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Meta-model for compliance management

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Abstract

Compliance checking and enforcement is the act of establishing internal controls with which adherence to regulations is guaranteed. Compliance management is the ongoing process of identifying relevant regulations to the organization; assessing the risk of not obeying the identified compliance requirements; establishing effective internal controls to prevent/avoid/detect violations to compliance; maintain the effectiveness of these controls. In order for an organization to conform to compliance regulations, it is necessary to study the structure and types of these legal documents, identify their features and ultimately define compliance rules in a formal manner easily automated. In order to depict compliance concepts and the relations between them a conceptual meta-model is proposed in this thesis. This should enable compliance enforcement in all the phases of business process lifecycle in a consistent fashion independently from the modelling approach adopted to describe business processes. The proposed meta-model is validated through the comparison with other meta-models and the instantiation of it.

Keywords: Compliance management, Compliance enforcement, Meta-model, Semantic analysis

Abstract in Greek

Η συμμόρφωση σε κανόνες και η επιβολή αυτών είναι η πράξη της δημιουργίας εσωτερικών ελέγχων με την οποία η τήρηση των κανονισμών είναι εγγυημένη. Η διαχείριση της συμμόρφωσης σε κανόνες είναι η εν εξελίξει διαδικασία της αναγνώρισης σχετικών κανονισμών για έναν οργανισμό, η αξιολόγηση του κινδύνου ανυπακοής στις καθορισμένες απαιτήσεις συμμόρφωσης, η θέσπιση αποτελεσματικών εσωτερικών ελέγχων για την πρόληψη / αποφυγή / εντοπισμό των παραβιάσεων και η διατήρηση της αποτελεσματικότητα των ελέγχων αυτών. Για την συμμόρφωση ενός οργανισμού στους κανονισμούς είναι αναγκαία η μελέτη της δομής και των ειδών των νομικών εγγράφων και ο προσδιορισμός των χαρακτηριστικών τους για τον τελικό καθορισμό κανόνων σε κωδικοποιημένη μορφή. Με σκοπό την απεικόνιση των οντοτήτων που περιγράφουν την συμμόρφωση και των σχέσεων μεταξύ τους , αυτή η εργασία προτείνει τη δημιουργία ενός εννοιολογικού μετά-μοντέλου. Αυτό το μετά-μοντέλο θα επιτρέψει την επιβολή της συμμόρφωσης σε όλες τις φάσεις του κύκλου ζωής των επιχειρηματικών διαδικασιών με συνεπή τρόπο , ανεξάρτητα από την προσέγγιση μοντελοποίησης που υιοθετείται για την περιγραφή τους. Το προτεινόμενο μετά-μοντέλο επικυρώνεται μέσω της σύγκρισης με άλλα μετά - μοντέλα και την δημιουργία στιγμιότυπων του.

Λέξεις-κλειδιά: Διαχείριση συμμόρφωσης, Επιβολή συμμόρφωσης, Μετά-μοντέλο, Σημασιολογική ανάλυση

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1 Introduction

1.1 The context

Globalization has amplified the problem of internationalizing and localizing software systems to ensure that they comply with both international and local regulations. Different international policies, laws and regulations, written in a wide range of languages even within one jurisdictional entity – such as the European Union – together with privacy and security requirements, pose serious challenges for software system developers world-wide.

In particular, IT professionals have to face the so-called regulation compliance problem, whereby companies and developers are required to ensure that their software systems comply with relevant regulations, either by design or through re-engineering.

With the start of the new millennium, a number of financial scandals in many places of the world, ending with the financial crisis from the year 2008, have drawn attention to the severe impact of lack of control over business. Fraudulent business transactions, lack of trusted reporting mechanism of companies and uncontrolled money transfer are just a few examples for what lack of control can lead to. As a reaction, several regulations, e.g., SOX, and financial guidelines, e.g., BASELII, were established to force organizations to have internal controls over their business and be able to show that to authorities. The objective behind these regulations and guide lines is of course to avoid such scandals and to safeguard the economic system.

Compliance checking and enforcement is the act of establishing internal controls with which adherence to regulations is guaranteed. Compliance management is the ongoing process of identifying relevant regulations to the organization; assessing the risk of not obeying the identified compliance requirements; establishing effective internal controls to prevent/avoid/detect violations to compliance; maintain the effectiveness of these controls.

A compliance officer is a new role created within the organization structure to be in charge of managing and following up the compliance status assessment of the organization. Compliance requirements might not just stem from regulations. Rather, an organization might want to establish controls for its own internal policies and to benefit from best practices in the business domain. Moreover, compliance is a

domain-specific problem where requirements vary from one domain to another. For instance, Sarbanes-Oxley act is concerned with regulating companies; Anti Money Laundering guidelines are relevant to financial institutions. This calls for a repeatable compliance checking and enforcement processes within the organization.

1.2 Problem statement

Achieving compliance requires massive effort and costs (Hartman, 2006). Currently, compliance is achieved by hiring expensive auditors who typically use a heuristic approach to select and investigate audit trails to show evidence about compliance. An audit trail could be any evidence on a business activity, e.g., bills, bank statement, or logs of information systems. In addition to the impact on the organization's budget, compliance checking with this approach incurs a large overhead in terms of time consumed to check for compliance. Moreover, the check is always of a detective nature. That is, an auditor can detect violations. In this case, organizations might be subject to penalties due to non-compliance or due to being late to declare compliance.

As the need for compliance checking is inextricably linked to business processes, the majority of the approaches are studying the conformance to rules in different phases of the business process lifecycle.

This thesis aims to explore the compliance domain independently from business process management activities in order to clarify the notions describing it. In order for an organization to conform to compliance regulations, it is necessary to study the structure and types of these legal documents, identify their features and ultimately define compliance rules in a formal manner easily automated.

1.3 The approach

In order to depict compliance concepts and the relations between them a conceptual meta-model is proposed in this thesis. This should enable compliance enforcement in all the phases of business process lifecycle in a consistent fashion independently from the modelling approach adopted to describe business processes.

Meta-modeling is the construction of a collection of "concepts" (things, terms, etc.) within a certain domain. A model is an abstraction of phenomena in the real world; a meta-model is yet another abstraction, highlighting properties of the model itself. A

model conforms to its meta-model in the way that a computer program conforms to the grammar of the programming language in which it is written (Gaarder, 1994).

Common uses for meta-models are:

- As a schema for semantic data that needs to be exchanged or stored
- As a language that supports a particular method or process
- As a language to express additional semantics of existing information
- As a mechanism to create tools that work with a broad class of models at run time (Smith, 1984)
- As a schema for modeling and automatically exploring sentences of a language with applications to automated test synthesis

This thesis aims to express through the meta-model the semantics and relations of the entities describing compliance.

In order to describe the procedure of designing and capturing the notions of compliance consisting the proposed meta-model, this thesis is presenting the design rationale in a structured fashion. The recording of design decisions by the modeler was facilitated by the use of the Compendium tool (Buckingham Shum 2002; Compendium-Institute 2008) that acted as a common framework for enabling a systematic analysis of design decisions across all design efforts.

After the phase of designing, it was essential for the plenitude of this thesis to proceed to the validation of the proposed compliance meta-model. Thus, two validation methods were selected:

- Comparison against other meta-models,
- Instantiate the compliance meta-model by examining various legal documents.

1.4 Structure of the thesis

The rest of the thesis is organized as follows.

Chapter 2 discusses the existing approaches for compliance checking and compliance management and concludes to the scope of this thesis. In chapter 3 is presented the design rationale of designing the compliance meta-model. Chapter 4 explains the rationale of validating the designed meta-model through the comparison with other existing and meta-models and the instantiation of it. In chapter 4 this thesis proceeds

to an ontological analysis of the meta-model. This thesis concludes in chapter 5 with important remarks and observations and suggestions for future work.

2 Literature Review and current state of the art

2.1 Introduction

Since the passing of the Sarbanes-Oxley Act (SOX) (Sarbanes-Oxley Act 2002) the world's regulation environment has changed significantly. This has seen companies confronted with a steady increase of rules that have serious effects on internal business processes. Compliance to regulations is one of the major concerns of organizations. Compliance is mainly ensuring that business processes, operations and practices are conforming to a prescribed and/or agreed on set of norms (Sadiq, Governatori et al. 2007), namely compliance requirements. Compliance constraints may came from legal documents, such as legislation, regulatory bodies, standards, code of practices and contracts between interacting parties, e.g., Service-Level Agreements (SLAs). There is an increase in the number of regulations, standards, legislations and other sources of compliance requirements, which enforce organizations to assess their business processes and make sure that they adhere to the constraints set forth.

The concept of business process compliance denotes that the execution of certain processes complies with a set of regulations (Sadiq, Governatori et al. 2007).

Compliance is historically viewed as a burden, although there are indications that businesses have started to see the regulations as an opportunity to improve their business processes and operations. There are indications (BPM Forum, 2006) indicate that up to 80% of companies expect to reap business benefits from improving their compliance regimens. The compliance management of firms is faced with a challenging task: The audit of business processes in order to comply with regulations, such as SOX, the minimum requirements for risk management or money laundry laws (i.e., U.S. Money Laundering Suppression Act of 1994), becomes more and more sophisticated.

The purpose of this chapter is to present and discuss the existing approaches in compliance management and compliance checking scientific area. After an overall review, the focus of this chapter will be the description of existing compliance meta-models in order to understand the state of the art and to identify the possible drawbacks of each approach.

2.2 Compliance classes

According to (El-Kharbili, Stein et al. 2008), regulatory compliance consists of measures and directives, which are implemented by policies, internal controls and procedures and which are modeled for business processes. They identified three classes of compliance rules: Regulations, IT security standards, and quality standards. One of the most prominent examples for regulations is the Sarbanes-Oxley Act (SOX), which is a major regulation for investor protection in the United States. Its section 404 (Definition of Internal Controls over Financial Reporting) in particular is one of the most strongly regarded sections due to its impact on IS academia. Other regulations like IT security standards (i.e., ISO/IEC 27002:2005) and quality standards like ISO 20000 further increase the number of relevant compliance requirements. In order to enable an automated compliance checking, it is necessary that, besides a formal representation of process models, compliance requirements exist in an analyzable format. A formalized compliance requirement is a structural pattern (Ghose and Koliadis 2007), which defines how the structure of a subsection of a process model has to look like in order to comply with the underlying rule.

2.3 Compliance enforcement

Business process compliance is about ensuring that business processes, operations and practices are in accordance with a prescribed and/or agreed on set of norms (Papazoglou 2011). The term compliance describes the ability to act according to an order, set of rules or request.

Considering this environment, compliance experts, who are responsible for the legal checking of new and changed business processes, need automation support for compliance-checking. As companies increasingly make use of business process models – graph-based formal business process description techniques like Event-driven Process Chains (EPCs) (Keller, Nüttgens, and Scheer 1992), Petri Nets (Peterson 1977) or the Business Process Model and Notation (BPMN) (Object Management Group 2011) – in order to design and document their business processes, Information Systems (IS) research reacts to this requirement with the development of (partly) automated model-based compliance-checking approaches and tools. The idea is to identify potential compliance violations in business processes by looking at the models describing them. Compliance-checking approaches have in common that they

define compliance rule patterns, such as "activity A must be executed before activity B is executed" and apply them to a set of business process models to determine whether or not the process complies with the underlying rule. In real-world scenarios, such compliance-checking approaches are faced with two major challenges: First, a large number of conceptual modeling techniques exist and are used in practical environments (Davis, Green, Rosemann, Indulska, and Gallo 2006). In effect, a compliance-checking approach should not be restricted to a distinct modeling technique to allow widespread application by companies. Second, regulations and compliance rules might be complex. Such complex regulations (e.g., escalation procedures, which include loops of business process activities combined with several alternative paths and different organizational units with different competencies) are, for instance, directed through the German risk management requirements (Gerstlberger, Kreuzkamp, Harland, and Altholz 2010). Hence, compliance-checking approaches should support the definition of such rules and their application to process models.

2.3.1 Compliance enforcement phases

(El-Kharbili, Stein et al. 2008) classify the implementation of control mechanisms in three time-dependent phases "Design-Time Compliance Checking", "Runtime Compliance Checking" and "Backward Compliance Checking".

2.3.1.1 Design-Time Compliance Checking

These approaches have a preventive nature and their goal is the conformance of process instances. In this sense, some approaches propose the limitation of non-compliance deployed models during the modelling phase, while others use techniques like model checking to verify certain properties in already designed (but not yet deployed) business models.

The authors (Ghose and Koliadis 2007) propose an approach based on compliance patterns (i.e., pre-defined BP models for which compliance to regulations have been proven). The main idea is to compute the deviation of a given BP model to a certain compliance pattern. Governatori et al. (2006) view business processes (BPs) as social interaction processes and present a framework for managing the compliance of

contractual relationships in BPs. For this, deontic assignments are defined in a multi-modal logical framework in the form of policies/rules.

Namiri et al. (Namiri and Stojanovic 2008.) present a formal approach for defining BP compliance checking that relies on control patterns. Control patterns constitute a generic and reusable solution to a specific problem and, therefore, can be used to ensure that BP models containing them are regulatory compliant.

In a previous work (Namiri and Stojanovic 2007), the research is focused in the interpretation of process instances according to a defined set of controls. This is achieved by adding a semantic layer to the BPM stack. The actual implementation (e.g. database procedures, temporal logic or rules) of the controls is independent from the modelling. Another interesting approach is presented in 2007 (Sadiq, Governatori et al. 2007) where they are justify why automation and semantic enactment are necessary for effective BP compliance. They formalize modelling of controls for compliance by motivating the need for logics that are stronger than standard deontic logic. Finally, the work by Schmidt et al. (2007) is one of the rare semantic approaches to BP compliance where compliance ontology is designed and proposed to be integrated in BP models.

2.3.1.2 Runtime Compliance Checking

The target of these approaches is the business process models that are executable. Consequently, these approaches depend on the BP execution architecture and mechanisms. They typically work by annotating BP models or steps with atomic compliance assertions that are destined to be either used by compliance checking engines for verification or at later stages during execution. In this sense, regulations can either be defined into BP models (e.g. control flow properties such as BP anti-patterns (Vanhatalo et al.,2007) which seek to achieve better quality of processes or organizational properties such as Separation of Duty), or they can require run-time information (e.g. quality assertion enforcement while executing a BPEL (Rossak et al. ,2006)).

In the approach of Liu et al. in 2007, the authors identified the need for separate modeling of compliance and processes. Process models are transformed from BPEL into the Pi-Calculus (Milner, 1993) (an algebra for modelling concurrent communicating processes) and compliance rules are modeled in temporal logic using

a special graphical notation. Model checking techniques are then used to formally check a process pool.

Another approach (Pesic et al., 2007) introduces a framework in which process models are defined in a declarative way. The authors argue that constraint-based workflow models are more expressive and more flexible than procedural ones.

The approach of Milosevic in 2005 poses initial questions about architectures for process compliance monitoring integrating events and policies such as the need for a formal definition of events, event triggers and related resources, event patterns, message handling as well as state management. Additionally, business rule management systems are widely used in the industry for production rule execution. Some compliance measures can be modeled as business rules and be coupled to BP definitions.

2.3.1.3 Backward Compliance Checking

Backwards compliance checking (BCC) techniques verify if executions of BP (i.e., process instances) are in accordance with certain constraints or rules. Rozinat et al. (2008) has developed conformance checking techniques that quantify how much the behavior of a given control-flow process model matches the behavior registered in process instances of a given history log. Whenever differences (or non-compliance) are detected, the developed conformance checking techniques provide an exact indication of where the differences are. This approach has the advantage that a graphical notation is used for specifying the models. However, the provided compliance is restricted to control-flow-related constraints. Thus, no rules involving data fields or performers information can be checked.

2.4 Complexity of compliance rules

Compliance-checking approaches differ in the complexity of compliance rules they are able to support. The following categorization of compliance rule patterns was derived from the literature analysis, showing that compliance-checking approaches support different kinds of compliance rules. As any process model can be interpreted as a graph, it is necessary to classify this complexity according to the properties of different, generally accepted types of graphs. A compliance pattern that, for example, only depicts a temporal or linear rule (like, e.g., “activity A must be executed before

activity B starts") represents one of the simplest graph structures, namely a path (Diestel 2010). Therefore, the compliance patterns corresponding with a path are classified as simple compliance patterns. More sophisticated compliance rules require considering resource-related issues additionally and include, for instance, organizational requirements. A corresponding compliance rule of such medium complexity is, for example, the separation of duties. It requires two succeeding activities to be executed by different persons. The structure of such compliance rules corresponds with the medium complex graph structure of a tree (Diestel 2010). Therefore, the classification of compliance patterns corresponding with a tree is made as compliance patterns with a medium complexity. Complex compliance rules may incorporate graph structures that underlie no structural restrictions. They represent, for instance, particular loops as an effect of decision alternatives and use information from other types of models like data diagrams, organization or architecture diagrams.

Based on this categorization, a compliance-checking approach considering complex compliance rule patterns also supports medium complex and simple patterns. An approach supporting medium complex patterns also supports simple patterns. This correlation does not apply vice versa.

2.5 Compliance meta-models

To deal with the problem of regulatory compliance, there is a need for formal models of law that can be formally analyzed through various forms of reasoning to help requirements engineers find compliant solutions. Modeling approaches intended for law, have been studied for decades generally grounded on expressive, often modal, logics. Other approaches, grounded in Natural Language Processing and Information Retrieval, support different forms of analysis such as determining case similarity and relevance (Siena, Ingolfo et al. 2013). Neither heavy-handed logical representations, nor natural language ones properly support the analysis requirements engineers need when they tackle the problem of regulatory compliance. Instead, it is proposed to use conceptual models of law that sit somewhere between logical and natural language models with respect to complexity.

There are several approaches presenting conceptual meta-models or ontologies for compliance management. With the increase in attention paid to the role of compliance within business processes, several works have been produced in the area of

compliance management, attempting to address the current needs of organizations. Notably, the COSO (1994) framework is an early work introduced as a key guidance to establish internal control mechanisms in organizations. The COSO framework does not propose a model to describe compliance concepts; however, it elucidates the way the organization progresses from objectives, abstract requirements, to controls instituted into the processes. Other initiatives, such as COBIT (2007) and OCEG's GRC (2009) provide a governance model with control objectives for particular domains to help organizations to refine concrete controls. However, similarly these models do not provide explicit guidance addressing how compliance concepts and their interrelationships are defined and integrated.

However, these works fail to address several concepts, such as compliance requirements, sources and concerns, which are particular to BP compliance.

On the specification of compliance requirements (Sadiq, Governatori et al. 2007) proposes an approach for modelling control objectives within BP structures. Their work is one of the few works that actually introduce a basic model to capture compliance requirements (Fig.1).

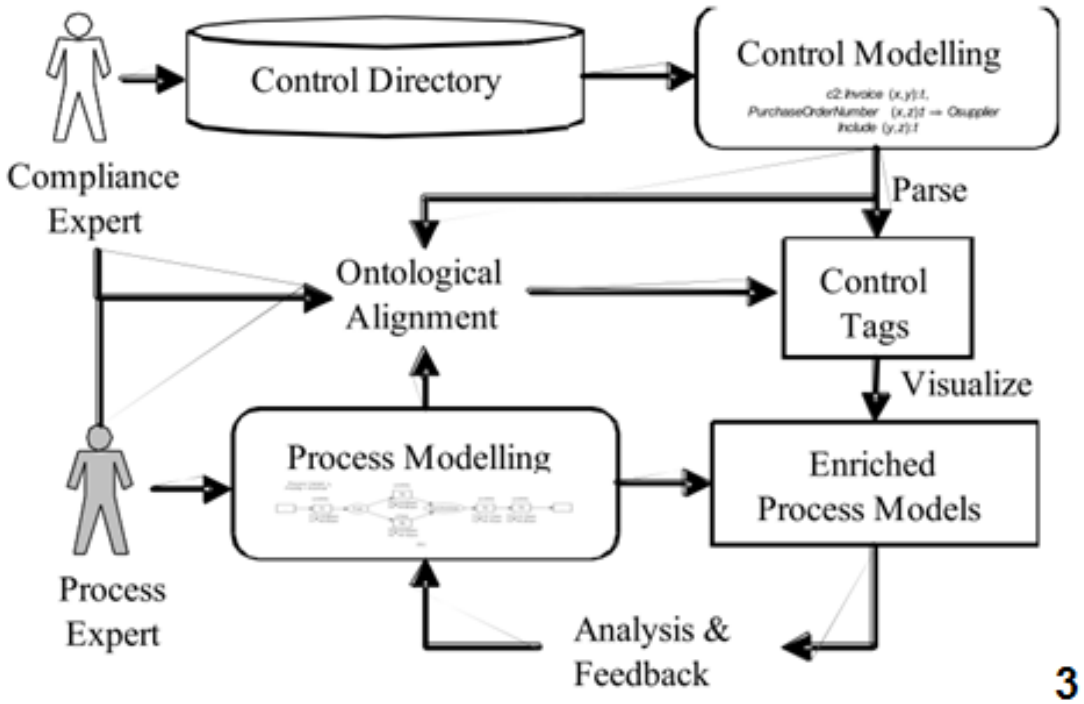

Figure 1-Interconnect of Process management and Controls management (Sadiq, Governatori et al. 2007)

In order to realize what Sadiq et al. (Sadiq, Governatori et al. 2007) refers to as 'compliance-by-design', BP models are enriched with, so-called, 'control tags'. They propose a modal logic based approach using Formal Contract Language (Governatori, Milosevic and Sadiq, 2006), which separates the prescriptive modelling of processes and the descriptive nature of compliance requirements. However, the complexity of the adopted formal language poses critical problems in practice. Similarly, a number of approaches and technologies have been developed, proposing a separate BP modelling and compliance requirements modelling phases, which is followed by a model checking based approach for compliance verification (Ghose and Koliadis, 2007, Liu et al., 2007, Namiri and Stojanovic, 2007).

In the sub-sections below several approaches of conceptual meta-models for compliance are presented.

2.5.1 Conceptual meta-model-COMPAS

The COMPAS meta-model was designed within a European project (fp7). The figure (Fig.2) below shows the conceptual model of the concepts which have been developed in the course of the project (Papazoglou 2011, Turetken, Elgammal et al. 2011, Turetken, Elgammal et al. 2012).

Pragmatically, COMPAS did not aim at over-engineering the compliance problem, e.g., by allowing compliance experts to enforce compliance of individual messages flowing through a company's IT infrastructure, and instead focused on compliance awareness, that is, on the design for, monitoring, and reporting on compliance.

The COMPAS project realized a practical modelling approach for specifying service oriented architectures with compliance concerns. In particular, business processes can be designed and compliance controls can be associated with processes and process elements. They applied a model-driven engineering approach and used annotation techniques for relating system and requirement models at design-time.

Fig.2 gives an overview of the key components in the compliance meta-model. The compliance model assumes that business processes are designed as a collection of process elements. Processes contain basic elements, such as activities, events, and business objects. They also contain roles, and organizational units. Business processes

instantiations are subject to compliance requirements as are business process elements.

The COMPAS meta-model achieved:

- to specify and document compliance requirements originating from laws, regulations, or policies;
- to link IT – in particular business processes and services – to compliance requirements originating from laws, regulations, or policies,
- to establish and realize compliance management for their IT-based business solutions and services.

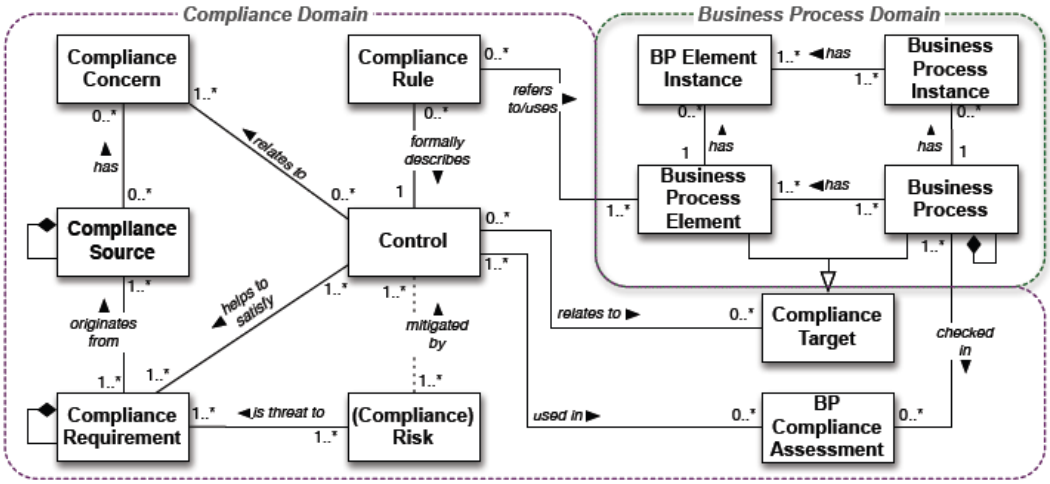

Figure 2-COMPAS conceptual meta-model (Papazoglou 2011, Turetken, Elgammal et al. 2011, Turetken, Elgammal et al. 2012)

2.5.2 A Meta-Model for Modelling Law-Compliant Requirements

Siena et al. (2009) introduce a detailed meta-model of a framework for modelling legal prescriptions. The framework is tailored to be integrates with existing goal-oriented requirements engineering techniques, in order to support the decision about requirements in a law-regulated domain.

When facing law it is essential to know the concepts used by law to give prescriptions. The Hohfeld's taxonomy (Hohfeld, 1913) is a milestone of juridical literature that proposes a widely accepted classification of legal concepts. It is grounded on the notion of right, which can be defined as "entitlement (not) to perform

certain actions or be in certain states, or entitlement that others (not) perform certain actions orbe in certain states"1. Rights are classified by Hohfeld in the 8 elementary concepts of privilege, claim, power, immunity, no-claim, duty, liability, disability, and organized in opposites and correlatives, as in Table 1.

Legal relation	**Opposite**	**Correlative**
Claim	Noclaim	Duty
Privilege	Duty	Noclaim
Power	Disability	Liability
Immunity	Liability	Disability

Table 1-The Hohfeldian taxonomy (Hohfeld, 1913)

The concept of normative proposition allows splitting the complexity of legal statements into their atomic elements. But the legal prescriptions contained in laws have more properties that have to be considered. In particular, legal prescriptions are articulated structures built with conditions, exceptions, and so on. It is important to capture the effects of these conditionals in order to obtain meaningful requirements set (Fig.3). The addressee of the legal prescription is the *Subject*. In this framework the concept of subject is identified with the concept of *Actor*. Because of the concept of correlativeness, both the right holder and its correlative are actors. If a person has a right, then another person has its complement. This is shown in Fig.3, where the class *Actor*, representing the subject, and the class *Right* are introduced and connected by the two relationships holder and counterparty. The last component of a normative proposition is called action, and it is the actual object of the right. Each *Right* is in concerns relations with exactly one *ActionCharacterization*, but an *ActionCharacterization* can be addressed by a number of rights. The Nomos modelling language adopts the hohfeldian taxonomy of legal concepts described above.

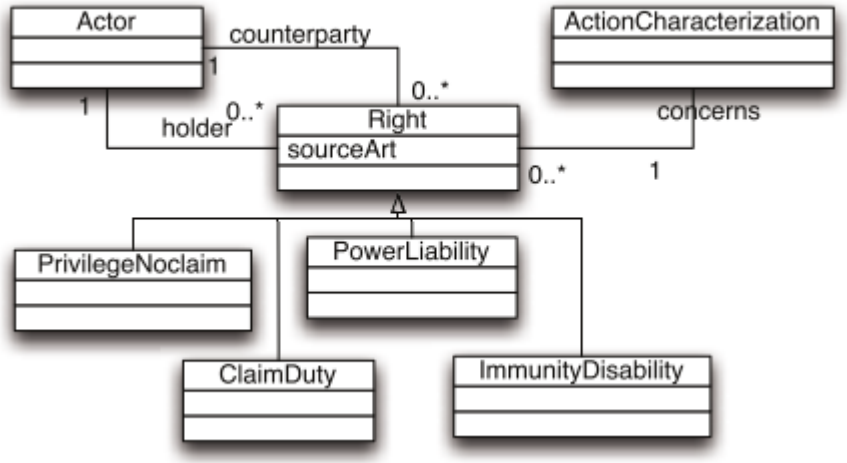

Figure 3- The Nomos meta-model - Siena et al. (2009)

The meta-model described above is intended to provide the concepts for producing goal-based models of requirements, in which laws are an explicit part of the model. Interleaving goals and laws will allow arguing about the alignment of those goals with the law.

This research was based in the paper of Anton and Breaux (2006). They have developed a systematic process, called semantic parameterization, which consists of identifying in legal text restricted natural language statements (RNLSs) and then expressing them as semantic models of rights and obligations (along with auxiliary concepts such as actors and constraints). Their approach has some advantages and some disadvantages. The advantage is the support of automatic extraction of requirements from legal text. The disadvantage is that the extracted requirements are not related with the context (i.e., with the actors goals) and the analyst can't reason about the best way to implement legal prescriptions.

2.5.3 Ontology-based representation of compliance requirements for service processes

This paper (Schmidt et al., 2007) has introduced an ontology-based approach to represent service processes and their compliance requirements. Thus, it lays the foundation for verifying the compliance of service processes. Two ontologies were defined: The process ontology defines the concepts needed to represent service processes. The compliance ontology contains concepts to represent objectives and

requirements for compliance standards. Three types of compliance requirements have been identified: syntactic, semantic, and pragmatic (Fig.4).

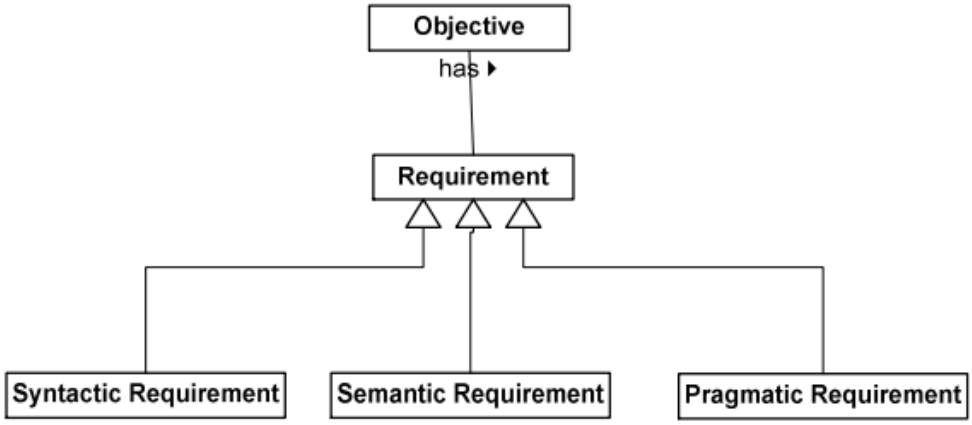

Figure 4- Types of compliance requirements-(Schmidt et al., 2007)

Syntactic requirements can easily be represented by constraining the properties used for connecting the process elements. Semantic requirements can be further differentiated into assertion, action and structure requirements (Fig.5). Assertion requirements define conditions which have to be met. They consist of a verb and an object. They do not specify directly who is responsible for the condition. Action requirements define actions to be performed as part of the process. An action is comprised of a verb and an object of the verb. Structure requirements define structures that must exist in the process in order to be compliant.

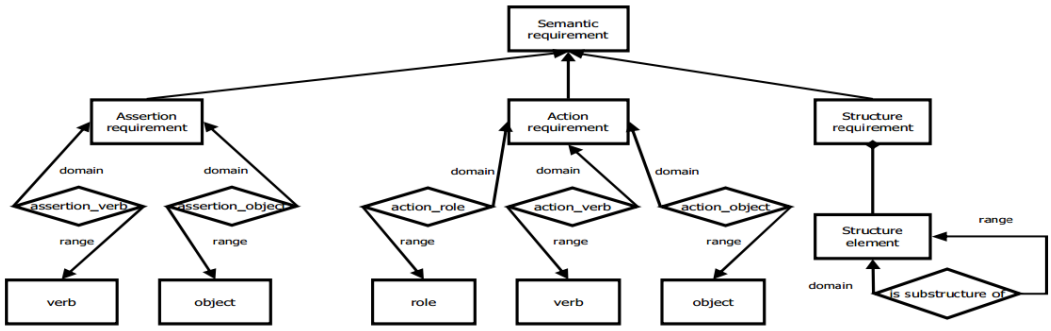

Figure 5- Semantic requirements categorization-(Schmidt et al., 2007)

The notion of pragmatic requirements is the definition of abstract goals of compliance standards. These requirements are difficult to achieve because their extraction is depended on each modeler.

2.5.4 A Compliance Management Ontology: Developing Shared Understanding through Models

In this paper (Abdullah et al., 2012), the authors have presented CoMOn - A Compliance Management Ontology, which was developed to address the need within the compliance management professional and research communities to have a common understanding of the various concepts that define the compliance management landscape. CoMOn is the result of a study that has spanned across the various phases of ontology development, evaluation and refinement.

The refined ontology consists of 81 concepts. These concepts are structured into four main tiers, representing different levels of detail derived through progressive decomposition of higher tier concepts. For example, the Program concept has been detailed into Obligations Identification and Assessment, Competency and Training, Controls and Monitoring, Record Keeping and Reporting, Review, and Structure in Tier 2, and so on. Each concept is equipped with a definition, attributes, and examples of realization where available. Fig.6 shows CoMOn with its first, second and third tiers concepts after the evaluation and refinement phases.

This approach because of its variety of concepts does not present a solid and comprehensive methodology of managing compliance issues.

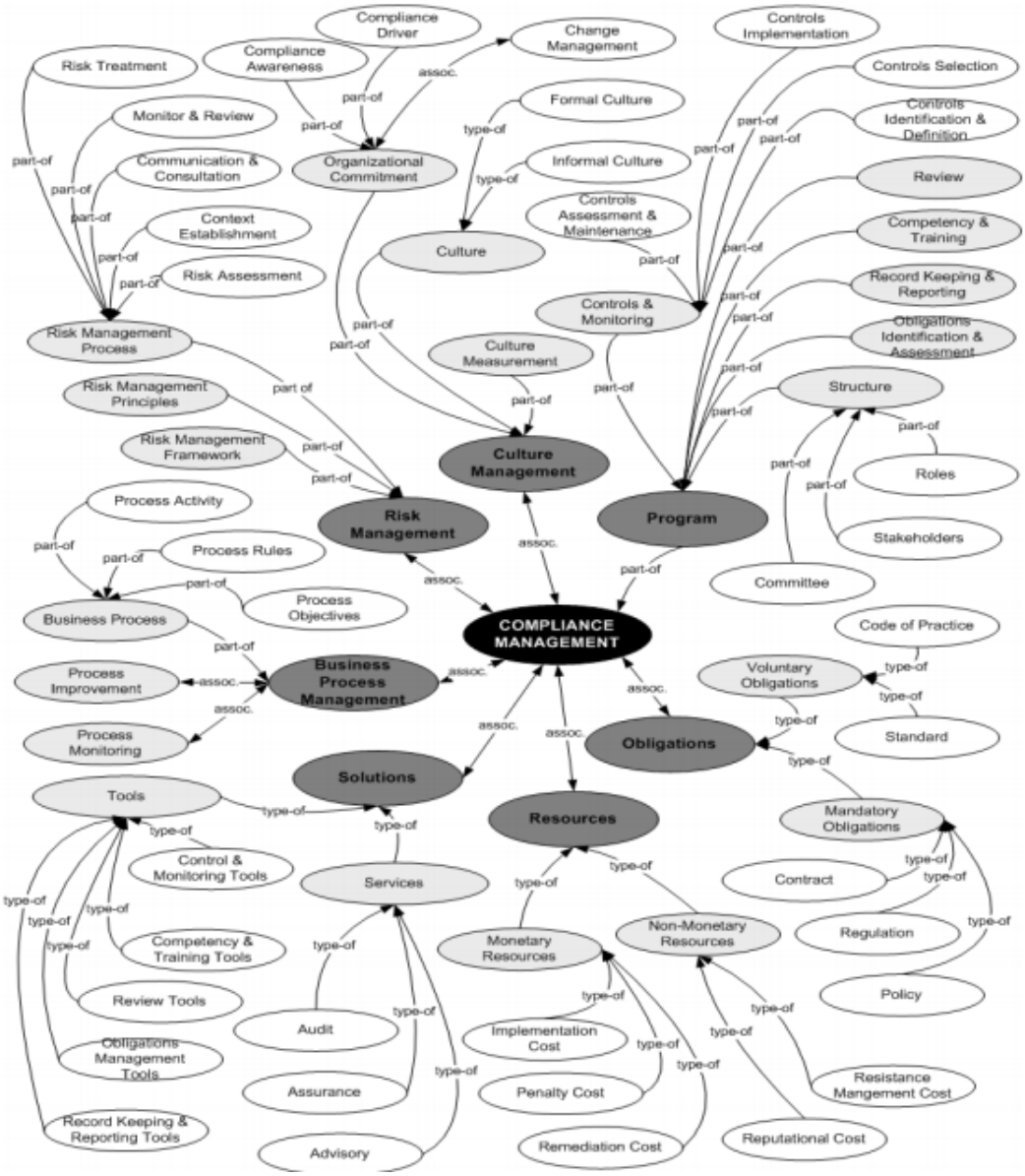

Figure 6- Refined CoMOn with its first, second and third tier concepts (Abdullah et al., 2012)

2.6 Summary of and discussion on existing approaches

The majority of the approaches mentioned above are limited to certain phases of the BP lifecycle, and locked into specific technologies/languages used for specifying BPs and compliance requirements. In general, the research on compliance has predominantly focused on exploratory studies, rather than proposition of solutions that can assist organizations in their compliance management regimens (Abdullah, Indulska and Sadiq, 2009).

In particular the approaches of Siena et al. (2009) and Breaux et al. (2006) have as concern the extraction of laws and requirements from legal documents as text and

their mapping to semantic meta-models. The main disadvantage of these two approaches is that the modeler can't reason in every case the legal textual description. Another disadvantage is that the meta-models are not related, in any way with business processes.

In the approach of Schmidt et al. (2007) the focus is on service processes and standards' requirements. Like other approaches there is no intention of generality of compliance management.

It is also important to point out that majority of existing compliance solutions automate some part of compliance detection by generating audit reports based on specific, pre-defined checks against data pulled from enterprise applications (Sadiq, Governatori et al. 2007). One of the drawbacks of these approaches is that such checks take place after a violation has occurred. Clearly, there is a need for a comprehensive framework that harmonizes automated static verification, runtime monitoring and retrospective reporting.

The intention of this thesis is the designing of a compliance meta-model with a specific focus on the compliance domain description and identification. It is essential to develop a meta-model for compliance management that will be useful and ready to be applied in all phases of BP lifecycle.

The envisioned meta-model has to focus on the extensive description of the notion of compliance rule regardless where is going to be applied and what is its concern.

3 Compliance meta-model

3.1 Designing the compliance meta-model

This thesis intends to identify the different aspects of compliance rules by creating a conceptual model of compliance. In order to understand the various aspects of compliance, the author examined all of the compliance conceptual approaches.

The majority of the literature relates the compliance with business processes which is an interesting aspect of approaching because a change in regulations and laws affects directly part or the whole of a business process. However it could be more accurate and different to analyze thoroughly only the compliance domain in order to understand the procedure of extracting rules from legal documents and the necessary components that are needed for the description of the notion of compliance.

In order to justify robustly the decisions we made during the designing of the compliance meta-model, we recorded our methodology by designing the rationale behind the creation of this meta-model. Through the design rationale (Conklin and Yakemovic 1991; Lee and Lai 1991; Jarczyk, Loffler and Shipman III 1992; Potts 1996) used as a Meta process.

The theoretical foundation of the design meta-process was based on the design reasoning framework introduced in (Louridas and Loucopoulos 2000) and used in various analyses of modeling techniques c.f. (Jansen 2013). The design reasoning cycle is depicted as in Fig. 7.

As shown in Fig. 7, the starting point is the declaration of a problem (desired goal). Then for analyzing this specific goal there is a need of expressing hypotheses that will be possible approaches of achieving that goal. The next step is the evaluation of those hypotheses by setting arguments for and against them. After the phase of evaluation, the phase of resolution is following were the modeler has to take one or more design decisions according to the prevailing hypotheses. These design decisions may or may not lead to the next goal.

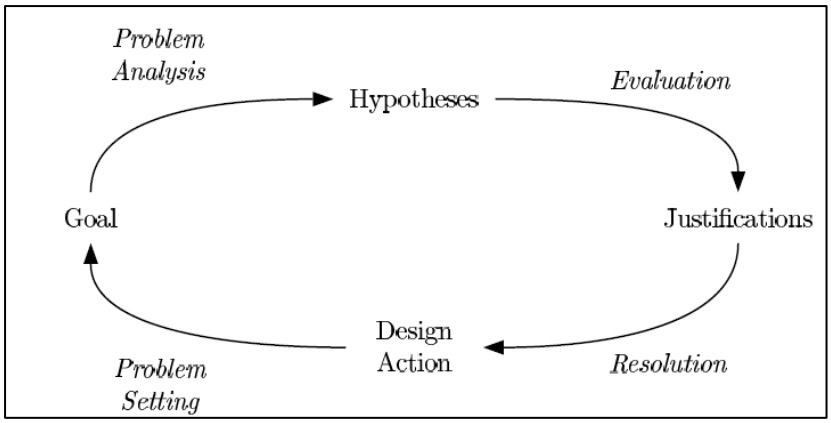

Figure 7 Design reasoning cycle

In the Compendium tool there is a specific set of nodes that a modeler can use for developing his design rationale. The notation used in this thesis for the design rationale is shown in Fig. 8.

Figure 8 Notation of design rationale

3.2 Design rationale towards the compliance meta-model

After the literature review analysis in Chapter 2 we've reached to the conclusion that the envisioned meta-model has to focus on the extensive description of the notion of compliance rule regardless where is going to be applied and what is its concern. This is our primary scope and the declaration of a clear purpose is a necessary step in order to identify a way to start the process of designing the meta-model as shown in Fig. 9. Another possible way to start the designing is to consult the existing meta-model approaches in the literature. The adding value of studying these approaches is the clarification of what it is important to be mentioned and held about compliance in the future meta-model and what it is missing and needs to be identified as an entity. The danger of reducing designer's creativity by consulting other approaches is judged as negligible because the designer needs a robust scientific background in order to proceed. Therefore, the decision made is the identification and maintenance of all of necessary components and the identification of the new entities which will help to compose and complete the future meta-model.

In order to understand and decide which components are useful to the envisioned meta-model, it has to be identified first the functionality of this meta-model. The rejection of the hypothesis of creating a meta-model depicting the enforcement of laws in business processes, is immediate. It doesn't suit with the scope, mentioned above, and by this approach the meta-model will not offer wide applicability and generalizability for compliance rules. Consequently the decision made is that the functionality of the meta-model will be the specific declaration and description of compliance rules.

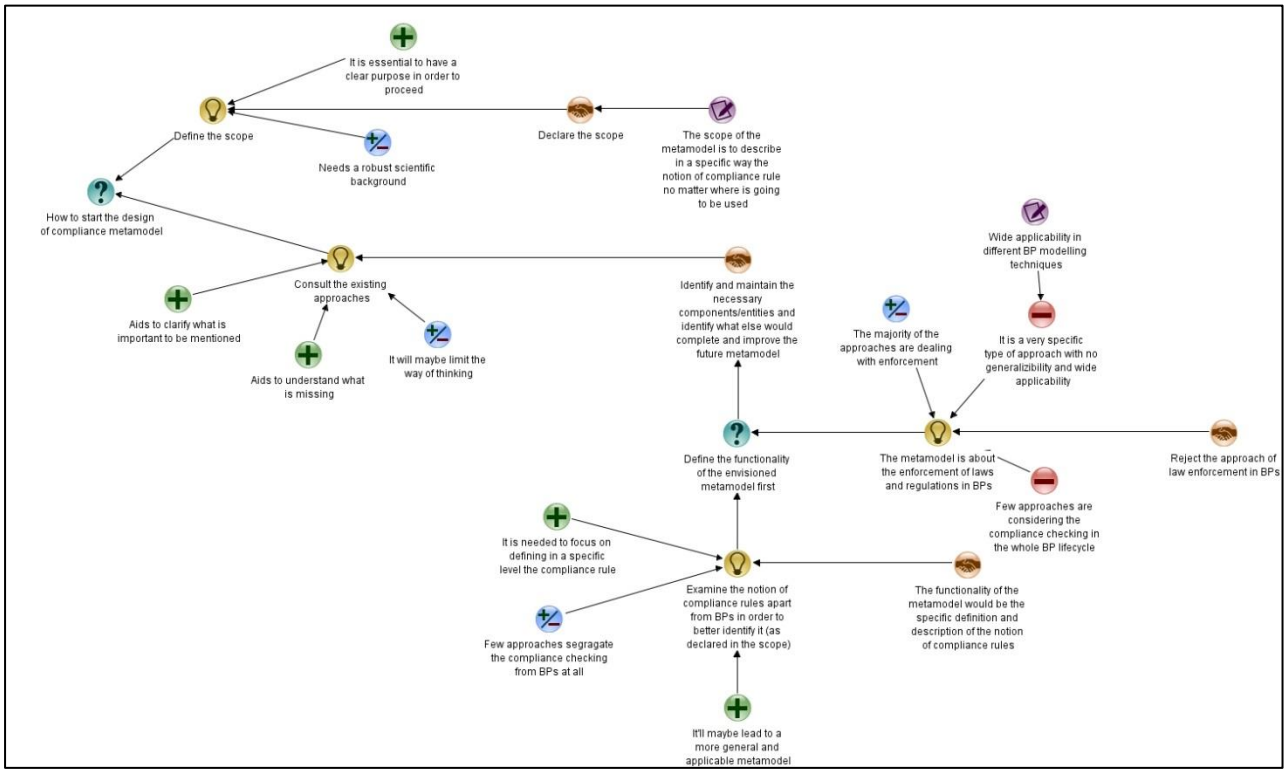

Figure 9- To design compliance meta-model- Starting point

Since the scope and the functionality of the envisioned meta-model are declared, the decision of identifying the necessary existing components and the new ones that will complete the compliance meta-model lead to the next desired goal which is to define the existing essential entities (Fig. 10). A possible approach would be to focus on the existing components describing a legal document. In the phase of evaluating this hypothesis, the arising arguments are that in the literature all of the researchers are agreeing about the different types of legal documents and that specifically on the approach of (Turetken, Elgammal et al. 2012) they are named as compliance sources (entity). Also there are many approaches who have tried to segregate a legal document

into fragments and sections in order to extract the desirable and needed information. It is also very interesting that in the majority of existing meta-models there is auto-reference to the compliance source entity which means that a legal document may refer to another legal document. A disadvantage of this approach is that there is a lack of specialization about the compliance source in the existing meta-models. This is very important because, in the effort of describing and analyzing the notion of compliance is important to refer to the specific types of a legal document. After the evaluation of all of the arising arguments it is clear that the compliance source entity is very important to maintain (with a reference to itself) but it will be needed to design its specializations and identify a way to segregate a legal document into logical fragments. This decision leads to two different goals which are the identification of specializations of a compliance source and the segregation of a legal document.

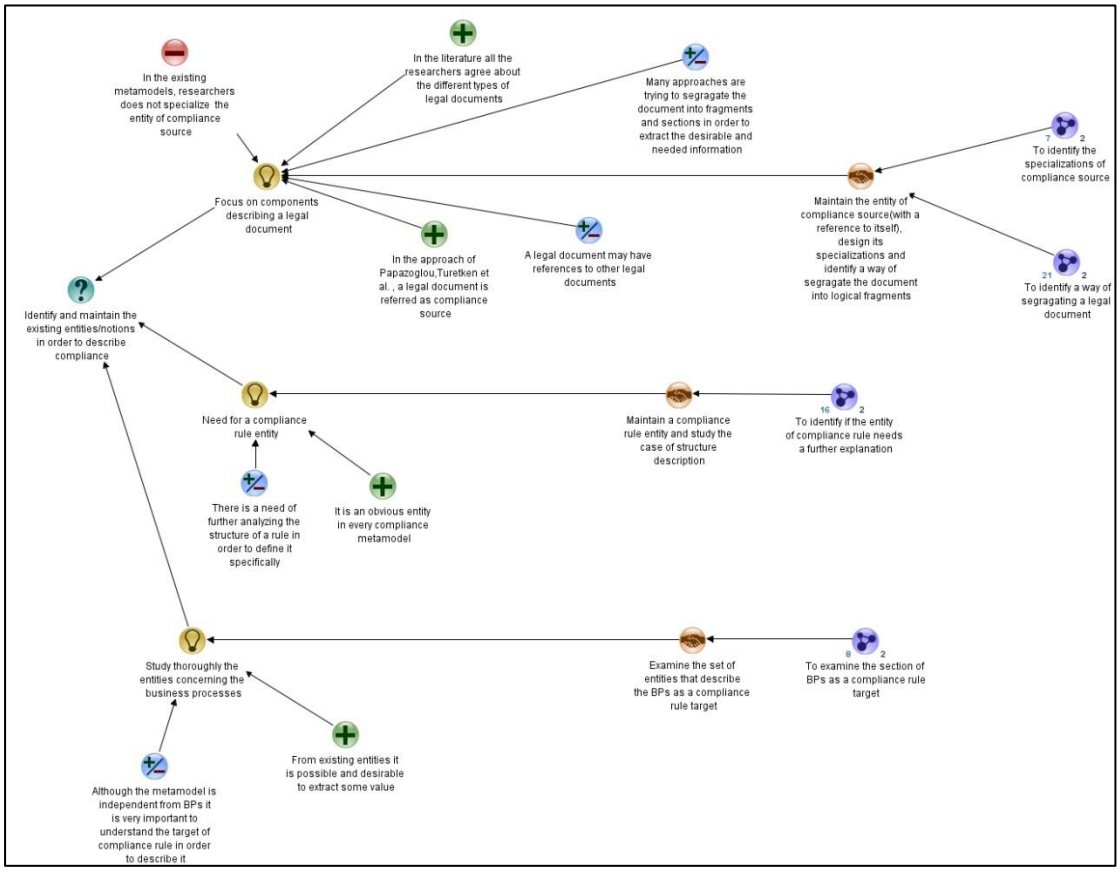

Figure 10 -To identify and maintain the existing entities in order to describe compliance.

For the designing of specializations as shown in Fig. 11, in order to categorize the types of a legal document it is necessary to recur to the literature for further information. It occurs from the literature that the source of a legal document it is either an enforcement of laws by the State or a Union (e.g. European Commission) or

a conclusion to an agreement between two independent parties (e.g. two organizations). The conclusion of this hypothesis is the specialization of the compliance source entity to internal and external and then to define the components of these two based on the declared types of legal documents. In more detail the internal source entity will be either a business partner contract or a Service Level Agreement (SLA). On the other hand the external source entity will either be some kind of regulation or a standard.

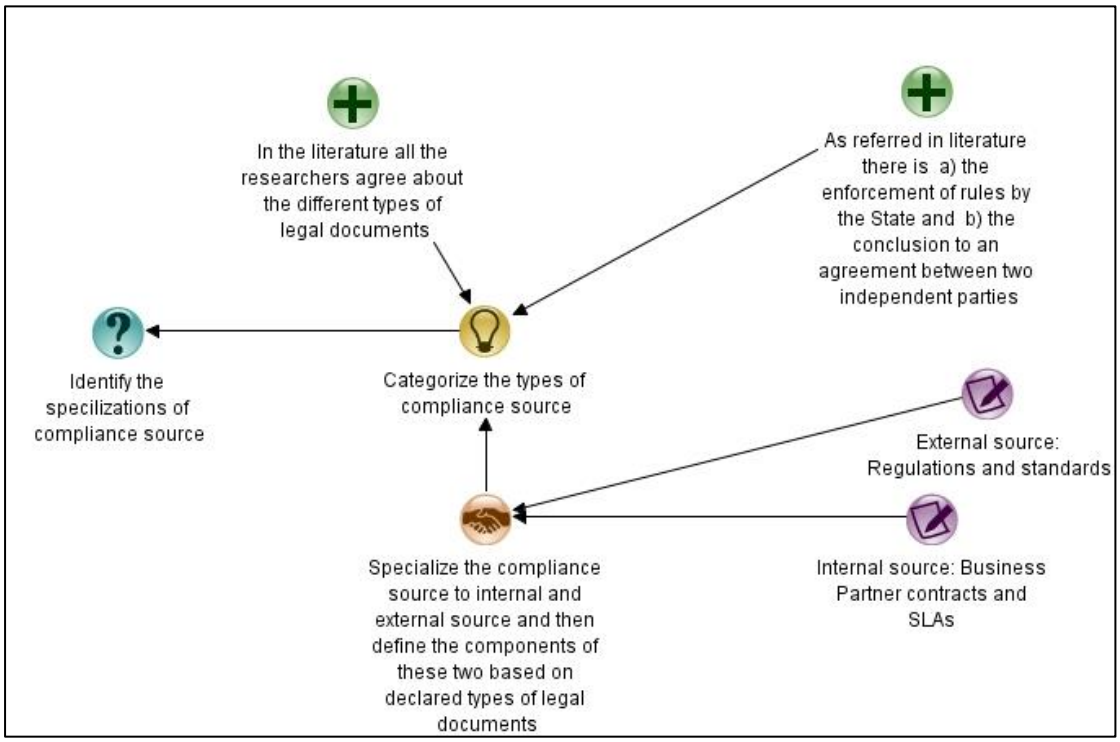

Figure 11- To identify the specializations of compliance source.

After the conclusion to this decision the meta-model came into being as shown in Fig 12.

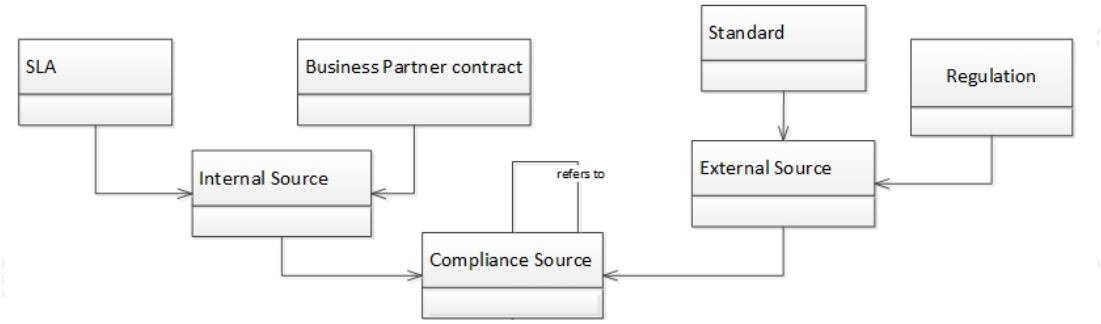

Figure 12-Compliance source entity and its specializations

For the identification of how to segregate a legal document, the best approach is to study a set of legal documents in order to understand their structures. By working on

this hypothesis, the arising arguments are that every one of these legal documents has a structure of chapters, sections and subsections semantically divided. Also it is obvious that in every section or subsection is declared a set of rules. As noticed for the compliance source as a whole document, it is clear that it is also possible in a section to exist a reference to another section or subsection. Therefore, since there is a need of isolating fragments from a compliance source in order to obtain only the desirable information which is the rule, it is designed a new entity named compliance essential which is related to the entity of compliance source with a relationship of aggregation. There is also a need for this entity to be related to itself with a reflexive association.

As the research was moving on, it was realized that in order to describe thoroughly the notion of compliance rule, it was necessary to define in a more specific way the entity of compliance essential (Fig.13). At first the modeler thought about identifying the goal of each fragment of rules because this would help him categorize and classify the rules. So an entity named compliance goal was decided to be designed and be associated with the component of compliance essential. The second thought was to identify in which domain the rules will apply. By determining this kind of information, the entity of compliance will have another special characteristic to be described by. After the designing of the entity application domain, the modeler examined the hypothesis of describing a fragment of rules by their type of concern (e.g. rules about security, privacy, segregation of duties etc.). This kind of description completes the definition of compliance essential. In the compliance meta-model the compliance essential has a tertiary relationship with both application domain and compliance type entities. It has also a relationship with compliance goal. As shown on Table 2(example) the compliance essential has one or more goals, and one or more compliance types and application domains.

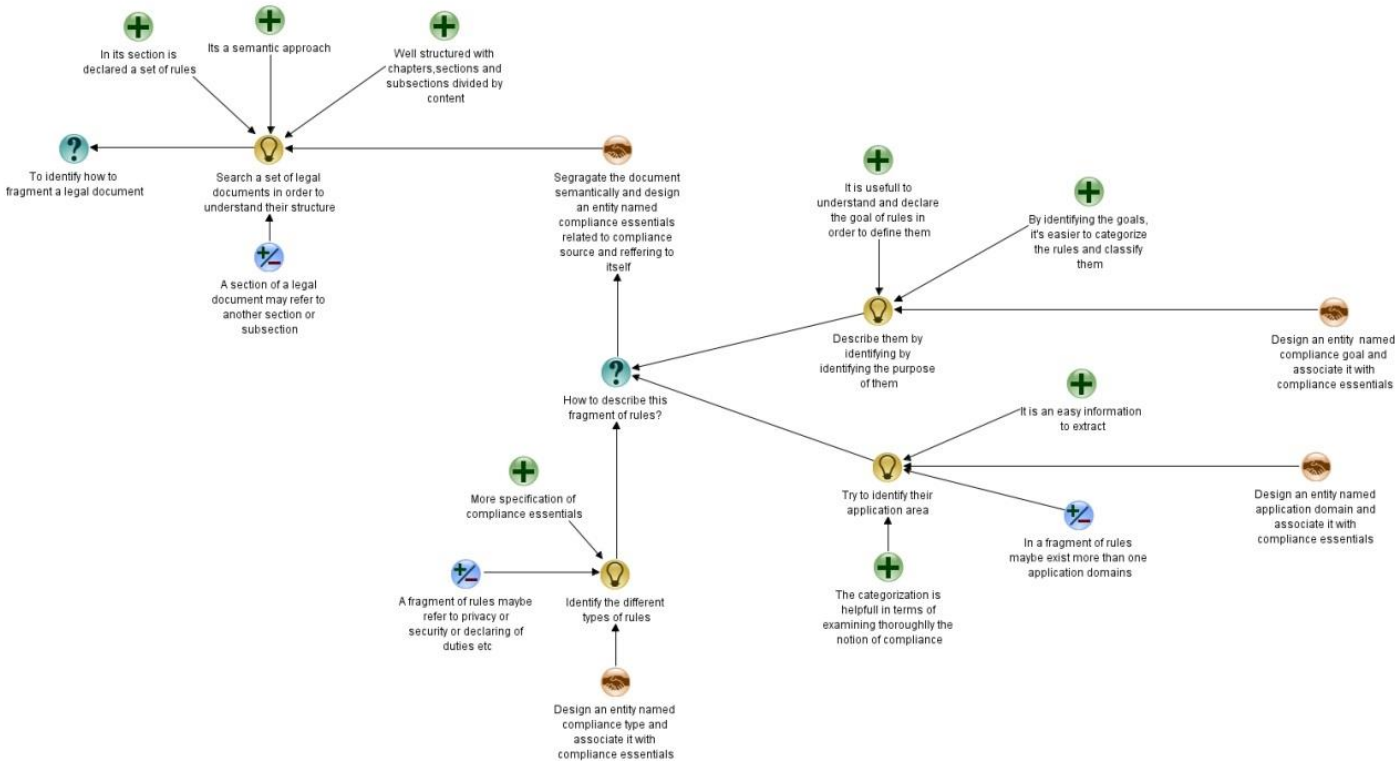

Figure 13- To identify a way of segregating a legal document

Compliance Essential	Compliance Goal	Application domain	Compliance Type
(a) ***IN GENERAL****.— The United States Patent and Trademark Office, subject to the policy direction of the Secretary of Commerce—* *(1) Shall be responsible for the granting and issuing of patents and the registration of trademarks; and* *(2) Shall be responsible for disseminating to the public information with respect to patents and trademarks.* *(b)* ***SPECIFIC POWERS****.— The Office—* *(1) Shall adopt and use a seal of the Office, which shall be judicially noticed and with which letters patent, certificates of trademark registrations, and papers issued by the Office shall be authenticated.*	*Declare the power and duties of The United States Patent and Trademark Office*	*Workplace*	Nomination of **duties** & **powers**

Table 2- Example describing the relationships of compliance essential entity

The meta-model was extended after the decisions made above as shown in Fig.14

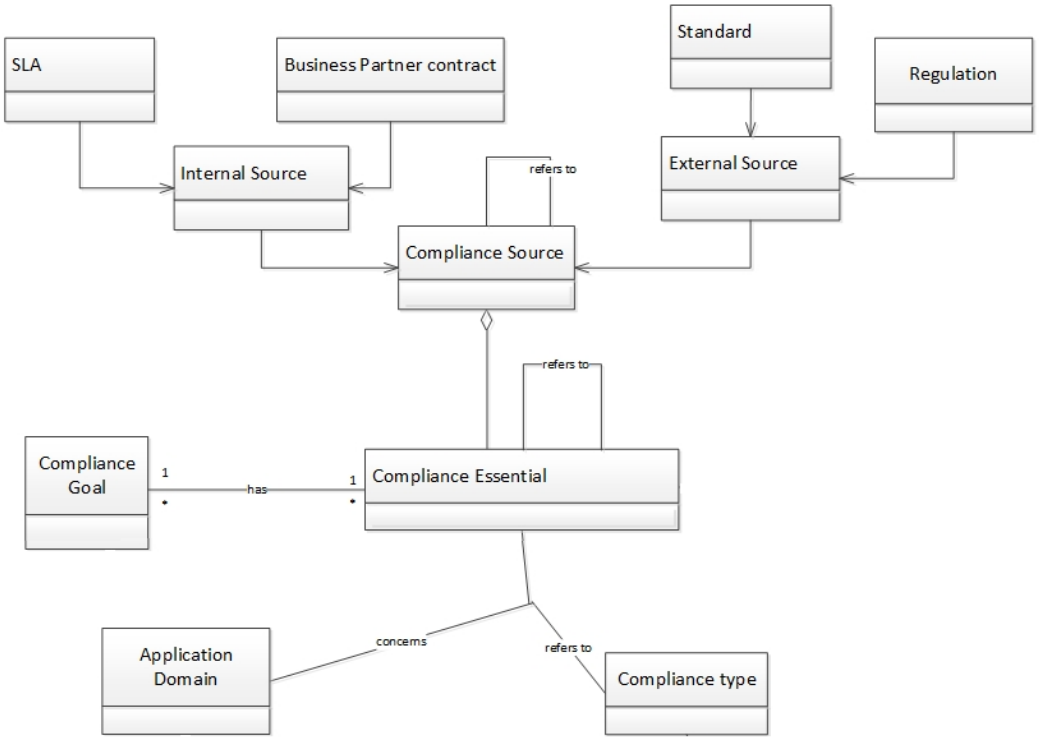

Figure 14-Entities of the compliance meta-model

After the thorough analysis of a legal document and the identification of certain entities to describe it, segregate it and categorize it, the next hypothesis about which entities to maintain from existing approaches is to define an entity about the compliance rule as shown in Fig.10. It is an entity existing in every meta-model because it is the purpose of them all to describe it. But it seems necessary to further analyze it as far as its structure is concerned (Fig.15). Based on the literature review, a compliance rule is expressed in three basic different structures complexities: simple, medium and complex. A complex rule is a composition of simple rules as referred in the literature. Consequently the entity of compliance rule is a complex rule composed by simple ones or just a simple rule. In order to define the notion of compliance rule more specifically is decided to add two attributes. The first attribute is the text description of the rule extracted by the compliance essential and the second one is a logical expression attribute, based on existing patterns from the approach of (Turetken, Elgammal et al. 2012) (MTL expressions). The structure of patterns is shown in Table 3. The same attributes will also appear in the complex rule entity.

As referred above, a compliance essential is a member of a tertiary relationship with the entities of application domain and compliance type where the multiplicity is one-to-many. By defining the compliance rule it is necessary to refer that a simple rule may only have one application domain and one compliance type.

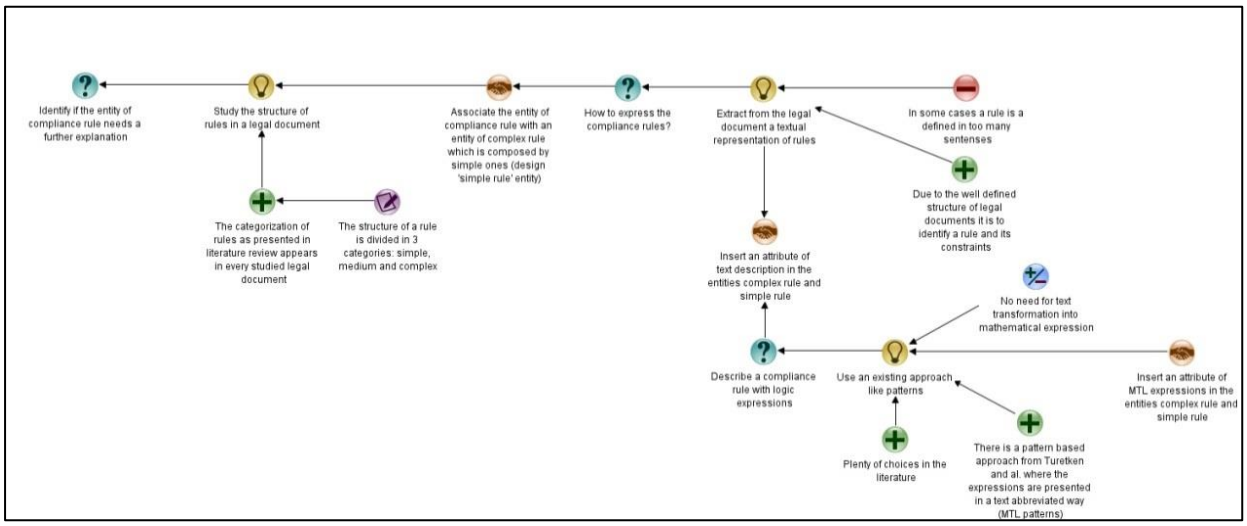

Figure 15- To identify if the entity of compliance rule needs a further explanation

After concluding to the decision that a compliance rule entity is needed, the meta-model was constructed as following (Fig.16):

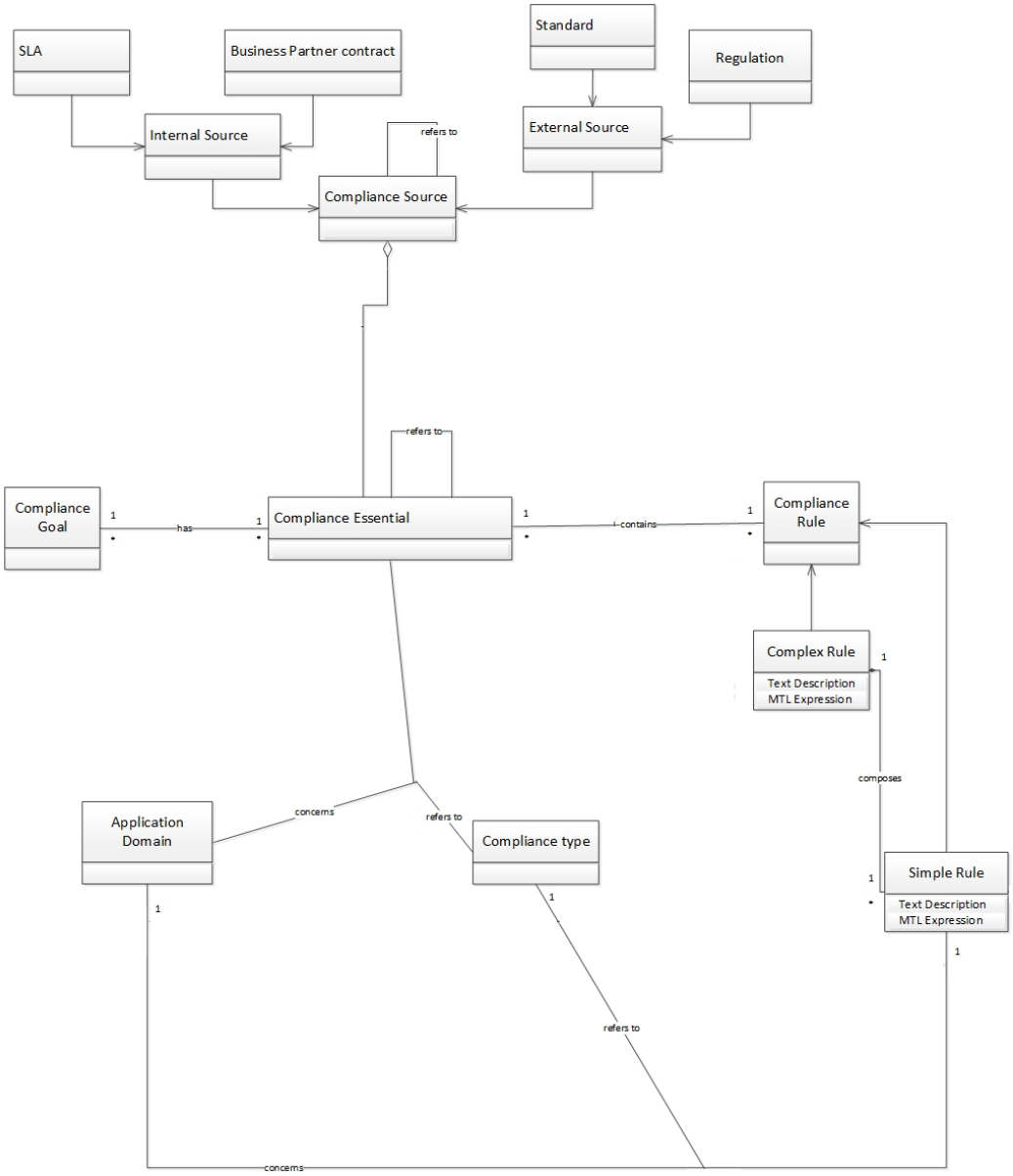

Figure 16 Version of the meta-model with the added entity of compliance rule

		Pattern	Description*
Order	Basic	*Q* Precedes *P*	*Q* must precede *P*.
		P LeadsTo *Q*	*Q* must follow *P*.
		P XLeadsTo *Q*	*Q* must immediately follow *P*.
		P PLeadsTo *Q*	*P* and *Q* must occur sequentially.
	Advanced	*(P, S, ...)* ChainLeadsTo *(Q, T, ...)*	A sequence of *Q, T, ...* must follow a sequence of *P, S, ...*
		(Q, T, ...) ChainPrecedes *(P, S, ...)*	A sequence of *Q, T, ...* must precede a sequence of *P, S, ...*
		P LeadsTo *Q* Else *S* Else *T* Else ...	If condition *P* is true, then *Q* should occur; if *Q* can't be satisfied, then *S* should occur (which compensates for the violation of *Q*); if *S* is violated, then *T* should occur; and so on.
Occurrence	Basic	*P* Exists	*P* must exist in the process specification.
		P Absent	The process specification must be free of *P*.
		P Universal	*P* must occur or be valid throughout the specification.
	Advanced	*P* CoExists *Q*	If *P* is present, then *Q* must also be present.
		P CoAbsent *Q*	If *P* is absent, then *Q* must also be absent.
		P Exclusive *Q*	If *P* is present, then *Q* must be absent, and vice versa.
		P CoRequisite *Q*	Both *P* and *Q* must be present or absent.
		P MutexChoice *Q*	Either *P* or *Q* must be present.
Resource	Basic	*P* PerformedBy *Q*	Role *Q* must perform (be assigned to) activity *P*.
		P SegregatedFrom *Q*	Activities *P* and *Q* must be assigned to different roles, and different users must perform them.
		P USegregatedFrom *Q*	Different users must perform activities *P* and *Q*.
		P BondedWith *Q*	Activities *P* and *Q* must be assigned to the same role, and the same user must perform them.
		P RBondedWith *Q*	Activities *P* and *Q* must be assigned to the same role, but different users must perform them.
	Advanced	*(P, Q, S, ...; m)* Multisegregated	A certain number of different users (*m*) must perform a set of activities (*P, Q, S, ...*).
		(P, Q, S, ...) Multibonded	The same user and role must perform a set of activities (*P, Q, S, ...*).
Time	Basic	Within *k*	Used with order patterns to denote a given *P* to happen within *k* time units. For example, *P* LeadsTo *Q* Within *k* indicates that *Q* must follow *P* within *k* time units.
		After *k*	Used with order patterns to denote a given *P* to happen after *k* time units. For example, *P* LeadsTo *Q* After *k* specifies that *Q* must follow *P* after k time units.
		ExactlyAt *k*	Used with order and occurrence patterns to denote a given *P* to happen exactly at time *k*. For example, *P* Exists ExactlyAt *k* indicates that *P* must occur at time *k*, starting from the process instance's initial state.
	Advanced	*P* Exists Max *k*	*P* can hold at most *k* time units once it happens.
		P Exists Min *k*	*P* must hold at least *k* time units once it happens.
		P Exists Every *k*	*P* must happen in every *k* time unit.

Table 3- Table of Rule- Patterns (Turetken, Elgammal et al. 2012)

Back to Fig.10 another way to identify the entities of the future meta-model is to study the section of business processes which is present in every existing meta-model. This approach seems interesting to examine because it will may be hidden an added value for the envisioned meta-model although it will be independent from the business processes (as declared in its scope and functionality). However in terms of completeness and in having a holistic view for compliance, it is important to

understand the target of each rule. As shown in Fig.17 below, the main hypothesis is to find a relation between the compliance rule and the core elements of a business process.

A rule by its definition is a description of constraints involving roles, data, activities and events. Thereafter it is essential to describe the entity of compliance rule with a rule target consisting of the entities of agent, activity, data and event.

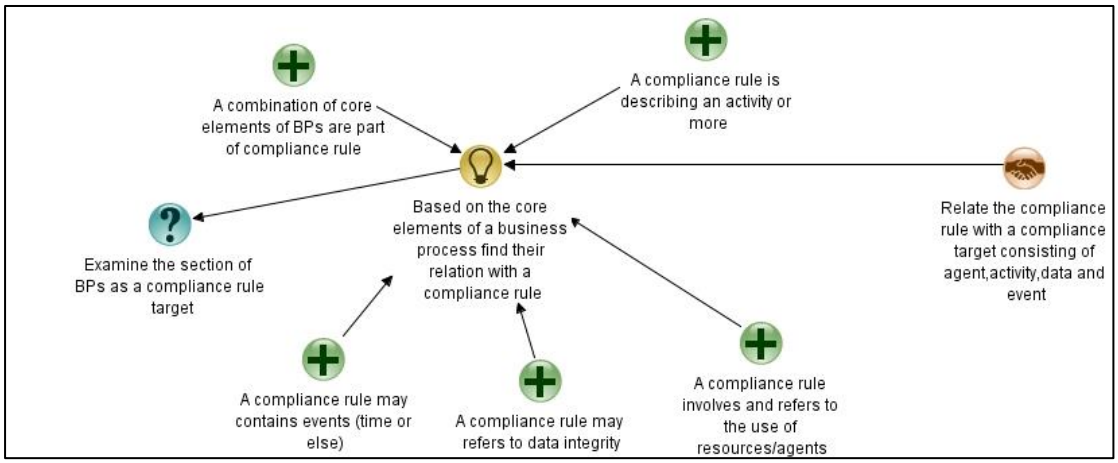

Figure 17- To examine the section of business processes as a compliance rule target

The decision of relating the simple rule entity with an entity named compliance target is the completing the design phase of the meta-model. The meta-model is formed as shown in Fig.18.

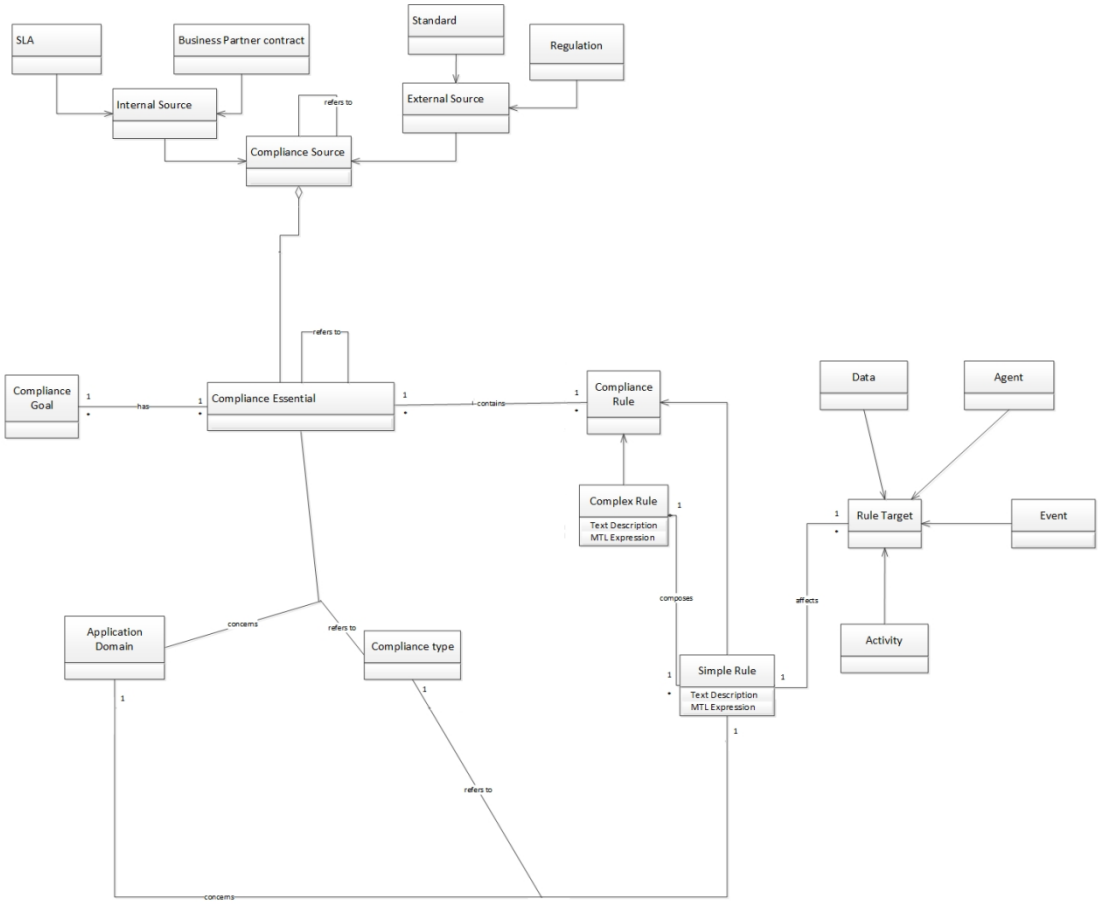

Figure 18-The designed meta-model

In Fig.19 is shown the whole decision tree which is depicting every sub goal needed in order to design the compliance meta-model as explained above.

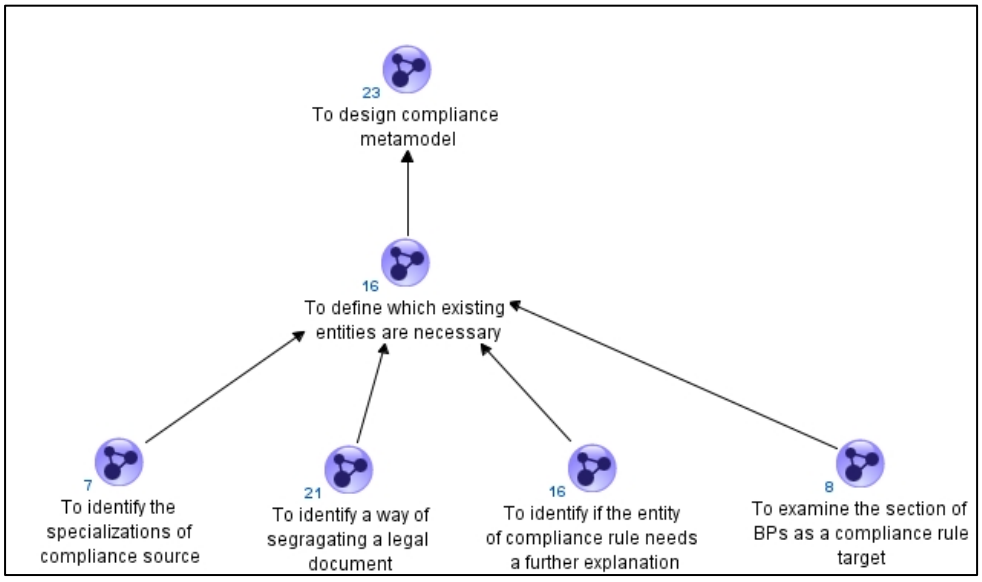

Figure 19- Decision tree of designing the compliance meta-model

3.3 Proposed Compliance Meta-model

The design rationale presented above lead the research to the designing of the compliance meta-model as shown in Fig.20.

In the compliance meta-model there is an obvious conceptual distinction in sections.

1. The section which describes the compliance source
2. The section describing the notion of compliance essential
3. The section defining the compliance rule and its target.

In a more abstract level the first section is about the teleology of compliance as a concept in which is explained the entity of compliance source and its specializations. The second section which includes the entity of compliance essential and its features is about the methodology of defining compliance. Last but not least is the section about describing ontology and applicability of compliance consisting of compliance rule entity and its target.

This conceptual distinction is so obvious because the effort of designing was approached that way too.

These three sections are highlighting the scope of this meta-model and its desired functionality. They are conferring to the meta-model a structure and a substantial dimension.

In APPENDIX A is presented a list of terms which were used in the conceptual model and a definition of their meaning. The terms are listed alphabetically.

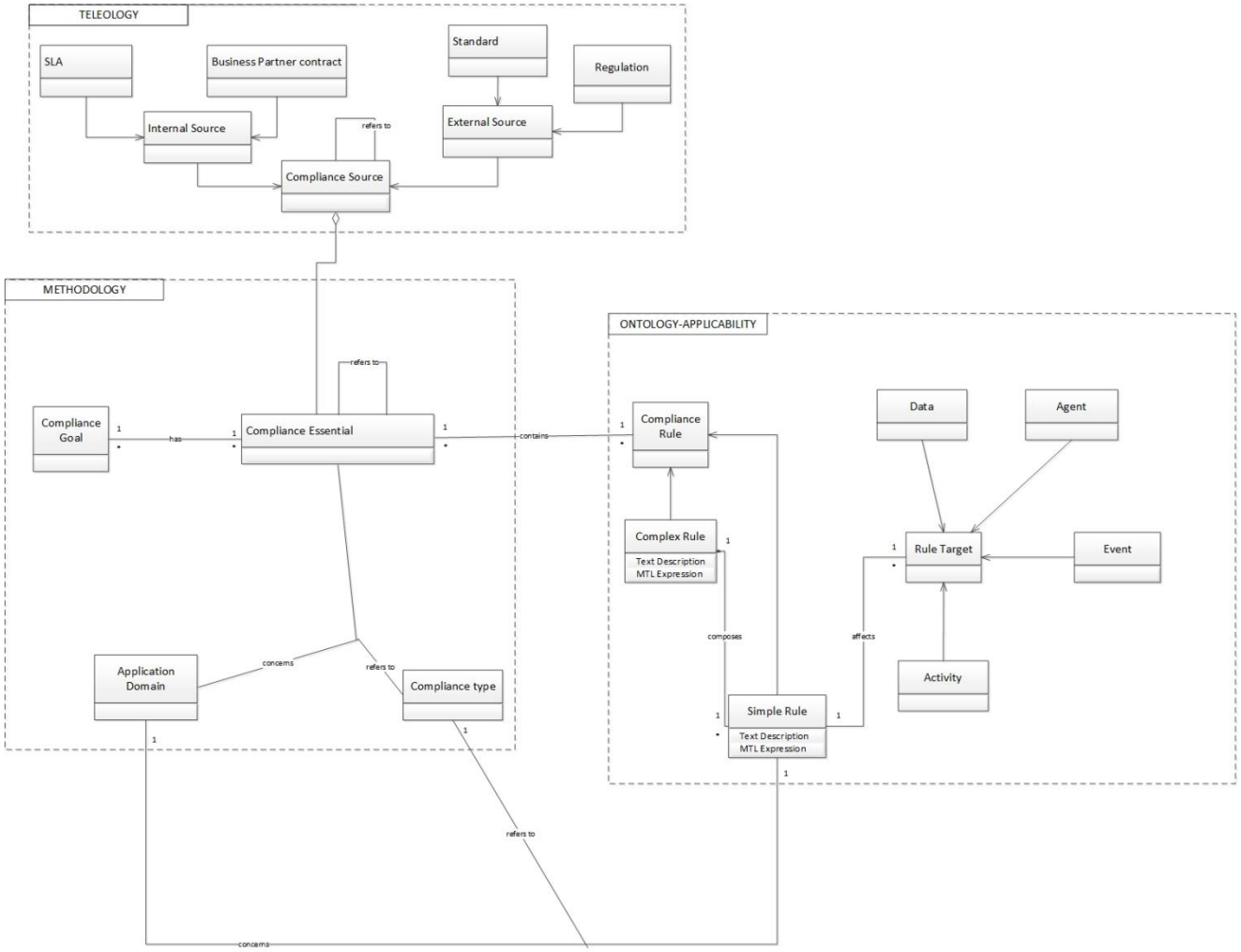

Figure 20- The compliance meta-model

4 Compliance meta-model validation

4.1 Rationale

After designing the compliance meta-model it is essential for the research to try its validation.

The quality of the meta-model is measured based on how it can fulfill the purpose of its development (Beydoun et al., 2011 and Garcia, 2007): addressing the needs of domain practitioners and increasing the transparency to the knowledge encoded within the domain applications.

So, in order to measure the quality of the meta-model it is crucial to compare it with the other existing approaches. This comparison is very helpful in identifying the similarities and differences between the new meta-model and the existing ones.

In order to examine if those two purposes are fulfilled, it is proposed to this thesis the instantiation of the meta-model. Models are instances of their meta-models. The features of the real world capturable by a model are determined by the meta-model. The compliance meta-model represents a conceptual view about the notion of compliance. It is an ontological commitment that specifies the things that an observer may see in different cases of compliance. Based on this observation and considering that the presented meta-model has a specific scope and a specific functionality; it is proposed to validate the meta-model by instantiating it. The instantiations will be useful in order to test the applicability and generalizability of the compliance meta-model.

Therefore, the validation techniques which are used are the following:

- Comparison against other meta-models
- Instantiate the compliance meta-model by examining various legal documents

4.1.1 Comparison against other meta-models

The comparison will focus on the approach of COMPAS project (Papazoglou 2011, Turetken, Elgammal et al. 2011, Turetken, Elgammal et al. 2012) since it was the base of the work described in this thesis.

4.1.1.1 COMPAS meta-model

As shown in literature review the COMPAS meta-model (Fig.21) describes the relation between the compliance domain and the business process domain.

The similarities of those two meta-models are noticed in the description of compliance domain. The entities of compliance source and compliance rule are the same.

On the one hand, in the meta-model presented here exists a section referring the applicability of compliance rules in the core components of the business process. On the other hand, in the COMPAS meta-model the domain of business process is well analyzed and interrelated to the compliance domain.

In the COMPAS meta-model there is a lack in the descriptive characteristics of compliance source namely the compliance essential entity in our meta-model.

Another similarity is that the two meta-models are using the same structure patterns in order to describe formally the rules.

The important differences between the COMPAS meta-model and the meta-model presented here, are:

- The approach of business process
- The differentiation in describing compliance essential
- There is no reference to the compliance risk notion in the meta-model presented here

The conclusion is that the COMPAS meta-model is very similar to the one presented here, but the key difference between them is that the compliance meta-model in this thesis is describing the notion of compliance and compliance rule with more details. This detailed description is in a more conceptual and abstract level and offers to the meta-model, possible applicability in a more wide range than COMPAS.

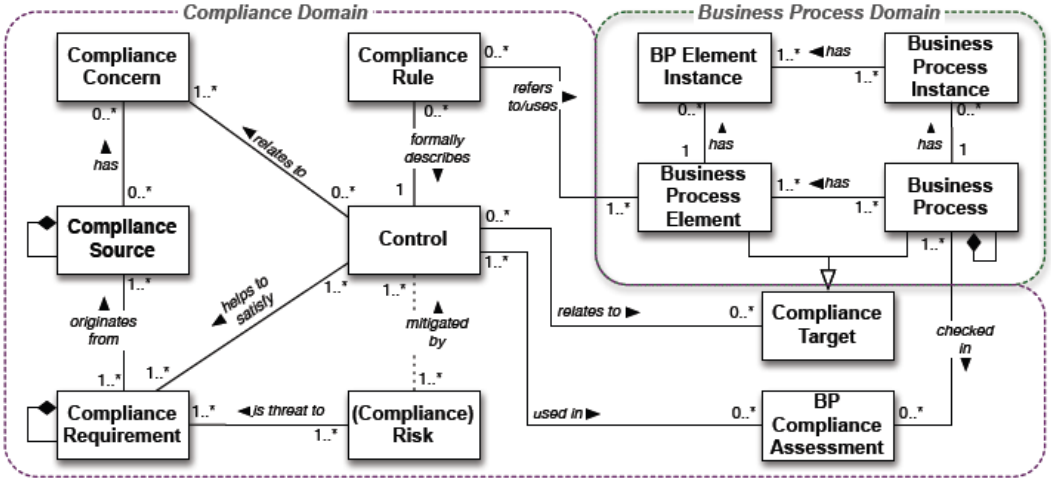

Figure 21 -COMPAS meta-model (Papazoglou 2011, Turetken, Elgammal et al. 2011, Turetken, Elgammal et al. 2012)

4.1.2 Reasoning about the instantiation of the compliance meta-model

In order to instantiate the meta-model and extract useful observations it was necessary to have a solid methodology. The methodology followed is shown as a decision tree in Fig.22.

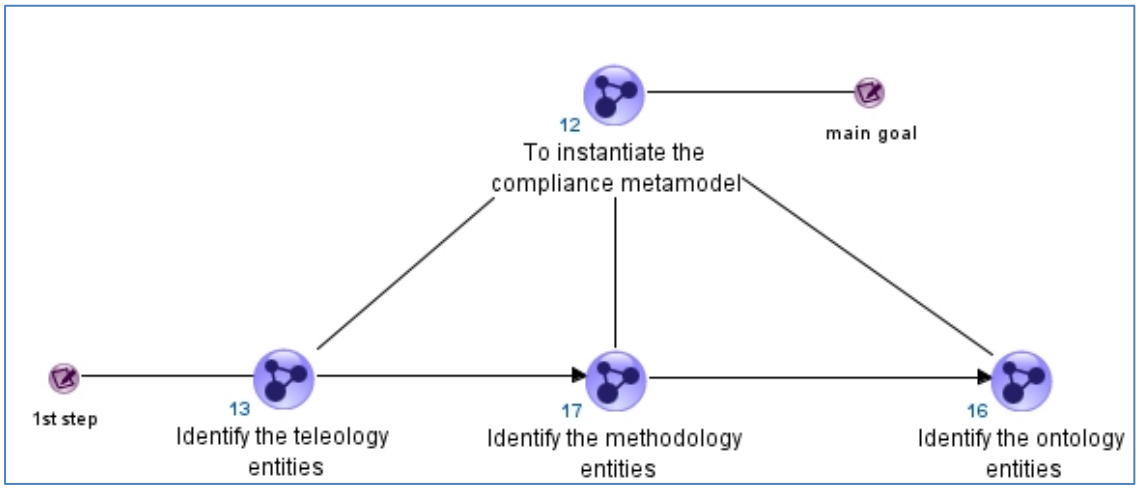

Figure 22-Decision tree

The main goal of this design rationale is to instantiate the compliance meta-model. For achieving this goal there were alternatives hypotheses taken under consideration as shown in Fig.23.

In the previous chapter, the meta-model was built up based on the existing approaches and the needs for improvement that were discovered through the research. Relying on

the typology and functionality of the meta-model and by studying several legal documents, it was decided to instantiate the meta-model by using its sections (teleology, methodology and ontology) as a conceptual compass. The only matter remained was to decide from which section was appropriate to start with.

It was quite obvious that in order to start an instantiation the first step was to choose a legal document. Having this as a constraint, the teleology section seemed the most suitable to begin with.

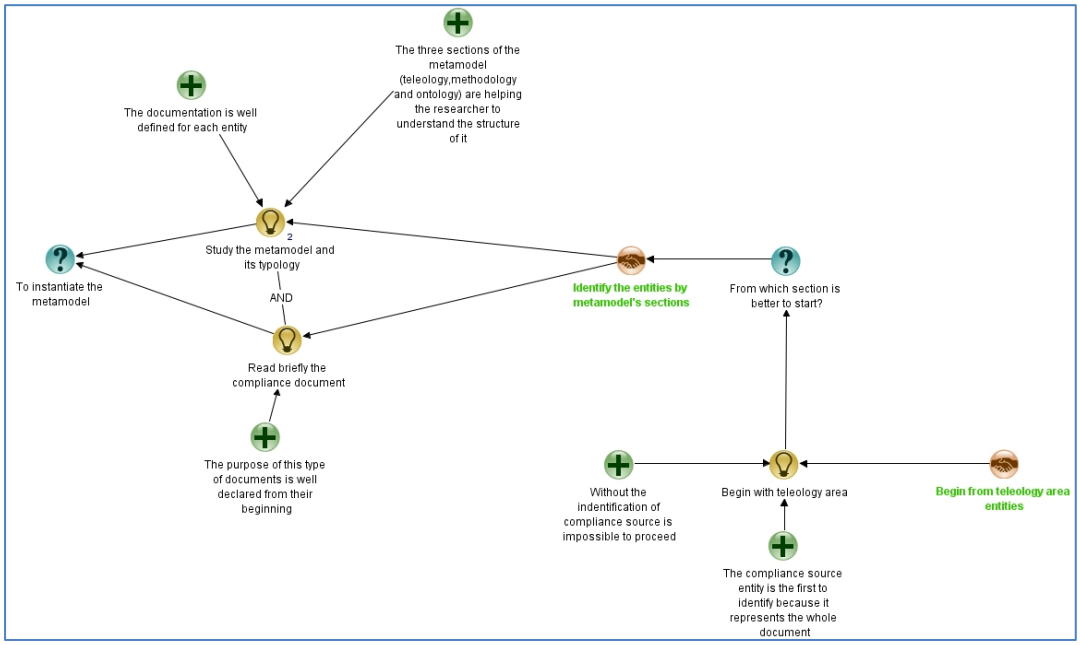

Figure 23-How to instantiate

In the teleology section (Fig.24) is needed to be identified the compliance source and its specializations. A legal document as whole is a compliance source. It is requested to categorize it based on its type. When the categorization is over the compliance source is fully described and so is the teleology section.

The next section should be the methodology section because it is important to identify which part of the compliance source will be examined and try to define it.

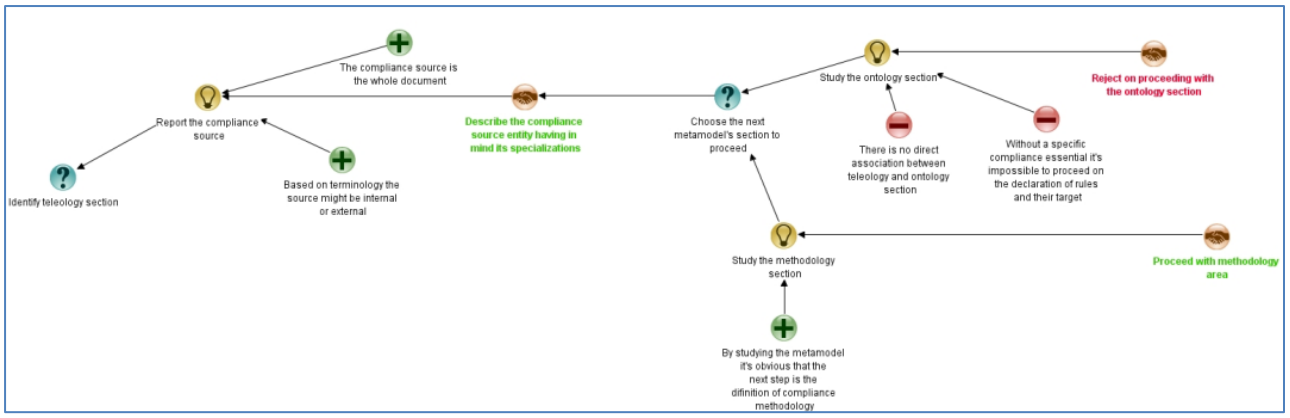

Figure 24-Identify teleology section

As shown in Fig.25 the entity of **compliance essential** is required for proceeding to the nodes of **application domain** (Fig.26), **compliance type** (Fig.27) and **compliance goal** (Fig.28).

Each modeler and researcher is responsible to choose a fragment of rules to examine. It is not an easy task to deliver but due to the formal and strict structure of every legal document there is no need for the researcher to be a legal expert in order to extract a set of rules by meaning.

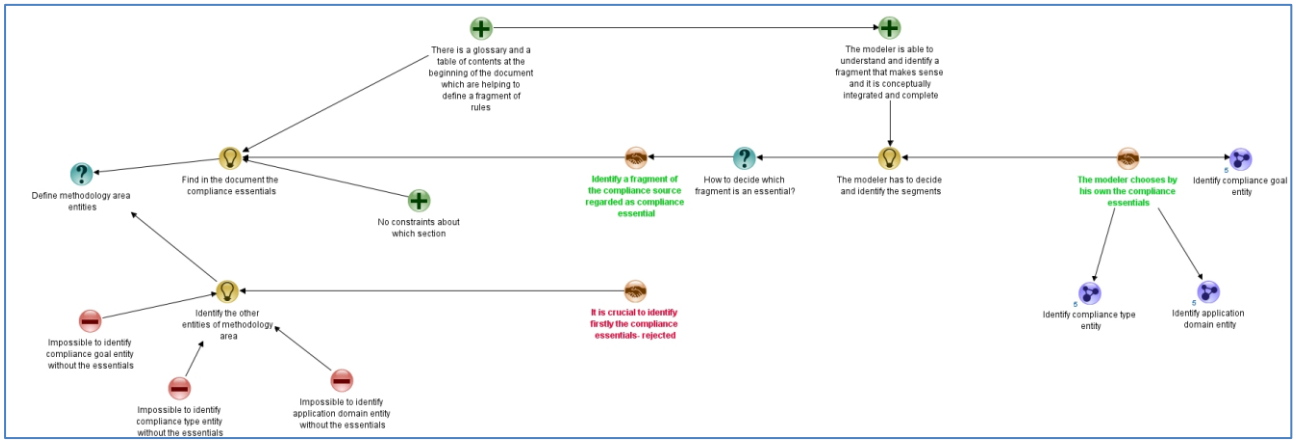

Figure 25-Identify methodology section

After extracting the compliance essential it is important to describe it. By studying these fragments and because of their strict structure and plain content it is easy to extract their domain of application and their type of concern (Figures 26 & 27). It was observed during the instantiations that in each segment the domain of application is often unique while the type of concern may be multiple.

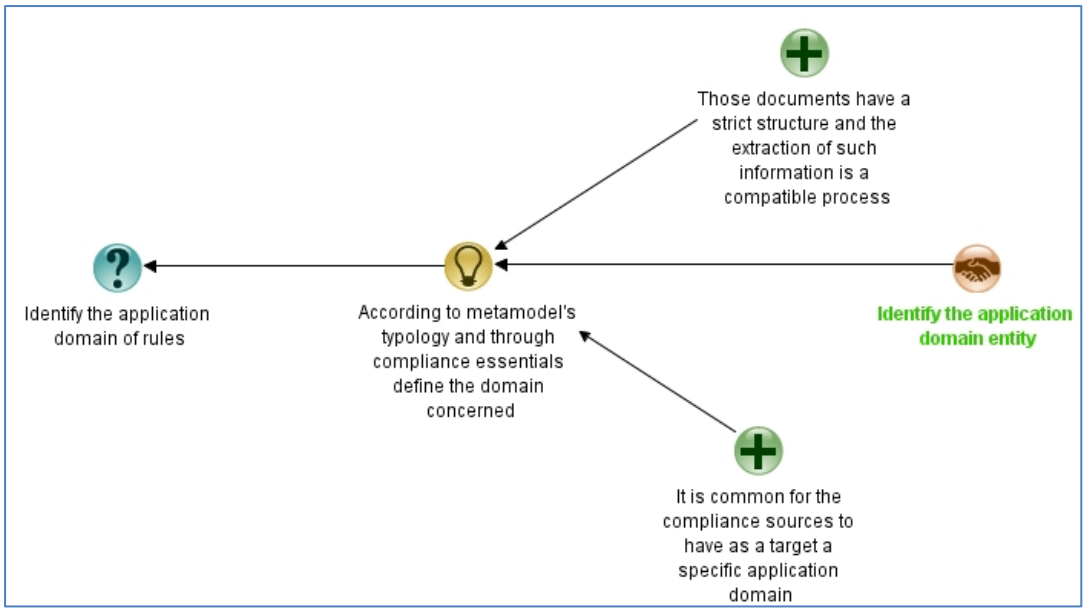

Figure 26-Identify application domain entity

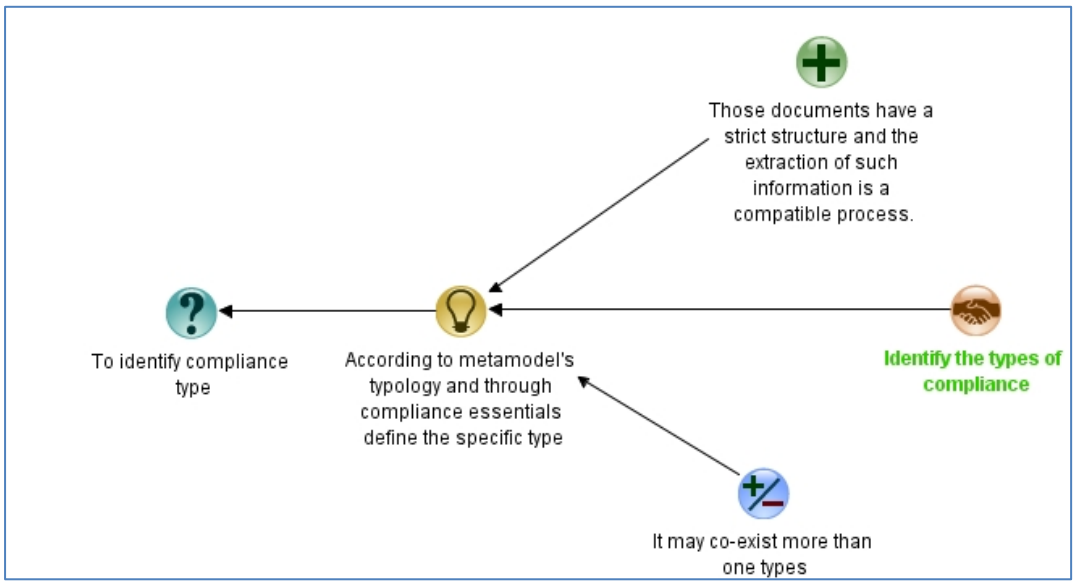

Figure 27- Identify compliance type entity

In order to identify the goal of a specific fragment of rules it is essential to understand its purpose of establishment (Fig.28). In the beginning of every legal document the legislators are declaring the general purpose of the including rules and the content of its fragment clearly states their goals. Considering the above a modeler can easily describe the goal or goals of its compliance essential.

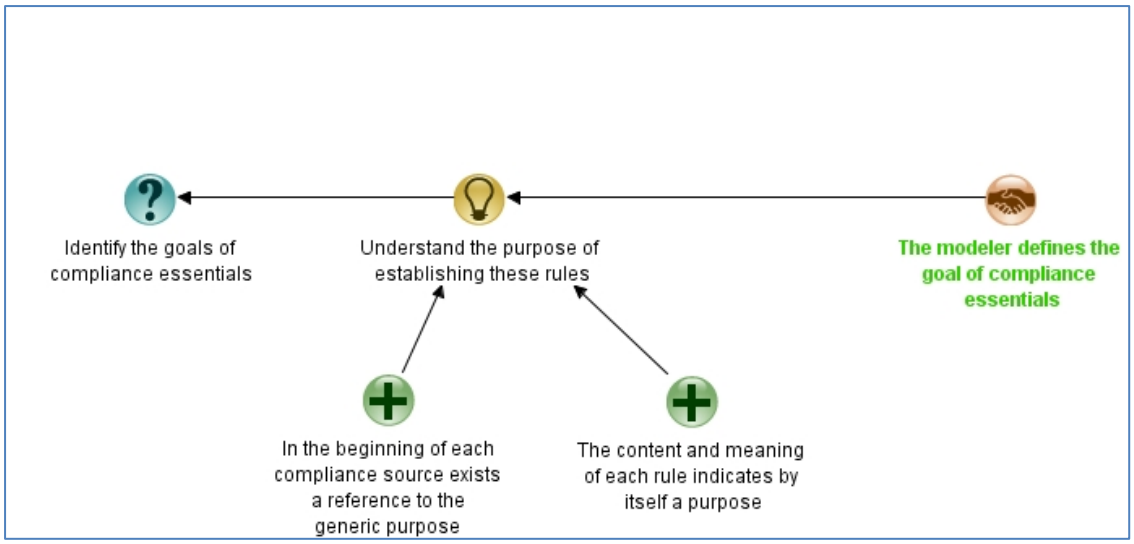

Figure 28-Identify compliance goal entity

Last but not least is the identification and instantiation of ontology section which is very important because it includes the formulation of rules and the definition of their target of affection (Fig.29).

The extraction of rules based on the available information is made through the compliance essential entity which is the instance of a fragment of rules. As mentioned before the researcher has to understand the textual meaning and recognize the phrases indicating restrictions and constraints. After defining the compliance rule entity it is time to examine the existence of complex and simple rules.

The complexity is recognized by the existence of combined actions in a sentence or a paragraph of the compliance rule. A simple rule reflects a single action or constraint.

So based on the actions and constraints declared in the compliance rule entity, the modeler formulates the complex and simple rules with a text description and then with a MTL expression.

The identification of rule target entity is based on the formulated simple rules. The content of its rule clearly declares the affected activity, the involved agent or/and data and the prerequisites events.

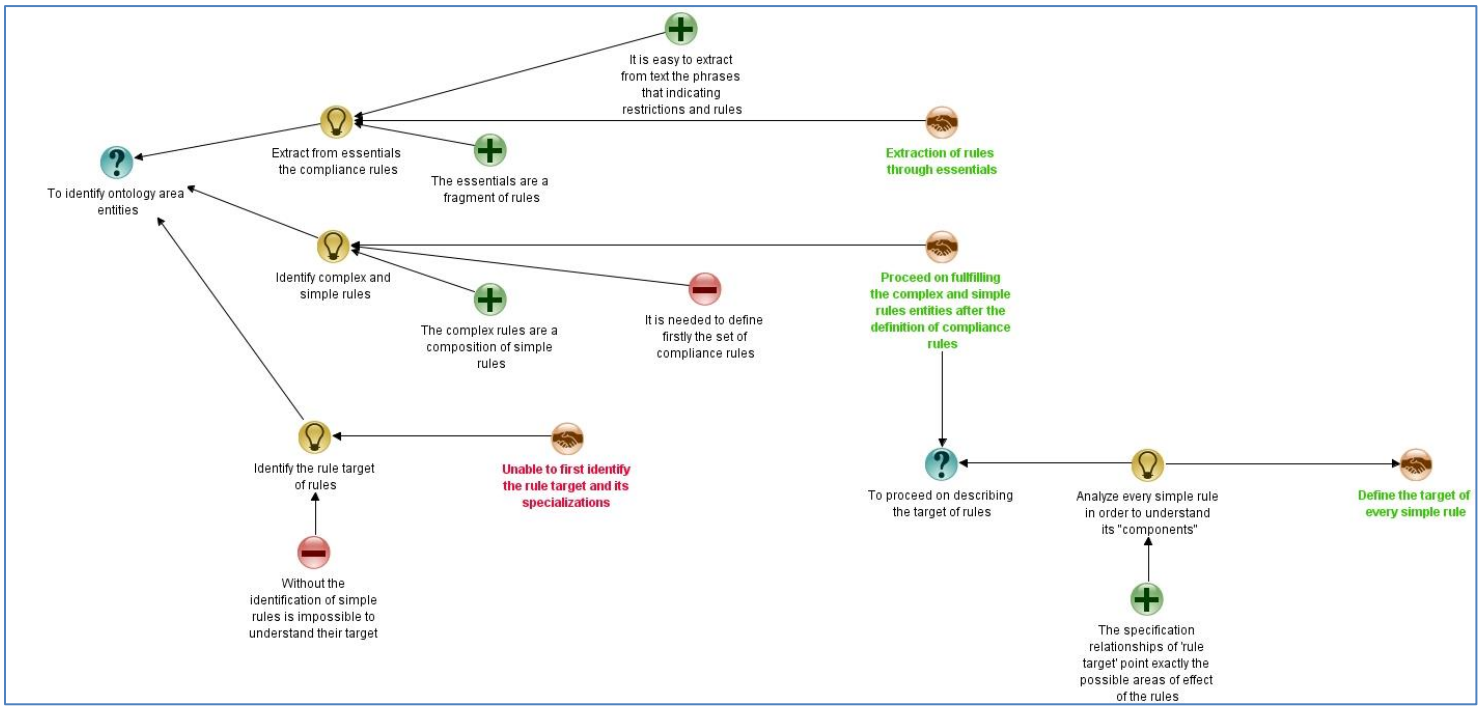

Figure 29-Identify ontology section

4.2 Instantiations of compliance meta-model

In this section the instantiations made are presented. They are made based on the above described methodology.

The criteria of choosing the certain legal documents were their accessibility and traceability and their variability and differentiability.

The instances presented below were trying to examine the behavior of all entities under a certain example.

4.2.1 Port authority act (Part I)

The Port authority Act is a legal document found after searching online and it is about the port authority regulations of Montserrat which is a British Overseas territory located in the Caribbean. This particular edition of the Act was published in the 1st of January of 2008.

The selected fragment of laws is a subsection of the Act referred as *Powers and Duties* and belongs to the PART III section of the Act which is named: *DUTIES AND GENERAL POWERS AND PROVISIONS RELATING TO LAND PROPERTY AND UNDERTAKINGS OF THE AUTHORITY*.

The application domain of this compliance essential is obviously the maritime domain and the type of concern is the segregation of duties of the Authority (Table 5). The role of the Authority which is referred to this subsection represents, as mentioned in the Act, a consortium of six members who are responsible for the operation of the port of Montserrat. The goal of this subsection is the declaration of duties of a specific agent.

Compliance Essential	**Compliance Goal**	**Application domain**	**Compliance Type**
It shall be the duty of the Authority, subject to any general or specific directions which the Governor in Council may from time to time issue— ***(a)*** *to administer and to operate the port as appears to it best calculated to serve the public interest;* ***(b)*** *to regulate and control navigation within the limits of the port and its approaches;* ***(c)*** *to maintain, improve and regulate the use of the port and the services and facilities therein as it considers necessary or desirable;* ***(d)*** *to provide for the Port and the approaches thereto such beacons, buoys and other navigational services and aids as it considers necessary or desirable.*	*Declaring duties of an agent*	*Maritime*	*Duties*

Table 4-Characteristics of compliance essential-Port Authority Act

The extraction of rules from this particular fragment it was easy to do because of its structure. As referred above the distinction of complex and simple rules is the multiplicity of the actions in one rule. In Table 6 is presented the set of compliance rules with their textual descriptions and their formal expression with MTL structure patterns.

Complex rules		Simple Rules	
CR1	**Description:** Duty of the authority to administer and to operate the port as appears to it best calculated to serve the public interest. **MTL Expression: Administration_of_Port CoExists Operation_of_Port PerformedBy Authority**	SR1a	**Text Description:** Duty of the authority to administer the port as appears to it best calculated to serve the public interest. **MTL Expression: Administration_of_Port PerformedBy Authority**
		SR1b	**Text Description:** Duty of the authority to operate the port as appears to it best calculated to serve the public interest. **MTL Expression: Operation_of_Port PerformedBy Authority**
CR2	**Description***:* Duty of the authority to regulate and control navigation within the limits of the port and its approaches. **MTL Expression: Regulate_Navigation CoExists Control_Navigation PerformedBy Authority**	SR2a	**Text Description:** Duty of the authority to regulate navigation within the limits of the port and its approaches. **MTL Expression: Regulate_Navigation PerformedBy Authority**
		SR2b	**Text Description:** Duty of the authority to control navigation within the limits of the port and its approaches. **MTL Expression: Control_Navigation PerformedBy Authority**
CR3	**Description:** Duty of the authority to maintain, improve and regulate the use of the port and the services and facilities therein. **MTL Expression: (Improve_Use_of_Port, Maintain_Use_of_Port) CoExists Regulate_Use_of_Port PerformedBy Authority**	SR3a	**Text Description:** Duty of the authority to maintain the use of the port and the services and facilities therein. **MTL Expression:Improve_Use_of_Port PerformedBy Authority**
		SR3b	**Text Description:** Duty of the authority to improve the use of the port and the services and facilities therein. **MTL Expression:Maintain_Use_of_Port PerformedBy Authority**
		SR3c	**Text Description:** Duty of the authority to regulate the use of the port and the services and facilities therein. **MTL Expression: Regulate_Use_of_Port PerformedBy Authority**
		SR4	**Text Description:** Duty of the authority to provide for the Port and the approaches thereto navigational services and aids. **MTL Expression: Provide_Navigational_Services PerformedBy Authority**

Table 5- Compliance rules- Port Authority Act

For the whole of eight simple rules extracted, the rule target is their described activity and the agent who is performing those activities as shown in Fig.30.

In Fig.31, the whole instantiation is presented containing all the information mentioned in this section.

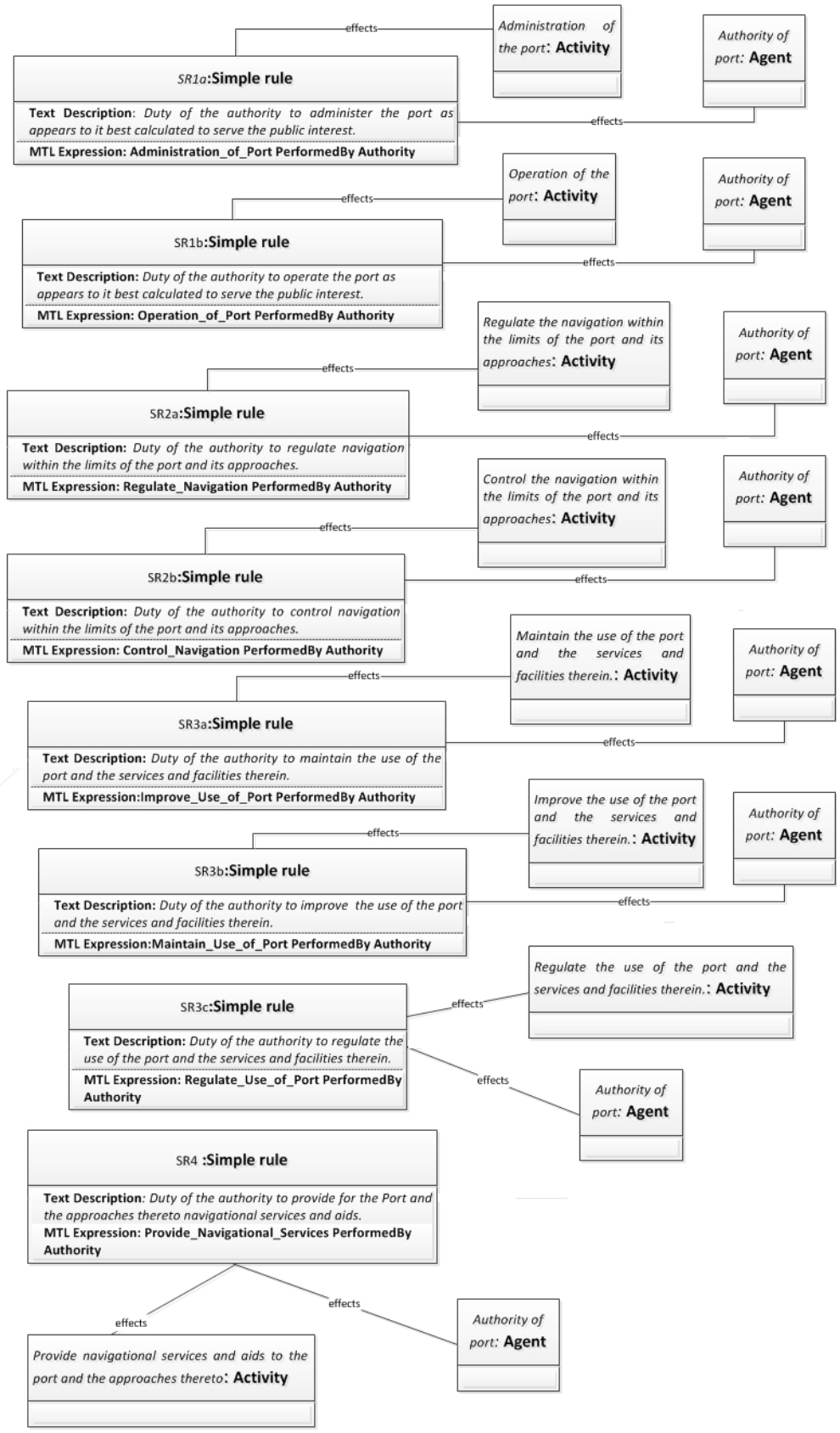

Figure 30- Rule target for port authority act rules

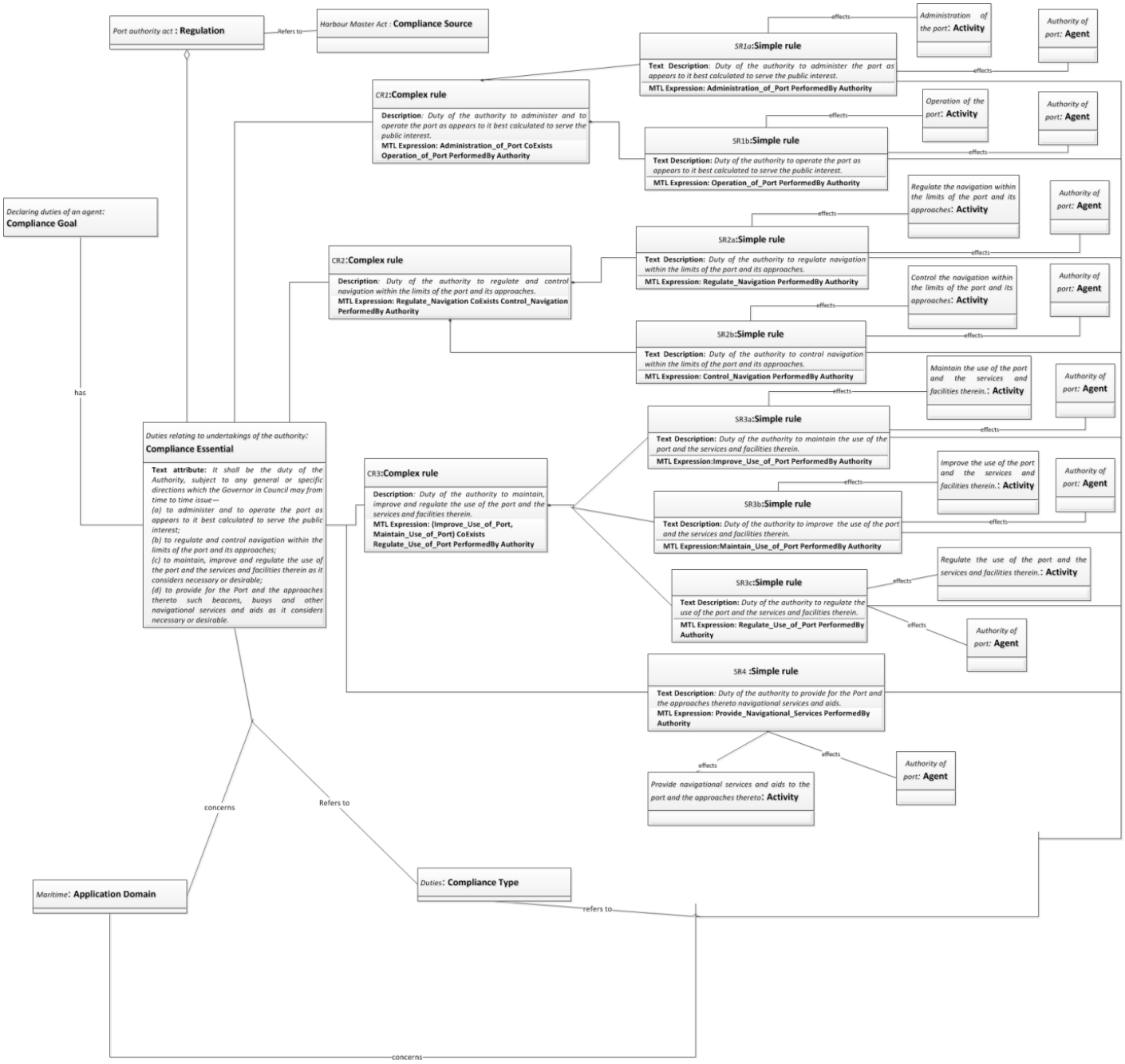

Figure 31- 1st instantiation of port authority act

4.2.2 Port authority act (Part II)

The Port authority act was preferred for a second instantiation in order to examine if there was a difference or a difficulty in handling different parts of the same law for the procedure of instantiating them.

The compliance essential selected this time is the subsection named: *Dues and charges in respect of ship* and it belongs to the PART VI section of the Act which is named: *DUES, CHARGES AND TARIFF BOOK.*

The application domain still remains the maritime domain but the type of concern of this segment of laws is about financial exchanges between the Port and other specific parties. The goal of this compliance essential is about the definition of dues and charges of a ship entering the port (Table 7).

Compliance Essential	Compliance Goal	Application domain	Compliance Type
Subject to the provisions of this Act and the regulations, every ship which— *(a) enters a port for the purpose of loading or discharging cargo or embarking or disembarking passengers; or* *(b) occupies an anchorage or berth within the Port,* *Shall pay to the Authority the dues and charges in respect of such ship and for any service performed or facility provided in respect of such ship in accordance with the regulations under this Act.*	*Definition of dues & charges of a ship entering the port*	*Maritime*	*Financial Exchanges*

Table 6- Characteristics of compliance essential-Port authority act (II)

As before the structure of the text is very helpful in the extraction of compliance rules. In this case the only activity detected is the payment of dues and charges. The purpose of performing this activity is considered as an event which is triggering the execution of payment the dues and charges to the Authority. So, as shown in Table 8 the compliance rules are simple and they are two.

Simple Rules	
SR1	**Description:** Every ship which enters a port for the purpose of loading or discharging cargo or embarking or disembarking passengers shall pay to the Authority the dues and charges in respect of such ship and for any service performed or facility provided in respect of such ship. **MTL Expression: Entering_the_Port LeadsTo Payment_of_Dues_and_Charges PerformedBy Ship**
SR2	**Text description:** Every ship which occupies an anchorage or berth within the port shall pay to the Authority the dues and charges in respect of such ship and for any service performed or facility provided in respect of such ship. **MTL Expression: Occupation_of_Anchorage_or_Berth_within_the_port LeadsTo Payment_of_Dues_and_Charges PerformedBy Ship**

Table 7- Compliance rules- Port authority act (II)

These two rules are relating to the same activity which is the payment of dues and charges and to the same agent which is the ship performing this activity. The separation point is the event that causes this activity. As shown in Fig.32 for the SR1

rule the triggering event is the entrance in the port when for SR2 rule is the occupation of anchorage or berth within the port.

In the next figure (Fig.33) the complete instantiation is presented.

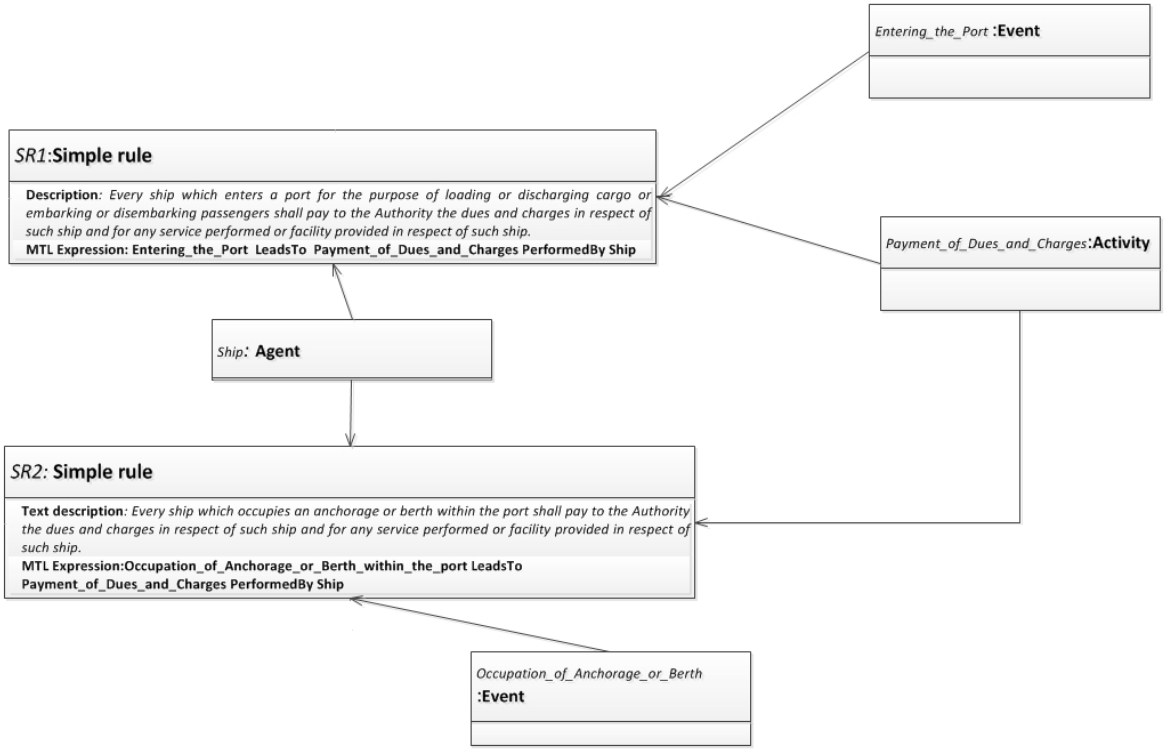

Figure 32- Rule target for port authority act rules (II)

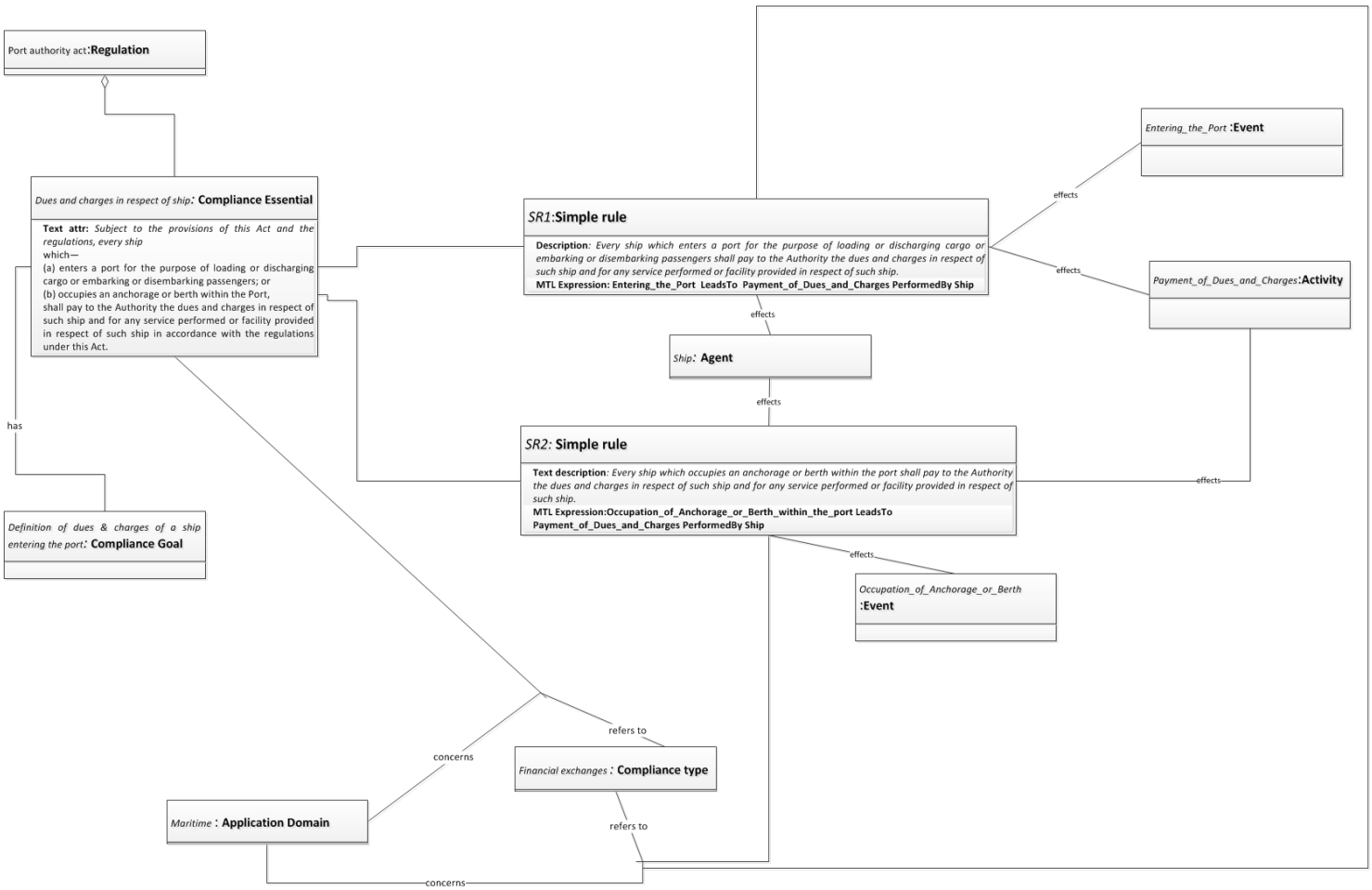

Figure 33-Second instantiation of port authority act

4.2.3 SLA-Definition of services between a service provider and a customer

This Service Level Agreement (SLA) defines the services and service levels between the service provider, ITS Customer Support Services, Managed IT Support (MITS), and the customers of that service (Customer). Eligible customers are the units, departments and colleges internal to the University of Texas at Austin.

It was selected as an example for instantiating the compliance meta-model because it is an internal type of compliance source.

The part of this SLA that it was judged as a compliance essential is shown in the Table 9 below and it refers to a crucial MITS responsibility. The goal of this compliance essential is to declare the duties of an agent (in this case MITS) and the domain of duties applicability is the IT support of an organization.

Compliance Essential	Compliance Goal	Application domain	Compliance Type
MITS responsibilities in support of this agreement include: *Deploy operating systems, applications, software patches and updates.*	*Declare the duties of an agent*	*IT Support*	*Duties*

Table 8- Characteristics of compliance essential- SLA

As it seems by the compliance essential the constraints declared are very well defined. The deployment of operating systems, applications, software patches and updates is considered by the modeler as a complex rule because its deployment has a very different workflow. As shown in Table 10 this one complex rule is composed by four different simple ones.

Complex rules		Simple Rules	
CR1	**Description:** MITS should deploy operating systems, applications, software patches and updates. **MTL Expression: (Deploy_operating_systems,Deploy_applications, Deploy_software_patches, Deploy_software_updates;m)Multisegragated**	**SR1a**	**Text Description:** MITS should deploy operating systems. **MTL Expression: Deploy_operating_systems PerformedBy MITS**
		SR1b	**Text Description:** MITS should deploy applications **MTL Expression: Deploy_applications PerformedBy MITS**
		SR1c	**Text Description:** MITS should deploy software patches **MTL Expression: Deploy_software_patches PerformedBy MITS**
		SR1d	**Text Description:** MITS should deploy updates **MTL Expression: Deploy_updates PerformedBy MITS**

Table 9- Compliance rules-SLA

The used patterns are not able to express the notion of data. But in this case the operating systems, the applications, the software patches and the updates are concerning and containing data which is influenced by the activity of their deployment. In Fig.34 it is presented the rule target of each simple rule. The agent for all four rules is the MITS.

The Fig.35 is representing the whole instantiation as analyzed in this section.

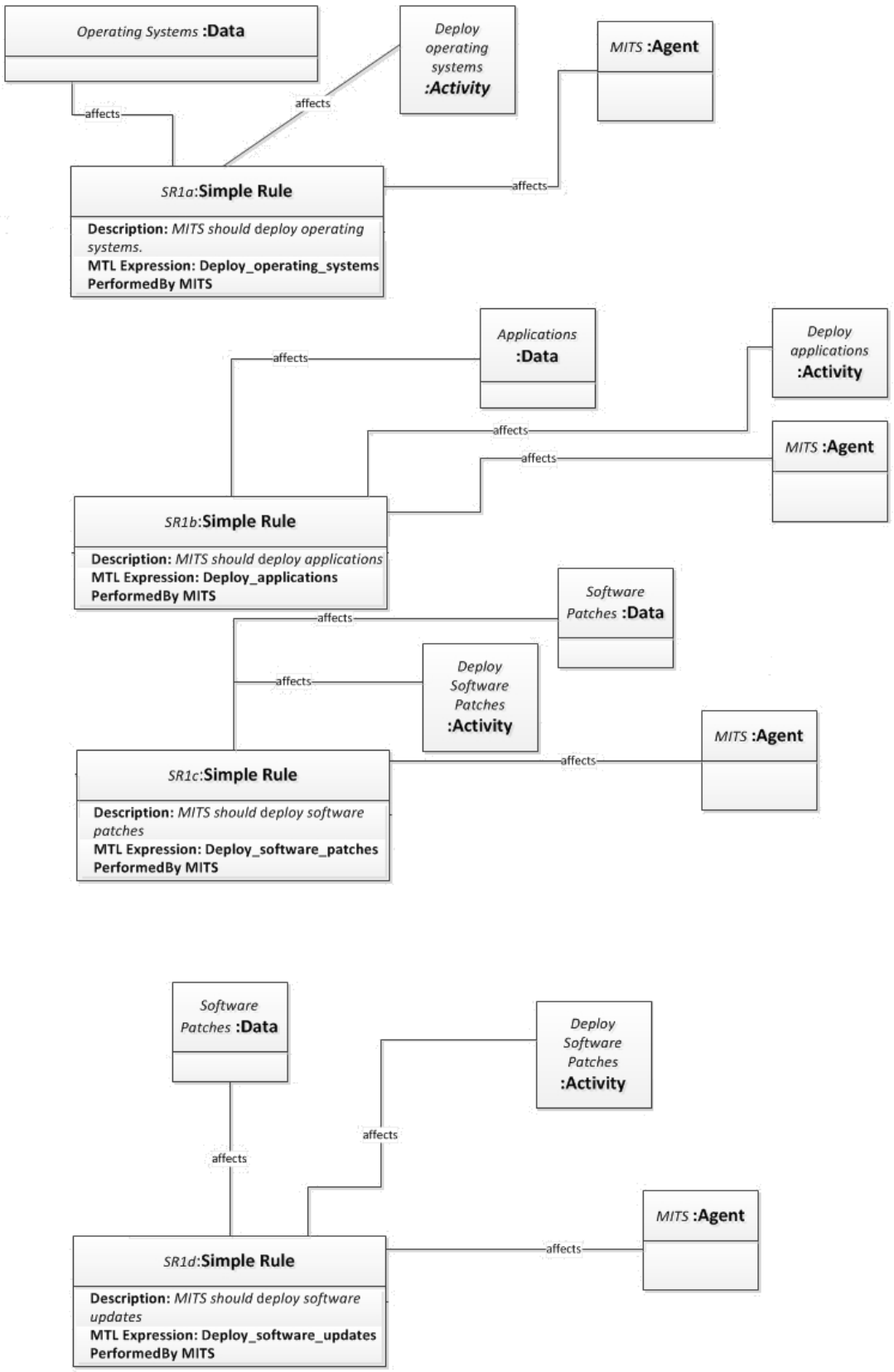

Figure 34-Rule target of SLA simple rules

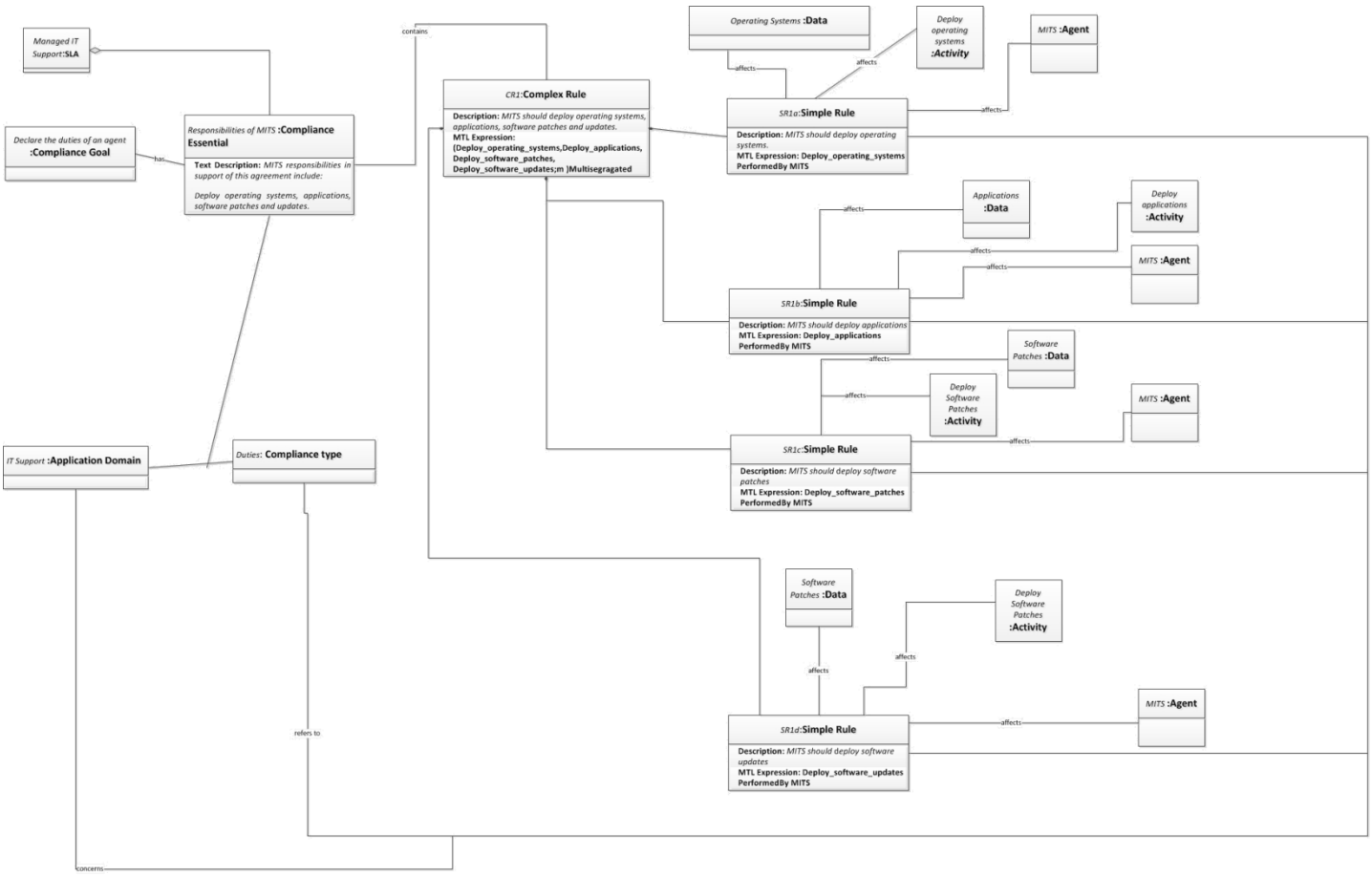

Figure 35- Instantiation of SLA/IT Support

4.2.4 Healthcare regulation-Abortion

This particular regulation is a healthcare regulation published and stated in the state of Massachusetts. It was found in an electronic form in the site of the General court of the commonwealth of Massachusetts. The structure of laws in general in this site is divided in chapters, sections and subsections.

After a lot of research due to the enormous size of information provided, the researcher had focused on the Section 12L of the regulation which was referring to the constraints of an abortion.

In this particular section the constraints of the abortion are concerning an existence of pregnancy for less than 24 weeks. The type of concern for this section is the authorization that a physician has as far as the approval of abortion is concerned (Table 11).

Compliance Essential	Compliance Goal	Application domain	Compliance Type
If a pregnancy has existed for less than twenty-four weeks no abortion may be performed except by a physician and only if, in the best medical judgment of a physician, the abortion is necessary under all attendant circumstances.	*Declare the constraints of an action*	*Healthcare*	*Authorization*

Table 10- Characteristics of compliance essential-Abortion regulation

This compliance essential instance is having several constraints declared:

1. A physician is the only one authorized to perform an abortion if the pregnancy is existing for less than twenty-four weeks
2. A physician should perform the abortion if it only decides it as necessary under all attendant circumstances.

As shown in Table 12 there is a complex rule describing all types of constraints which is composed by two simple rules.

Complex rules		Simple Rules	
CR1	**Description:** If a pregnancy has existed for less than twenty-four weeks no abortion may be performed except by a physician and only if, in the best medical judgment of a physician, the abortion is necessary under all attendant circumstances. **MTL Expression**: **Pregnancy CoExists Judgment_of_Abortion_as_Necessary LeadsTo Performance_of_Abortion PerformedBy Physician**	**SR1a**	**Text Description:** If a pregnancy has existed for less than twenty-four weeks no abortion may be performed except by a physician. **MTL Expression: Pregnancy ExistsMax 24 weeks LeadsTo Performance_of_Abortion PerformedBy Physician**
		SR1b	**Text Description:** The abortion may be performed only if the physician has ruled as necessary under all attendant circumstances. **MTL Expression: Judgment_of_Abortion_as_Necessary LeadsTo Performance_of_Abortion PerformedBy Physician**

Table 11- Compliance rules-Abortion regulation

The activity affected in this case is the performance of abortion by the physician which is triggered by two separate but interdependent events (Fig.36):

- Existence of pregnancy for less than 24 weeks
- Judgment of abortion as necessary

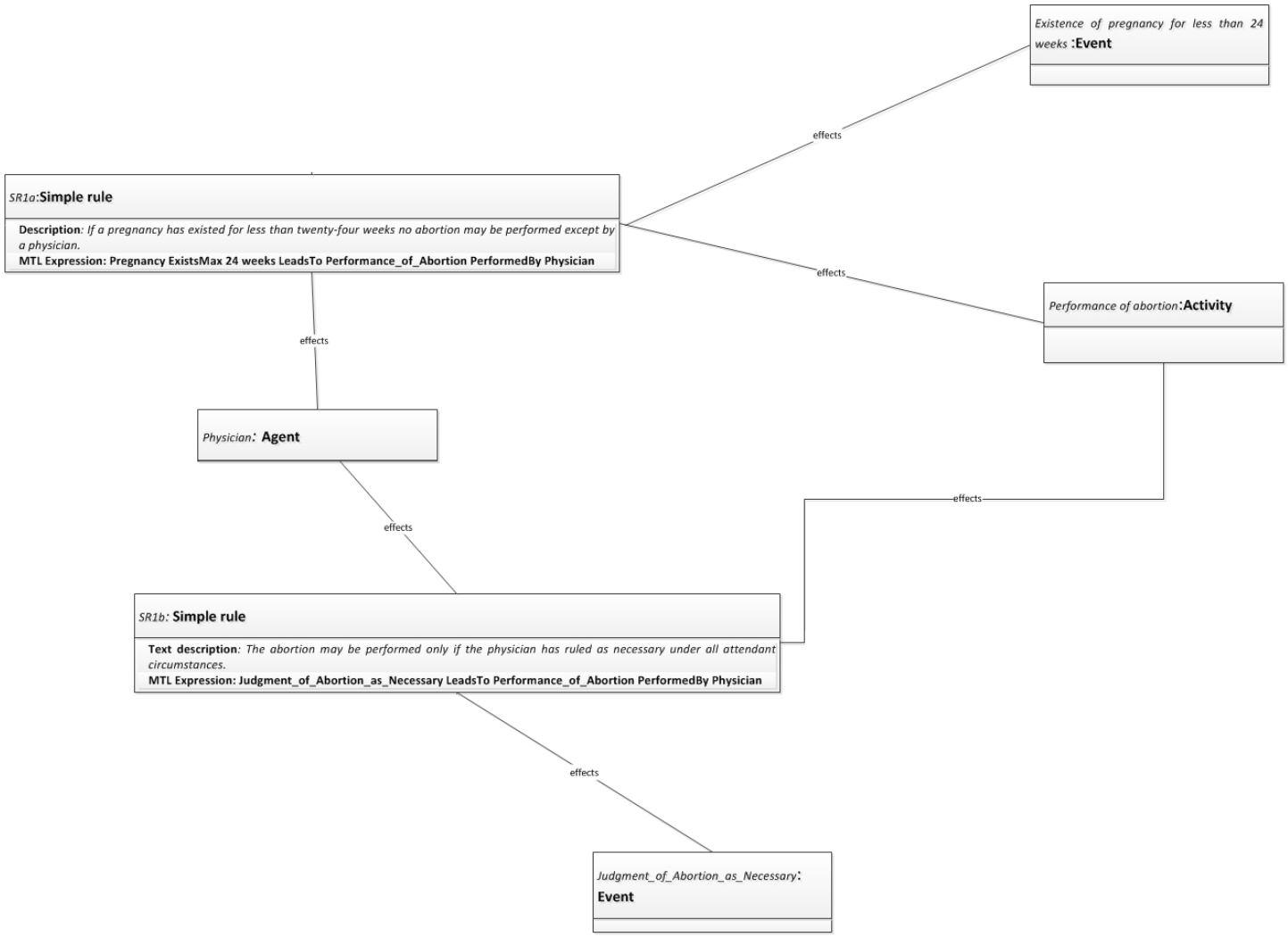

Figure 36-Rule target of abortion rules

In the Fig.37 below it is presented the whole instantiation.

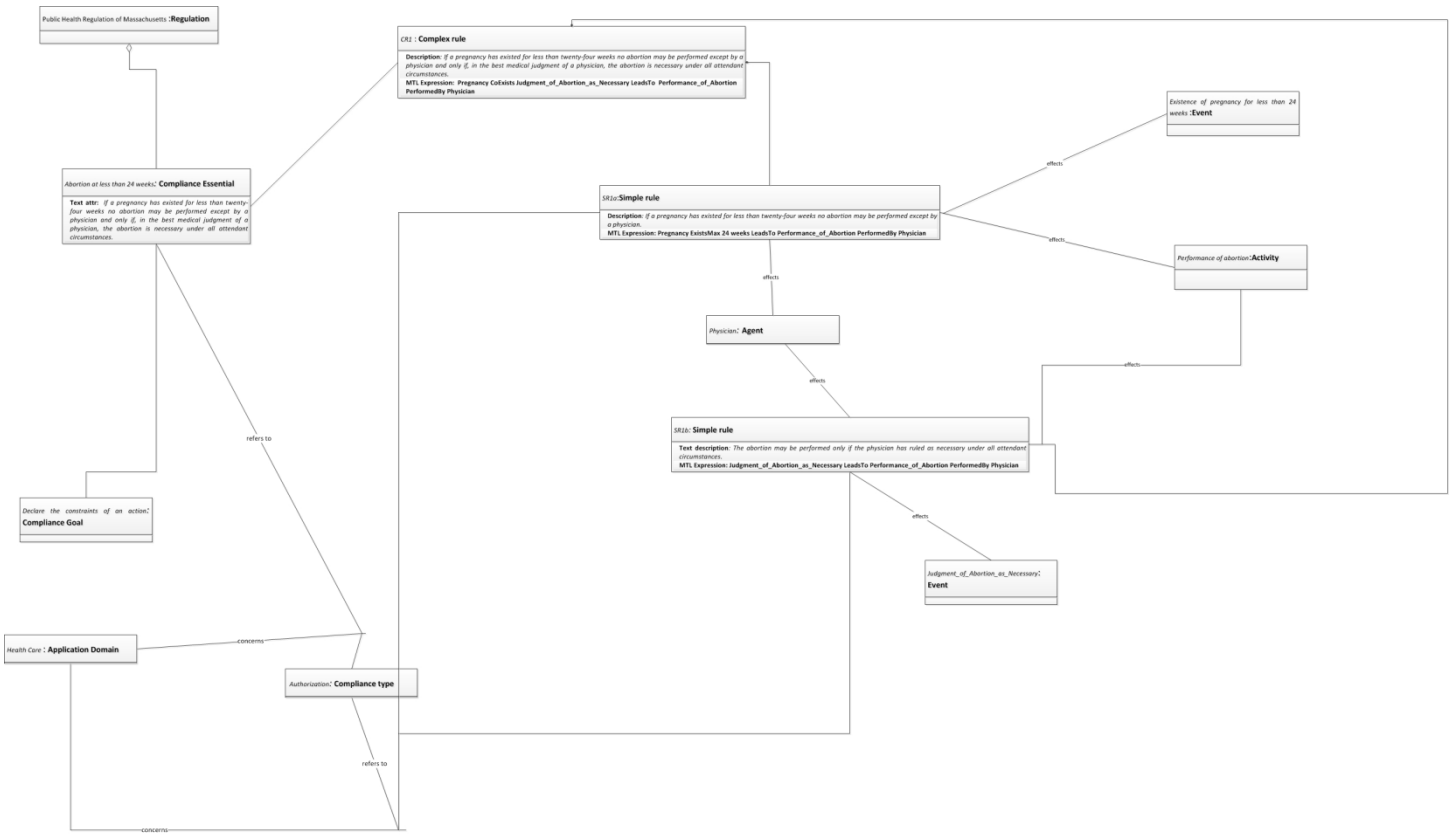

Figure 37- Instantiation of abortion regulation

4.3 Remarks about the instantiations

In order to validate the proposed compliance meta-model this thesis proceeds on comparing the meta-model with another existing one. The COMPAS meta-model was the base of the proposed meta-model because it supports the grounds of generality and wide applicability as far as compliance regulations are concerned. Thus the comparison made is between those two meta-models. The major observation from the comparison of the meta-models was that the meta-model proposed in this thesis is describing the notion of compliance and compliance rule with more details. This detailed description is in a more conceptual and abstract level and offers to the meta-model, possible applicability in a more wide range than COMPAS.

The purpose of the instantiations presented above was the testing of the usability and applicability of compliance meta-model. These four instances proved that the entities of the meta-model were well defined.

Through the instantiations, it was observed that all of the designed entities had served and represented their predefined functionality.

It was also noticed that the conceptual sections of the meta-model were helpful in the identification of each instance separately. Moreover each entity was perceived in the same way in every instantiation which indicates the clearance of its definition and typology.

Moreover the methodology section of the meta-model has proven very helpful in the defining of compliance notion. In future use of the meta-model the variability of fashions for describing compliance would be a key feature in terms of categorization. Through the identification of application domain and compliance type of concern, the compliance officer will be able to search and categorize rules from every legal document.

A more specific observation was that the MTL expressions had a strong relation and pairing to the rule target entity. This pairing is translating to a solid and powerful connection between the content of a rule and their affecting components.

The uprising argument is that the perspective of the instantiations is subjective because they were made by one modeler. The results may be different if another modeler was trying to instantiate the meta-model.

The perception of what it is or not a complex rule and what are its components is one-dimensional. The same opinion is prevailing as far as the interpretation of rule target entity is concerned. From another perspective the composition of complex rules and their affected elements may be different by the one presented in this thesis.

5 Conclusions and future work

5.1 Conclusions

This thesis proposes a generic compliance meta-model for the definition of compliance concepts and notions. After an extended scientific research and study of existing approaches, the concluded scope was the designing of a conceptual meta-model based on defining the notion of compliance and the methodology of extracting rules and requirements in a semantic level.

The construction of the compliance meta-model was presented step by step through a design rationale analysis depicting the decisions made for this purpose.

Through the design rationale analysis, it was formed a meta-model describing three sections of compliance:

- Teleology section: Definition of legal document
- Methodology section: Definition of compliance essential
- Applicability/Ontology section: Definition of rules and their target

In order to validate the proposed meta-model it was necessary to compare it with an existing and similar one. The comparison proved that the proposed meta-model is more efficient as far as applicability and generality are concerned. Another way of validating the meta-model was to test the behavior of the entities through the instantiation of it. The important remarks of those instantiations were:

- In every instance the perception for each entity was the same for the modeler
- The use of patterns and MTL expressions improve the understanding of rule's syntax
    - Disadvantage: MTL expressions are not able to describe the notion of data entity
- Easy extraction of compliance essential from a compliance source
- The methodology section of the meta-model is very important for compliance management and categorization
- The differentiation between complex and simple rule is describing in an accurate way the structure of rule as both semantically and lexically.

- The applicability/ontology section of the meta-model is perfectly defining the core components of what a rule can effect regardless the workflow and their relations

Figure 38 is presenting the key points of this thesis in a chronological order of evolution.

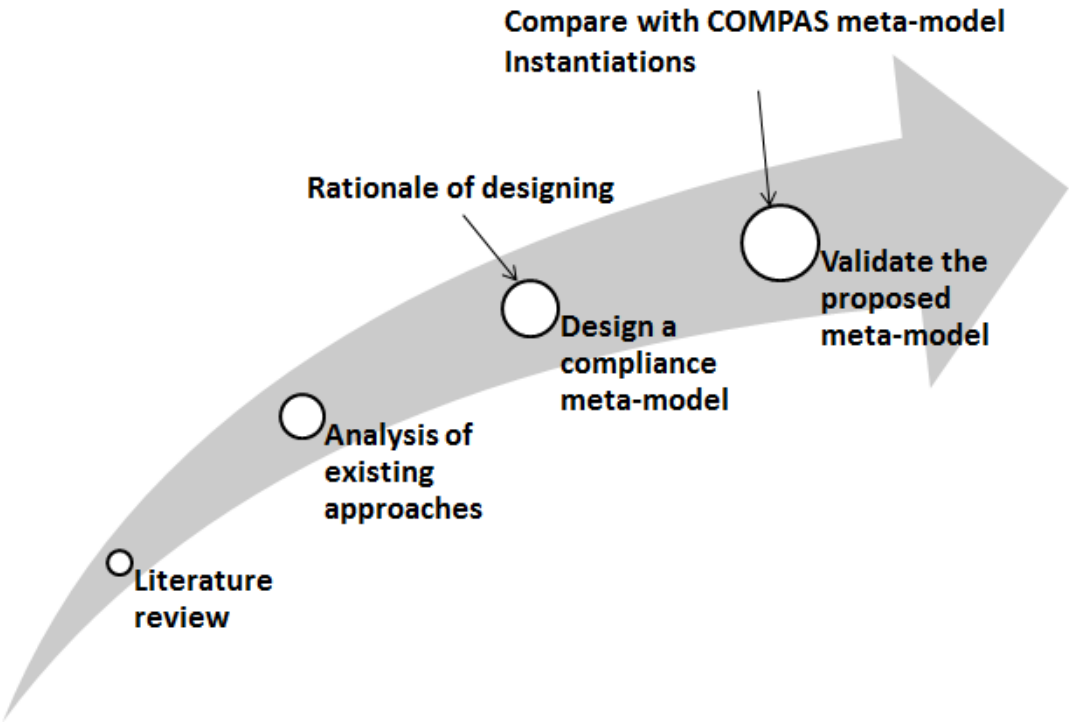

Figure 38-Evolution of this thesis

By the ending of the review of this thesis, the concluding opinion is that the proposed meta-model is offering something different to scientific research. The reason is that this meta-model is describing plainly three different aspects of compliance:

- Who?
- What?
- Where?

The **"Who"** aspect concerns the source of compliance and its type. The **"What"** aspect is about the description of key features that identify and characterize compliance; and finally the "**Where**" aspect is referring to the identification of the conformance target.

5.2 Future work

Compliance management is an evolving scientific area. The research presented here is an effort of describing concepts concerning compliance and the relations between them in a semantic level through the designing of a meta-model. The proposed meta-model is based on a solid scientific background but as the level of analysis is conceptual, it is likely to be changed and transformed in time.

In order to enhance the meta-model, in this subsection we propose some different aspects for future work.

- ***Automate the extraction of rules***

  It would be of great importance to study further the approaches dealing with the automated or semi-automated extraction of rules via textual recognition and analysis. The attainment of matching semantic and textual recognition and extraction of rules from legal documents will improve the procedure of compliance enforcement in general. In particular as far as the proposed meta-model is concerned, it will enhance the notion of compliance rule and its relation to rule target entity. It will confer to the meta-model the dynamic of representing rules both semantically and lexically with certainty that the content of legal document has properly been attributed.

- ***Ontological analysis***

  The ontological analysis is a theoretical approach used for the evaluation of modelling languages and in particular the evaluation of their completeness and expressiveness. The ontological analysis requires a representation of mapping of the ontological concepts to its corresponding meta-model concepts. The purpose of this is to identify the degree of completeness of the notation.

  Ontologies can be written in various formats and can be used by computers to reason about the domain they describe. They are also useful as a common format that allows for exchange of knowledge across applications/ platforms.

For the completion of this effort, this thesis concludes with an analysis and early implementation of an ontology.

Due to lack of time for the preparation of this thesis, we weren't able to validate the created ontology. Nevertheless, an initial observation is that the visual representation

of ontological entities has a conceptual consistency with meta-model entities. It is essential to further analyze the designed ontology because it would offer the base to start using the meta-model in a more applicable version.

5.2.1 Ontological analysis

The ontology presented in this thesis is written in the Protégé tool. Protégé Desktop is a feature rich ontology editing environment with full support for the OWL 2 Web Ontology Language. OWL 2 is an ontology language that defines the concepts of an ontology.

5.2.1.1 Ontology components

An ontology is a description of a domain. The components consisting an ontology are classes, properties and individuals.

5.2.1.2 Classes

Ontology classes are very similar to classes in an object oriented program. Just like in object oriented programming classes in ontologies form a hierarchy.

The root class which is at the top of the inheritance hierarchy is **Thing** (this is true of all OWL ontologies).

5.2.1.3 Properties

OWL distinguishes between two main categories of properties that an ontology builder may want to define:

- Object properties link individuals to individuals.
- Data type properties link individuals to data values.

A property axiom defines characteristics of a property. In its simplest form, a property axiom just defines the existence of a property. For example:

<owl:ObjectProperty rdf:ID="is_a"/>

This defines a property with the restriction that its values should be individuals.

Object properties and classes are separate concepts and we use restrictions to connect them together.

5.2.1.4 Individuals

Like RDF classes, every OWL class is associated with a set of individuals, called the class extension. The individuals in the class extension are called the instances of the class.

5.2.2 Mapping the ontological concepts to the meta-model concepts

The first step followed for the development of the ontology was the creation of classes. All the entities of the meta-model are the classes of the ontology. As shown in Fig.39 below, we created a hierarchy of classes by defining classes and sub-classes.

The notion of sub-classes was used in order to express the existing relationships between some of the classes. For example the entity of Regulation is type of External source which is type of Compliance source.

An uprising issue was the mapping of ternary relationships existing between the entities of the meta-model to the classes in the ontology. The only acceptable solution was the creation of a new class expressing the two of three classes. For example the ternary relationship between compliance essential, application domain and compliance type entities was expressed with the creation of a new class named App_domain&Type (Fig.40).

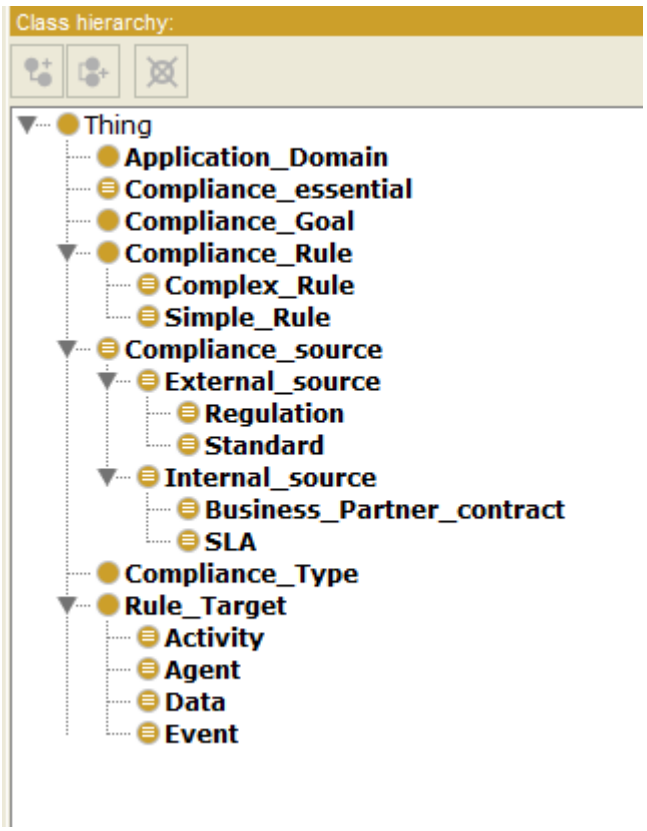

Figure 39-Class hierarchy

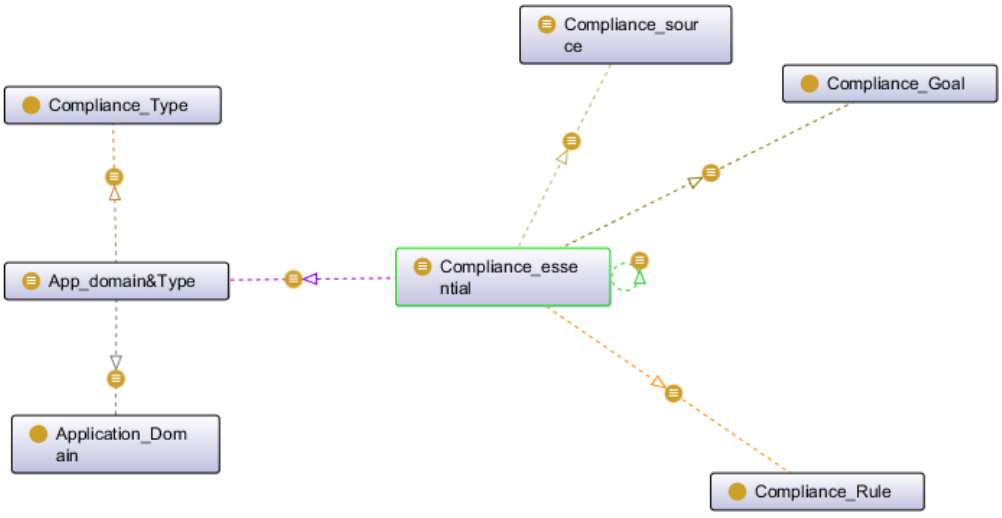

Figure 40-Expressing the ternary relationship of compliance essential

In order to express the relations among classes, it was essential to define the object properties. As mentioned above the object properties are designed manually by the designer.

The existing relationships for the meta-model were created as object properties in Protégé. As expected the graph of ontology had no deviation from the meta-model.

1. The teleology section of the meta-model is depicted in Fig.41. In order to achieve this kind of visualization it was necessary after the creation of properties to connect and relate the classes.

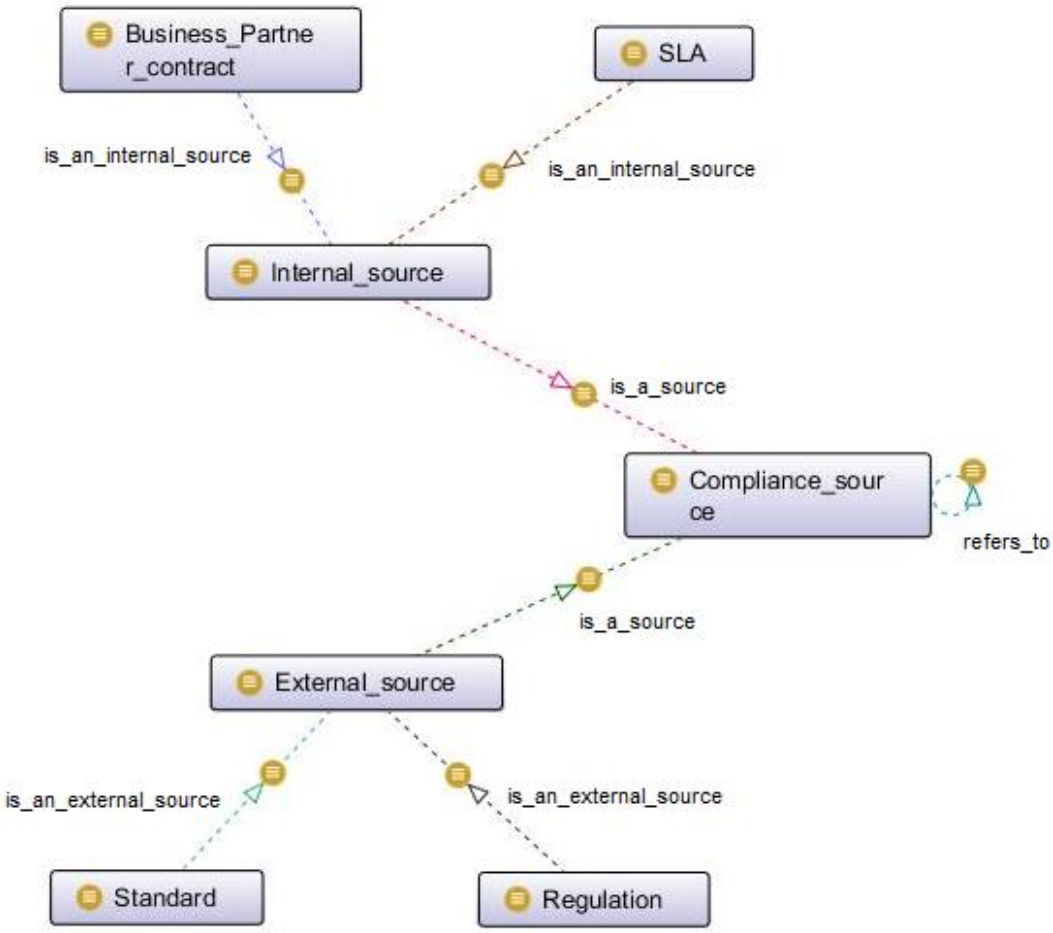

Figure 41-Teleology section

2. The methodology section shown below (Fig.42) follows the same rationale as the one presented above.

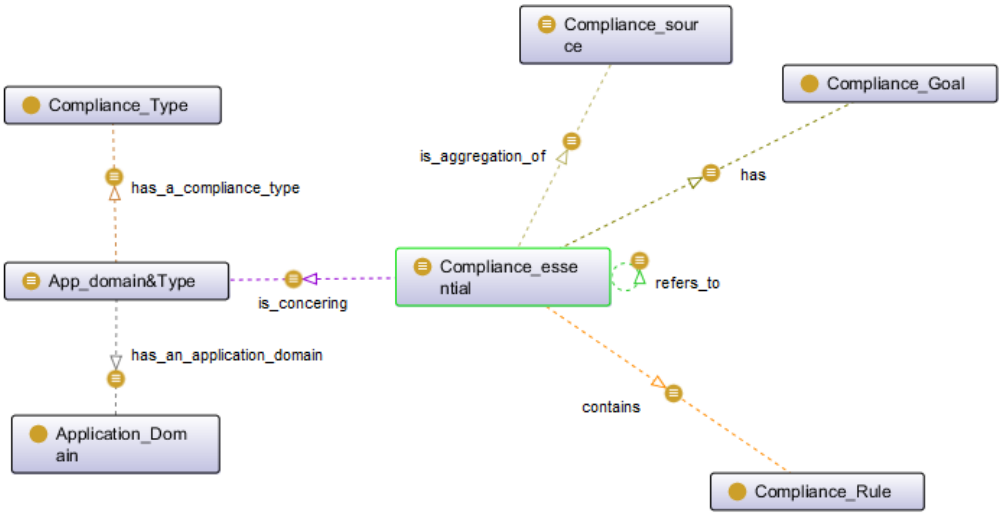

Figure 42-Methodology section

3. Last but not least the ontology/application section is presented in Fig.43.

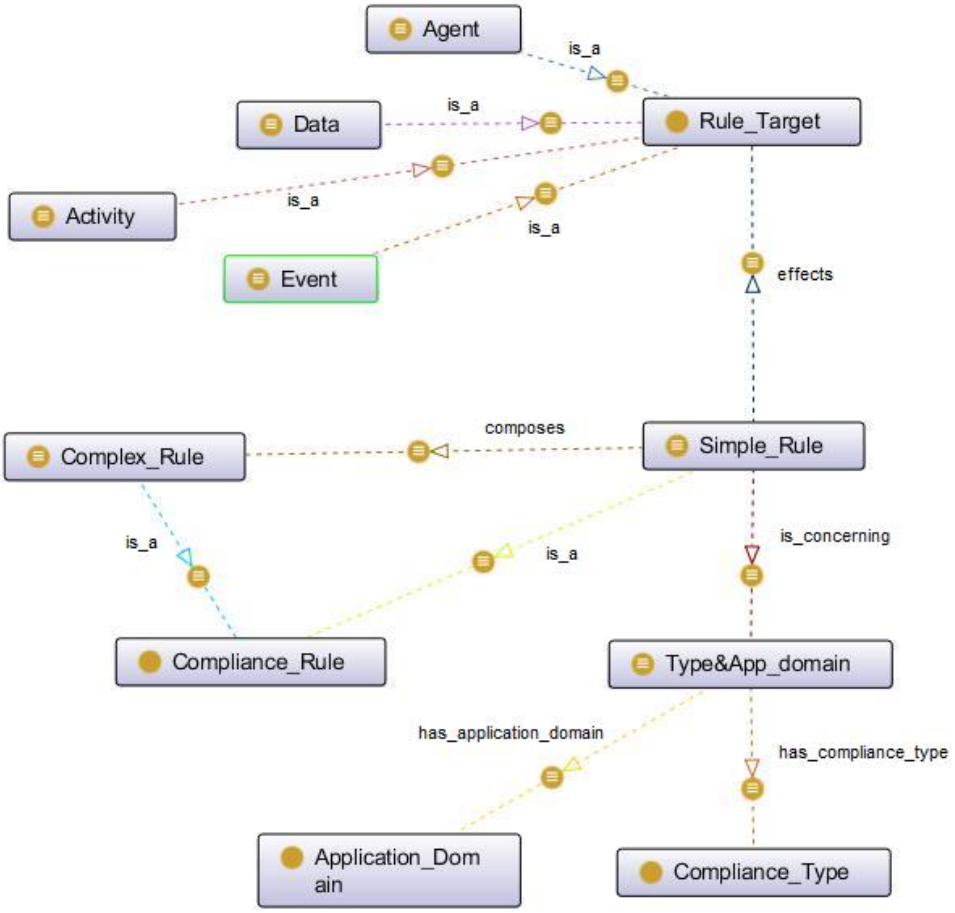

Figure 43- Application section

The syntax of owl is presented in APPENDIX A.

5.2.3 Owl ontology instance

The Owl ontology is composed by classes, properties and individuals. In order to test the applicability of classes, an instance was designed. The selected instance was one of the four presented in Chapter 4 and in particular it was the instantiation of HealthCare law of Massachusetts. The code generated for this instantiation is presented in APPENDIX B.

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APPENDIX A

Terminology of compliance meta-model

TERM	DESCRIPTION
Activity	A unit of work performed automatically or manually by actors.
Agent	A role or actor involving.
Application Domain	The affected business domain by the compliance source.
Business Partner Contract	Specialization of internal source. A set of compliance requirements that defines the relationship constraints between business partners.
Complex Rule	A composition of simple rules.
Compliance Essential	A statement that describes the restraining or directing influence to check, verify, or enforce rules to satisfy one or more compliance requirement.
Compliance Goal	The purpose of the compliance essential.
Compliance Rule	An operative definition of compliance essential.
Compliance Source	A document that is the origin of compliance essential.
Compliance Type	Different aspects and concerns of compliance such as privacy, security, segregation of duties etc.
Data	It is given or needed information that suggests conformance.
Event	An action causing other actions or activities.
External Source	A compliance source that is generated by the state or a commission or a union.
Internal Source	A compliance source that is generated in and between organizations.
Simple Rule ***2 attributes:*** ***Text Description*** ***MTL Expression***	A simple structure of rule.

SLA	Specialization of internal source. A formal representation of an agreement of services between two independent parties.
Standard	Specialization of external source.
Regulation	Specialization of external source.
Rule Target	The generic target of rules. The influence by rule conformance.

APPENDIX B

OWL Ontology

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<Ontology xmlns="http://www.w3.org/2002/07/owl#"
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xmlns:xsd="http://www.w3.org/2001/XMLSchema#"
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OWL instance

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134.<NamedIndividual IRI="#CR1"/>
```

135. *<Literal datatypeIRI="&rdf;PlainLiteral">Pregnancy CoExists Judgment_of_Abortion_as_Necessary LeadsTo Performance_of_Abortion PerformedBy Physician</Literal>*
136. *</DataPropertyAssertion>*
137. *<DataPropertyAssertion>*
138. *<DataProperty IRI="#Text_description"/>*
139. *<NamedIndividual IRI="#CR1"/>*
140. *<Literal datatypeIRI="&rdf;PlainLiteral">If a pregnancy has existed for less than twenty-four weeks no abortion may be performed except by a physician and only if, in the best medical judgment of a physician, the abortion is necessary under all attendant circumstances.</Literal>*
141. *</DataPropertyAssertion>*
142. *<DataPropertyAssertion>*
143. *<DataProperty IRI="#MTL"/>*
144. *<NamedIndividual IRI="#SR1a"/>*
145. *<Literal datatypeIRI="&rdf;PlainLiteral">Pregnancy ExistsMax 24 weeks LeadsTo Performance_of_Abortion PerformedBy Physician</Literal>*
146. *</DataPropertyAssertion>*
147. *<DataPropertyAssertion>*
148. *<DataProperty IRI="#text_descr"/>*
149. *<NamedIndividual IRI="#SR1a"/>*
150. *<Literal datatypeIRI="&rdf;PlainLiteral">If a pregnancy has existed for less than twenty-four weeks no abortion may be performed except by a physician.</Literal>*
151. *</DataPropertyAssertion>*
152. *<DataPropertyAssertion>*
153. *<DataProperty IRI="#MTL"/>*
154. *<NamedIndividual IRI="#SR1b"/>*
155. *<Literal datatypeIRI="&rdf;PlainLiteral">Judgment_of_Abortion_as_Necessary LeadsTo Performance_of_Abortion PerformedBy Physician</Literal>*
156. *</DataPropertyAssertion>*
157. *<DataPropertyAssertion>*
158. *<DataProperty IRI="#text_descr"/>*
159. *<NamedIndividual IRI="#SR1b"/>*
160. *<Literal datatypeIRI="&rdf;PlainLiteral">The abortion may be performed only if the physician has ruled as necessary under all attendant curcumstances.</Literal>*
161. *</DataPropertyAssertion>*