanoparticles are Fe3O4 nanoparticles.

10. The method according to claim 8, wherein the surface-modified iron oxide nanoparticles are hydroxylated or coated with serum proteins.

11. The method according to claim 8, wherein the surface-modified iron oxide nanoparticles are in a concentration between about 0.5 and about 1 mg/ml.

12. The process according to claim 2, wherein the process is carried out at a temperature between 30° C. and 70° C.

13. The process according to claim 2, wherein the microorganism is a mesophilic bacterium.

14. The process according to claim 3, wherein the diameter of the surface-modified iron oxide nanoparticles is between 3 nm and 20 nm.

15. The process according to claim 3, the surface-modified iron oxide nanoparticles having surfaces, wherein the surfaces of the surface-modified iron oxide nanoparticles are hydroxylated or coated with serum proteins.

16. The process according to claim 3, wherein the surface-modified iron oxide nanoparticles are in a concentration between 0.5 and 1 mg/ml.

17. The process according to claim 3, wherein the microorganism is a mesophilic bacterium.

18. The method according to claim 8, wherein the diameters of the surface modified iron oxide nanoparticles are between 3 nm and 20 nm.

22. Appendix 9: Patent Applications from UFRGS

a. United States Patent Application 20120140636 - Methods and apparatus to determine network link weights

1. A method to determine link weights for routing in a communication network, the method comprising: iteratively updating a plurality of vectors using a genetic algorithm, the vectors including a plurality of individual values decodable into possible link weights; and decoding a first one of the vectors updated using the genetic algorithm into a first plurality of link weights providing a possible routing of a load through the communication network, the load to be split among a plurality of paths having respective path lengths determined from the plurality of link weights, at least two of the paths having different path lengths.

2. A method as defined in claim 1 wherein iteratively updating the plurality of vectors further comprises: partitioning the plurality of vectors into a first group of vectors and a second group of vectors based on routing costs associated with the vectors; and randomly combining a first subset of the first group of vectors and a second subset of the second group of vectors based on a crossover probability.

3. A method as defined in claim 2 wherein iteratively updating the plurality of vectors further comprises: randomly generating a third group of vectors for inclusion in the plurality of vectors; and randomly setting a first individual value of a second vector formed by combining one of the first group of vectors and one of the second group of vectors based on a mutation probability.

4. A method as defined in claim 2 further comprising including the first group of vectors in the updated plurality of vectors.

5. A method as defined in claim 1 wherein, after an iteration of the genetic algorithm, the method further comprises: decoding the updated plurality of vectors into respective pluralities

of link weights supporting dynamic exponentially-weighted flow splitting; determining respective dynamic exponentially-weighted flow splitting routing costs for the pluralities of link weights; and when a processing convergence is detected, selecting a first of the pluralities of link weights associated with a minimum dynamic exponentially-weighted flow splitting routing cost to perform dynamic exponentially-weighted flow splitting routing in the communication network.

6. A method as defined in claim 1 wherein, after decoding the updated plurality of vectors into the respective pluralities of link weights, the method further comprises: incrementing a first link weight of a first of the pluralities of link weights decoded from a first vector updated using the genetic algorithm; determining whether incrementing the first link weight improved a first dynamic exponentially-weighted flow splitting routing cost associated with the first plurality of link weights; if the first dynamic exponentially-weighted flow splitting routing cost is improved, again incrementing the first link weight and determining whether the first dynamic exponentially-weighted flow splitting routing cost is improved; and if the first dynamic exponentially-weighted flow splitting routing cost is not improved, iteratively incrementing a next link weight of the first of the pluralities of link weights and determining whether an associated dynamic exponentially-weighted flow splitting routing cost is improved until no improvement is observed after examining a number of link weights of the first of the pluralities of link weights.

7. A method as defined in claim 1 wherein the at least two paths comprise one or more links, and the load is not to be split onto a link having a gap distance exceeding a gap threshold, the gap distance determined from the plurality of link weights.

8. A method as defined in claim 1 wherein decoding the first one of the vectors into the first plurality of link weights comprises: scaling individual values included in the first vector by a scale factor; and rounding the scaled individual values to respective nearest integer values to determine respective link weights.

9. A tangible article of manufacture storing machine readable instructions which, when executed, cause a machine to at least: iteratively update a plurality of vectors using a genetic

algorithm, each vector including a plurality of individual values decodable into possible link weights for performing routing in a communication network; and decode a vector updated using the genetic algorithm into a plurality of link weights providing a possible routing of a load through the communication network, the load to be split among a plurality of paths having respective path lengths determined from the plurality of link weights, at least some of the paths having different path lengths.

10. A tangible article of manufacture as defined in claim 9 wherein the machine readable instructions, when executed, further cause the machine to: partition the plurality of vectors into a first group of vectors and a second group of vectors based on a routing cost associated with each vector; and randomly combine a first subset of the first group of vectors and a second subset of the second group of vectors based on a crossover probability to determine an updated plurality of vectors during an iteration of the genetic algorithm.

11. A tangible article of manufacture as defined in claim 10 wherein the machine readable instructions, when executed, further cause the machine to: include the first group of vectors in the updated plurality of vectors; randomly generate a third group of vectors for inclusion in the updated plurality of vectors; and randomly set a first individual value of an updated vector formed by combining one of the first group of vectors and one of the second group of vectors based on a mutation probability to determine the updated plurality of vectors during the iteration of the genetic algorithm

12. A tangible article of manufacture as defined in claim 9 wherein the machine readable instructions, when executed, further cause the machine to: decode each of the updated plurality of vectors into a respective plurality of link weights supporting dynamic exponentially-weighted flow splitting after each iteration of the genetic algorithm; determine a dynamic exponentially-weighted flow splitting routing cost associated with each plurality of link weights; and when a processing convergence is detected, select a first plurality of link weights associated with a minimum dynamic exponentially-weighted flow splitting routing cost for performing dynamic exponentially-weighted flow splitting routing in the communication network.

13. A tangible article of manufacture as defined in claim 9 wherein the machine readable instructions, when executed, further cause the machine to: increment a link weight of a first plurality of link weights decoded from a first vector updated using the genetic algorithm; determine whether incrementing the link weight of the first plurality of link weights improved a first dynamic exponentially-weighted flow splitting routing cost associated with the first plurality of link weights; if the first dynamic exponentially-weighted flow splitting routing cost is improved, again increment the link weight of the plurality of link weights and determine whether the first dynamic exponentially-weighted flow splitting routing cost is improved; and if the first dynamic exponentially-weighted flow splitting routing cost is not improved, increment other link weights of the first plurality of link weights and determine whether associated dynamic exponentially-weighted flow splitting routing costs are improved until no improvement is observed after examining a number of link weights of the first plurality of link weights.

14. A tangible article of manufacture as defined in claim 9 wherein the machine readable instructions, when executed, further cause the machine to: scale each individual value included in the vector by a scale factor; and round each scaled individual value to a nearest integer value to determine a respective link weight.

15. An apparatus to determine link weights for routing in a communication network, the apparatus comprising: a processor to iteratively update a plurality of vectors using a genetic method, the vectors including respective pluralities of individual values decodable into possible link weights; and a weight decoder to: decode the plurality of vectors updated by the processor into respective pluralities of link weights providing respective pluralities of possible solutions to route loads through the communication network, the link weights supporting dynamic exponentially-weighted flow splitting; and determine dynamic exponentially-weighted flow splitting routing costs associated respectively with the pluralities of link weights, the processor to partition the vectors for subsequent updating based on the dynamic exponentially-weighted flow splitting routing costs.

16. An apparatus as defined in claim 15 wherein the processor is to update the vectors by: partitioning the vectors into a first group of vectors and a second group of vectors based on the dynamic exponentially-weighted flow splitting routing costs; and randomly combining a first subset of the first group of vectors and a second subset of the second group of vectors based on a crossover probability.

17. An apparatus as defined in claim 16 wherein the genetic algorithm processor is to update the vectors by: including the first group of vectors in the plurality of vectors; randomly generating a third group of vectors to include in the plurality of vectors; and randomly setting a first individual value of an updated vector formed by combining one of the first group of vectors and one of the second group of vectors based on a mutation probability.

18. An apparatus as defined in claim 15 wherein, when a convergence is detected, the weight decoder is to select a first plurality of link weights associated with a minimum dynamic exponentially-weighted flow splitting routing cost to perform dynamic exponentially-weighted flow splitting routing in the communication network

19. An apparatus as defined in claim 15 further comprising a weight updater to: increment a first link weight of a first of the pluralities of link weights decoded from a first updated vector after decoding the updated plurality of vectors into respective pluralities of link weights; determine whether incrementing the first link weight improved a first dynamic exponentially-weighted flow splitting routing cost associated with the first plurality of link weights; if the first dynamic exponentially-weighted flow splitting routing cost is improved, again increment the first link weight and determine whether the first dynamic exponentially-weighted flow splitting routing cost is improved; and if the first dynamic exponentially-weighted flow splitting routing cost is not improved, iteratively increment a next link weight of the first plurality of link weights and determine whether an associated dynamic exponentially-weighted flow splitting routing cost is improved until no improvement is observed after examining a number of link weights of the first of the pluralities of link weights.

20. An apparatus as defined in claim 15 wherein the weight decoder is to: scale individual values included in the vectors by a scale factor; and round the scaled individual values to respective nearest integer values to determine respective link weights.

b. United States Patent Application 20120009687 - Hybrid chemical sensor, and, sensitive polymeric composition

1. A hybrid chemical sensor comprising a sensitive compound encapsulated by a hybrid capsule obtained by sol-gel reaction, said hybrid capsule using siliceous andor titanium alkoxides, wherein at least one of said alcoxides is substituted with one or more alkyl chains.

2. The hybrid chemical sensor according to claim 1, wherein the hybrid capsule is compatible with thermoplastic or thermosetting organic polymer.

3. The hybrid chemical sensor according to claim 1, wherein the hybrid capsule is stable up to a temperature of 300° C. and it endures the shear stress generated in standard extruders.

4. The hybrid chemical sensor according to claim 1, wherein it produces a color change in the presence of amine and/or amide and/or oxide-reducing compounds, and/or vapor thereof

5. The hybrid chemical sensor according to claim 1, wherein said siliceous alkoxides are selected from tetraethoxysilane (TEOS), ethyltrimethoxysilane (ETMS), methyltrimethoxysilane (MTMS), phenyltrimethoxysilane (PTMS), n-octylethoxysilane, or n-butylethoxysilane.

6. The hybrid chemical sensor according to claim 1, wherein said titanium alkoxides are selected from tetraethoxytitanium, ethyltriethoxytitanium, methyltriethoxytitanium, phenyltriethoxytitanium, n-octylethoxytitanium, or n-butylethoxytitanium.

7. The hybrid chemical sensor according to claim 1, wherein the hybrid chemical sensor presents a spherical, fibrillary, laminar or amorphous morphology.

8. A sensitive polymeric composition comprising the hybrid chemical sensor as defined in claim 1.

9. The sensitive polymeric composition according to claim 8, wherein it is made of thermoplastic or thermosetting organic polymers, especially polyolefins of the type Polyethylene (PE) and/or Polypropylene (PP) and/or Vinyl Polychloridc (PVC) and/or blends or composites of these polymers.

10. The sensitive polymeric composition according to claim 8, wherein it produces a color change in the presence of amine and/or amide and/or oxide-reducing compounds, and/or vapor thereof.

23. Appendix 10: Granted Patents from UFRGS

a. United States Patent 8730817 - Methods and apparatus to determine network link weights

1. A method to determine link weights in a communication network, the method comprising: iteratively updating a plurality of vectors using a genetic algorithm, the vectors including a plurality of individual values decodable into possible link weights; and decoding a first one of the vectors updated using the genetic algorithm into a first plurality of link weights providing communication network, the load to be split among a plurality of paths having respective path lengths determined from the first plurality of link weights, at least two of the paths having different path lengths, wherein iteratively updating the plurality of vectors further comprises: partitioning the plurality of vectors into a first group of vectors and a second group of vectors based on routing costs associated with the vectors; and randomly combining a first subset of the first group of vectors and a second subset of the second group of vectors based on a crossover probability.

2. The method as defined in claim 1 wherein iteratively updating the plurality of vectors further comprises: randomly generating a third group of vectors for inclusion in the plurality of vectors; and randomly setting a first individual value of a second vector formed by combining one of the first group of vectors and one of the second group of vectors based on a mutation probability.

3. The method as defined in claim 1 further comprising including the first group of vectors in the plurality of vectors updated using the genetic algorithm.

4. The method as defined in claim 1 wherein, after an iteration of the genetic algorithm, the method further comprises: decoding the plurality of vectors updated using the genetic algorithm into respective pluralities of link weights supporting dynamic exponentially-weighted flow splitting; determining respective dynamic exponentially-weighted flow splitting routing costs for the respective pluralities of link weights; and when a processing convergence is

detected, selecting a first plurality of link weights from the pluralities of link weights, the first plurality of link weights associated with a minimum dynamic exponentially-weighted flow splitting routing cost to perform dynamic exponentially-weighted flow splitting routing in the communication network.

5. The method as defined in claim 4 wherein, after decoding the plurality of vectors updated using the genetic algorithm into the respective pluralities of link weights, the method further comprises: incrementing a first link weight of a first plurality of link weights from the pluralities of link weights, the first plurality of link weights decoded from the first one of the vectors updated using the genetic algorithm; determining whether incrementing the first link weight improved a first dynamic exponentially-weighted flow splitting routing cost associated with the first plurality of link weights; if the first dynamic exponentially-weighted flow splitting routing cost is improved, again incrementing the first link weight and determining whether the first dynamic exponentially-weighted flow splitting routing cost is improved; and if the first dynamic exponentially-weighted flow splitting routing cost is not improved, iteratively incrementing a next link weight of the first plurality of link weights and determining whether an associated dynamic exponentially-weighted flow splitting routing cost is improved until no improvement is observed after examining a number of link weights of the first plurality of link weights.

6. The method as defined in claim 1 wherein the at least two paths comprise one or more links, and the load is not to be split onto a link having a gap distance exceeding a gap threshold, the gap distance determined from the first plurality of link weights.

7. The method as defined in claim 1 wherein decoding the first one of the vectors into the first plurality of link weights comprises: scaling individual values included in the first one of the vectors by a scale factor; and rounding the scaled individual values to respective nearest integer values to determine respective link weights.

8. A tangible machine readable medium comprising machine readable instructions which, when executed, cause a machine to perform operations comprising: iteratively updating a plurality of vectors using a genetic algorithm, the vectors respectively including a plurality of individual values decodable into possible link weights for performing routing in a

communication network; decoding a first vector updated using the genetic algorithm into a first plurality of link weights providing a possible routing of a load through the communication network, the load to be split among a plurality of paths having respective path lengths determined from the first plurality of link weights, at least some of the paths having different path lengths; partitioning the plurality of vectors into a first group of vectors and a second group of vectors based on routing costs associated with respective ones of the vectors; and randomly combining a first subset of the first group of vectors and a second subset of the second group of vectors based on a crossover probability to determine an updated plurality of vectors during an iteration of the genetic algorithm.

9. A tangible machine readable medium as defined in claim 8 wherein the operations further comprise: including the first group of vectors in the updated plurality of vectors; randomly generating a third group of vectors for inclusion in the updated plurality of vectors; and randomly setting a first individual value of an updated vector formed by combining one of the first group of vectors and one of the second group of vectors based on a mutation probability to determine the updated plurality of vectors during the iteration of the genetic algorithm.

10. A tangible machine readable medium as defined in claim 8 wherein the operations further comprise: decoding respective ones of the updated plurality of vectors into respective pluralities of link weights supporting dynamic exponentially-weighted flow splitting after iterations of the genetic algorithm; determining a dynamic exponentially-weighted flow splitting routing cost associated with respective ones of the pluralities of link weights; and when a processing convergence is detected, selecting a first plurality of link weights associated with a minimum dynamic exponentially-weighted flow splitting routing cost for performing dynamic exponentially-weighted flow splitting routing in the communication network.

11. A tangible machine readable medium as defined in claim 8 wherein the operations further comprise: incrementing a link weight of a first plurality of link weights decoded from the first vector; determining whether incrementing the link weight of the first plurality of link weights improved a first dynamic exponentially-weighted flow splitting routing cost associated

with the first plurality of link weights; if the first dynamic exponentially-weighted flow splitting routing cost is improved, again incrementing the link weight of the first plurality of link weights and determining whether the first dynamic exponentially-weighted flow splitting routing cost is improved; and if the first dynamic exponentially-weighted flow splitting routing cost is not improved, incrementing other link weights of the first plurality of link weights and determining whether associated dynamic exponentially-weighted flow splitting routing costs are improved until no improvement is observed after examining a number of link weights of the first plurality of link weights.

12. A tangible machine readable medium as defined in claim 8 wherein the operations further comprise: scaling individual values included in the first vector by a scale factor; and rounding the scaled individual values to nearest integer values to determine respective link weights.

13. An apparatus to determine link weights for routing in a communication network, the apparatus comprising: a processor to iteratively update a plurality of vectors using a genetic method, the vectors including respective pluralities of individual values decodable into possible link weights; and a weight decoder to: decode the plurality of vectors updated by the processor into respective pluralities of link weights providing respective pluralities of possible solutions to route loads through the communication network, the link weights supporting dynamic exponentially-weighted flow splitting; and determine dynamic exponentially-weighted flow splitting routing costs associated respectively with the pluralities of link weights, the processor to partition the vectors for subsequent updating based on the dynamic exponentially-weighted flow splitting routing costs.

14. The apparatus as defined in claim 13 wherein the processor is to update the vectors by: partitioning the vectors into a first group of vectors and a second group of vectors based on the dynamic exponentially-weighted flow splitting routing costs; and randomly combining a first subset of the first group of vectors and a second subset of the second group of vectors based on a crossover probability.

15. The apparatus as defined in claim 14 wherein the processor is to update the vectors by: including the first group of vectors in the plurality of vectors; randomly generating a third group of vectors to include in the plurality of vectors; and randomly setting a first individual value of an updated vector formed by combining one of the first group of vectors and one of the second group of vectors based on a mutation probability.

16. The apparatus as defined in claim 13 wherein, when a convergence is detected, the weight decoder is to select a first plurality of link weights associated with a minimum dynamic exponentially-weighted flow splitting routing cost to perform dynamic exponentially-weighted flow splitting routing in the communication network.

17. The apparatus as defined in claim 13 further comprising a weight updater to: increment a first link weight of a first plurality of link weights from the pluralities of link weights, the first plurality of link weights decoded from a first updated vector after decoding the updated plurality of vectors into respective pluralities of link weights; determine whether incrementing the first link weight improved a first dynamic exponentially-weighted flow splitting routing cost associated with the first plurality of link weights; if the first dynamic exponentially-weighted flow splitting routing cost is improved, again increment the first link weight and determine whether the first dynamic exponentially-weighted flow splitting routing cost is improved; and if the first dynamic exponentially-weighted flow splitting routing cost is not improved, iteratively increment a next link weight of the first plurality of link weights and determine whether an associated dynamic exponentially-weighted flow splitting routing cost is improved until no improvement is observed after examining a number of link weights of the first plurality of link weights.

18. The apparatus as defined in claim 13 wherein the weight decoder is to: scale individual values included in the vectors by a scale factor; and round the scaled individual values to respective nearest integer values to determine respective link weights.

b. United States Patent 9063111 - Hybrid chemical sensor, and, sensitive polymeric composition

1. A hybrid chemical sensor comprising a sensitive compound completely dispersed within a polyolefin matrix and encapsulated by a hybrid capsule obtained by sol-gel reaction, said hybrid capsule using siliceous alkoxides or titanium alkoxides, wherein at least one of said alkoxides is substituted with one or more alkyl chains, wherein the hybrid chemical sensor responds to the presence of amine and/or amide and/or oxide-reducing compounds, and/or vapor thereof by color change after being dispersed through the polyolefin matrix, and wherein the hybrid chemical sensor is incorporated into the polyolefin matrix by extrusion and without any loss in chemical characteristics during polyolefin processing, and is used as an indicator of conditions in a particular environment in contact with said hybrid chemical sensor.

2. The hybrid chemical sensor according to claim 1, wherein the hybrid capsule is stable up to a temperature of 300° C. and endures the shear stress generated in standard extruders.

3. The hybrid chemical sensor according to claim 1, wherein said siliceous alkoxides are selected from the group consisting of tetraethoxysilane (TEOS), ethyltrimethoxysilane (ETMS), methyltrimethoxysilane (MTMS), phenyltrimethoxysilane (PTMS), n-octylethoxysilane, or n-butylethoxysilane.

4. The hybrid chemical sensor according to claim 1, wherein said titanium alkoxides are selected from the group consisting of tetraethoxytitanium, ethyltriethoxytitanium, methyltriethoxytitanium, phenyltriethoxytitanium, n-octylethoxytitanium, or n-butylethoxytitanium.

5. The hybrid chemical sensor according to claim 1, wherein the hybrid chemical sensor presents a spherical, fibrillary, laminar or amorphous morphology.