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Report and tutorial materials on new formal techniques for modelling the representation of embedded legal knowledge in legal texts, concept holism in the legal domain

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Executive Summary

This document is the first part of Deliverable D1.2, which reports on part of second year of research activities conducted in MIREL for WP1. The remaining activities are reported in D1.2 - Part II.

According to the workplan of this workpackage we focused, in this D1.2 - Part I, on the following:

• **Task 1.1 Transdisciplinary Research and Conceptual Models for Legal Knowledge Representation and Reasoning**: by offering further results in completing the analysis presented in Deliverable D1.1, especially regarding constitutive norms and legal supervenience (relevant for concept holism in law);

• **Task 1.2 Formal Languages for Representing Norms, Policies, and Values in the Law**: by extending the logical model of norm change reported on in Deliverable D1.1, by developing a complete formalism for modelling preferences and value orderings;

• **Task 1.3 Logics for Modelling the Interpretation of Legal Provisions** by further developing fuzzy logic for legal interpretation; devising an argumentative system for meaning negotiation in the law that operates within the framework of Deliverable D1.1.

The layout of Part I of the deliverable is as follows. Chapter 2 accounts for the logical nature of constitutive norms as a type of legal supervenience. Chapter 3 offers a new model of temporal dynamics of law, which reconciles previous frameworks (described in Deliverable D1.1) based on Defeasible Logic or on AGM techniques. Chapter 4 discusses how the logic for ⊗ recalled for deontics in Deliverable D1.1 can be used to model preferences and value orderings. Chapter 5 briefly offers some developments on legal interpretation of ideas presented in Deliverable D1.1.

Part II of D1.2 is describes LegalRuleML XML standard, which is capable to model all the legal requirements presented in this Part I and in the previous Deliverable D1.1.

The main contribution of all chapters is to offer a state of the art on the above research issues: all chapters

• recall and are based on previous research and on publications by MIREL partners for the project;

• summarise open problems by formally stating research challenges for future MIREL activities: see the list of Research Challenges in the subsequent page for a complete overview.
1 Introduction

This document is the first part of Deliverable D1.2, which reports on part of second year of research activities conducted in MIREL for WP1. The remaining activities are reported in D1.2 - Part II.

In Deliverable D1.1 (Introduction), we have summarised the main aspects and topics in law that are of interest for MIREL WP1. For this second year of activities, we have focused on the following ones:

Reification (1). Norms are objects with properties, such as

Temporal properties (2). Norms usually are qualified by temporal properties, such as:
1. the time when the legal provision and the corresponding norm is in force and/or has been enacted;
2. the time when the norm can produce legal effects (when the norm is applicable and supports the derivation of legal effects);
3. the time when the normative effects hold.

Defeasibility (1; 3; 4). When the antecedent of a norm is satisfied by the facts of a case, the conclusion of the norm presumably holds, but is not necessarily true. In particular, we worked on:

Conflicts (3). Norms can conflict, namely, they may lead to incompatible legal effects. Conceptually, conflicts can be of different types, according to whether two conflicting norms

• are such that one is an exception of the other (i.e., one is more specific than the other);
• have a different ranking status;
• have been enacted at different times;

Norm validity (2). Norms can be invalid or become invalid. Deleting invalid norms is not an option when it is necessary to reason retroactively with norms which were valid at various times over a course of events. For instance:
1. The annulment of a norm is usually seen as a kind of repeal which invalidates the norm and removes it from the legal system as if it had never been enacted. The effect of an annulment applies ex tunc: annulled norms are prevented from producing any legal effects, also for past events.
2. An abrogation on the other hand operates ex nunc: The norm continues to apply for events which occurred before the norm was abrogated.

Normative effects. There are many normative effects that follow from applying norms, such as obligations, permissions, prohibitions and also more articulated effects such as those introduced, e.g., by Hohfeld (see (4)). In particular,

Evaluative, which indicate that something is good or bad, is a value to be optimised or an
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Legal knowledge in legal texts, concept holism in the legal domain

evil to be minimised. For example, “Human dignity is valuable”, “Participation ought to be promoted”;

**Qualificatory**, which ascribe a legal quality to a person or an object. For example, “\(x\) is a citizen”;

**Definitional**, which specify the meaning of a term. For example, “Tolling agreement means any agreement to put a specified amount of raw material per period through a particular processing facility”;

**Persistence of normative effects (5)**. Some normative effects persist over time unless some other and subsequent event terminate them. For example: “If one causes damage, one has to provide compensation.”. Other effects hold on the condition and only while the antecedent conditions of the norms hold. For example: “If one is in a public office, one is forbidden to smoke”.

**Values and goals (6)**. Usually, some values and goals are promoted by the legal norms. Modelling norms sometimes needs to support the representation of values and value preferences (and of goals and goal preferences), which can play also the role of meta-criteria for solving norm conflicts. (Given two conflicting norms \(r_1\) and \(r_2\), value/goal \(v_1\), promoted by \(r_1\), is preferred to value/goal \(v_2\), promoted by \(r_2\), and so \(r_1\) overrides \(r_2\).)

In particular, according to the workplan of WP1 we focused on:

- **Task 1.1 Transdisciplinary Research and Conceptual Models for Legal Knowledge Representation and Reasoning**: by offering further results in completing the analysis presented in Deliverable D1.1, especially regarding constitutive norms and legal supervenience (relevant for concept holism in law);

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- recall and are based on previous research and on publications by MIREL partners for the project;
- summarise open problems by formally stating research challenges for future MIREL activities: see the list of Research Challenges in the subsequent page for a complete overview.
## List of MIREL Research Challenges in WP1

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2 Semantic Holism, Constitutive Norms, and Supervenience

The MIREL research conducted in the first year argued that constitutive norms can be related with the idea of concept (and in particular, meaning) holism (as developed in (7) and briefly reported in Deliverable D1.1). We worked this year on some aspects of this issue, and in particular on the link between legal constitutiveness and normative supervenience (NS). A complete discussion was developed in (8).

On the one side, we should recall that Chapter 2 of Deliverable D1.1, in Research Challenge 3, stated the following:

[Types of Legal Norms] Design a formal language that covers and accommodates all basic normative logics and functions behind norms, which cannot be formalised by simply distinguishing between different legal effects/judgements. In particular, the formal language must handle

- rules and principles;
- dynamic normative effects–distinction between initiation norms, termination norms, and supervenience norms;
- constitutive vs regulative–distinction between regulative and constitutive norms.

Here, we argue that there could be a significant relation between supervenience and constitutive norms.

On the other side, let us recall that concept/meaning holism is a broad view maintaining that the meanings of all of the words in a language are interdependent. This thesis gathers different ideas from philosophers such as Willard Van Orman Quine, Donald Davidson, Wilfrid Sellars, Robert Brandom, and which can be summarised for our purposes as follows (7; 9; 10):

Definition 1 (Meaning Holism in the Law). Meaning Holism in the law can characterised as follows:

- Inferential role semantics: the meaning of an expression (in the law) is determined by its relationship to other expressions, typically its inferential relations;
- The meaning is connected with the reasoning process;
- The activity of using meanings presupposes that individuals have practical mastery of inferential relations to other meanings;
- The relation among legal meanings is made via constitutive norms.

The following figure illustrates with an example how constitutive norms define and connect concepts, and then relate such norms with regulative norms. In the example, three regulative norms are considered, one prohibiting for vehicles to enter public parks, one permitting to install childseats on velocipedes, and one permitting circulating in the city centre with eco-friendly vehicles. Constitutive norms are instead four: one stating that a bike is a vehicle, two stating that a bike is a velocipede and that a velocipede is a vehicle, and one stating that a velocipede is an eco-friendly vehicle. As you can see, a network of concepts/meanings is generated through rules and the use of them requires to draw inferences involving constutive norms:
2.1 Normative Supervenience (NS)

Supervenience is generically understood as a special kind of relation between properties, and is usually viewed as weaker than entailment (11): hence we could usually say that NS is a binary relation between properties such that normative properties of kind A supervene on non-normative properties of kind B.

However, according to (8) a more comprehensive way for defining NS does not amount to partitioning the set of predicates into two sorts, but to identifying a normative way through which possible worlds (where predicates are made true of individuals) are related—as standardly done in possible-world semantics for deontic logic (12).

Definition 2 (Supervenience and normativity). NS is a logical entailment that makes properties normative and that corresponds to ways for identifying the set of normative possible worlds (normative necessity).

Hence, normative properties in any world w are nothing but those properties that are true of individuals in worlds that are selected as the most-preferred (or ideal) ones with respect to w.

The basic philosophical and logical move behind NS is pictorially rendered in Figure 2.1. Figure 2.1 shows four possible worlds w, v, z, and s. The worlds v and z are normatively ideal with respect to w, while s is not. In v and z the individual a is Q, thus Q can be seen as a normative property with respect to w and a. We will show how this idea is suitable for defining Q as supervenient, e.g., with respect to P.
2.2 Constitutive Rules/Norms as Counts-as Supervenience Relations

2.2.1 Introduction

John Searle famously introduced constitutive rules as counts-as relations in the context of his theory of the rule-based nature of social institutions (13; 14):

**Definition 3** (Informal 1). *The counts-as (constitutive) rules have the following canonical form:*

\[ X \text{ COUNTS AS } Y \text{ in the context } C \]

where, typically, \( X \) denotes a “brute” fact and \( Y \) an “institutional” fact (13; 14).

**Definition 4** (Informal 2). *The counts-as rules establish a counts-as relation that assigns a status \( Y \) to \( X \), and with it, a function that \( X \) does not already have before just in virtue of its being an \( X \) (13; 14).*

Two paradigmatic examples of counts-as relations are

\[
\begin{align*}
\text{This piece of paper counts as a five euro bill} & \quad (2.2.1) \\
\text{X counts as a presiding official in a wedding ceremony} & \quad (2.2.2)
\end{align*}
\]

The most we formally learn from (14, 28, 44, 45) is that

1. counts-as contexts are *intensional* in the usual sense of failing the substitutivity test, and
2. the \( X \) and \( Y \) terms in the counts-as relation are *causally unrelated.*

These properties seem to capture crucial features of Searle’s counts-as construction. For example, if \( X = \) ‘US president’s declaration’ and this counts as a certain \( Y \), it is not hard to understand that
‘Donald Trump’s declaration’ in itself may not count as $Y$ since Trump’s declaration is institutionally relevant insofar as Donald Trump is the president of US. Also point 2 is reasonable, especially when we consider the peculiarities of institutional ontology as opposed to the domain of brute (empirical) facts. In this perspective, a US president’s declaration is not a causal reason for obtaining $Y$.

This analysis offers some general directions for clarifying the logical nature of counts-as link:

- First, since the counts-as relation is intensional, it can be reconstructed in the context of modal logics; this thesis is in line with most literature on supervenience and, more specifically, with the intuition according to which NS corresponds to a normative way through which we select ideal worlds;
- Second, since the counts-as relation does not correspond to a causal link, its logical reconstruction cannot enjoy the same formal properties that causal relations usually have; we will see that Searle’s view is just an option and that alternative philosophical (and logical) views are possible. Such alternatives are perhaps better for reconstructing the counts-as relation as NS.

### 2.2.2 Is the Counts-as Relation a Type of NS?

The counts-as link exhibits some intuitive similarities with supervenience. Consider this legal example:

Electronic signature COUNTS AS handwritten signature
IN CONTEXT Italian contract law

Indeed, for the sake of illustration let us now assume the following standard definitions (15):

**Definition 5** (Indiscernibility and Weak Supervenience). *Let $B$ be a set of properties.*

- **Indiscernibility**: Any two individuals $x$ and $y$ are $B$-indiscernible iff $P(x) \rightarrow P(y)$ for all $P$’s belonging to $B$.

- **Weak supervenience**: $B$-properties weakly supervene on $A$-properties iff, for any two individuals $x$ and $y$ that belong to the same possible world $w$, if $x$ and $y$ are $A$-indiscernible in $w$, then they are also $B$-indiscernible in $w$.

The just mentioned legal example illustrates well at what extent counts-as relations are similar to (weak) supervenience (11). Indeed, if we consider any two individuals $x$ and $y$, we can conceptually admit the following cases ($Esign$ and $Hsign$ stand for electronic signature and handwritten signature, respectively):

1. $Esign(x), Esign(y)$  $Hsign(x), Hsign(y)$
2. $\neg Esign(x), \neg Esign(y)$  $Hsign(x), Hsign(y)$
3. $\neg Esign(x), \neg Esign(y)$  $\neg Hsign(x), \neg Hsign(y)$

Given Definition 5, these cases are formally admissible.

What about the following?

4. $Esign(x), \neg Esign(y)$  $Hsign(x), Hsign(y)$
5. $\neg Esign(x), \neg Esign(y)$  $\neg Hsign(x), Hsign(y)$
These cases should be in principle ruled out, as they do not meet Definition 5. In addition, individuals y (case 4.) and x (case 5.) either

1. are true instances of handwritten signatures: they are not electronic signatures because they are just brute handwritten signatures; or
2. are not even brute instances of handwritten signatures (but, e.g., smoke signals): i.e., the fact that they count as handwritten signatures depends on a different counts-as relation (e.g., stating that smoke signals count as handwritten signatures).

The second case does not help here, as it simply refers to another counts-as rule. The first case, instead, suggests that we should reject that, for any property \( P \), \( P \)’s count as \( P \)’s, especially if \( P \) is not an institutional property. Hence, under the analysis above, case 2., too, should be ruled out: if so, the remaining cases for the counts-as relation satisfy Definition 5\(^1\).

In the specific legal example, if we use \( \Rightarrow \) to denote the counts-as link

\[
H_{\text{sign}}(x) \Rightarrow H_{\text{sign}}(x)
\]

must be assumed to be invalid. In other words, under the hypothesis that the counts-as link is NS, whenever brute facts are related with institutional facts we have to reject the general view (16, par. 3.2 ) that NS is reflexive as the classical logical entailment is: if the counts-as must ensure co-variance and thus is genuine NS, it may be argued that counts-as relations do not enjoy the following schema:

\[
A \Rightarrow A. \quad \text{(Reflexivity)}
\]

### 2.2.3 A Formal Analysis of the Counts-as Relation

The logical nature of counts-as rules has been investigated following several directions (for a general overview, cf. (17)). Here, we will consider two options that express the counts-as link as a non-classical (modal) conditional\(^2\).

In their seminal paper, (19) develop an analysis of the notion of institutionalised power by introducing a new conditional connective ‘\( \Rightarrow_s \)’. This connective expresses the counts-as connection holding in the context of an institution \( s \). In short, this approach is roughly in line with Goldman’s theory of actions generating actions (20). In this perspective, it may be argued that the generation of institutional facts via counts-as rules is quite close to the idea of a causal relation—contrary to Searle’s argument—and assumes that reflexivity does not hold—as required above.

A second formalisation, though openly inspired by Jones and Sergot, proposes some substantial changes in the light of a different philosophical interpretation of the counts-as relation (21). Counts-as rules are meant to capture the constitutive, but classificatory character of institutional ontology. Accordingly, their function is to represent the constitutive ingredients of institutional facts, whose nature is conceptually distinct from that of the empirical facts. On the other hand, counts-as rules have a normative status. They are norms insofar as their conditional nature exhibits some basic

---

\(^{1}\)In addition to the intuitive observation that cases 2., 4., and 5. speak of being a handwritten signature as a brute fact, we should also recall that NS, in the sense of Definition 2, does not rely on distinguishing in the formal language different sorts of predicates or propositional letters.

\(^{2}\)A formal analysis of NS may require to use predicate logics. For the sake of simplicity, we will work in this section with a propositional language, referring to (18)’s investigations on quantification in conditional logics.
properties enjoyed by the usual normative links.

### 2.2.3.1 Counts-as Link as NS: A Generative (Dynamic) Relation

Jones and Sergot developed a formal approach to the notion of institutionalised power by introducing a conditional connective \( \Rightarrow_s \) to express the counts-as connection holding in the context of an institution \( s \). Accordingly, an expression like \( A \Rightarrow_s B \) means that \( A \) counts as \( B \), where \( A \) is viewed as a sufficient condition for obtaining \( B \) within \( s \).

Jones and Sergot characterise the logic for \( \Rightarrow_s \) as a classical conditional logic (RCEA, RCEC) (22), plus the axioms

\[
\begin{align*}
((A \Rightarrow_s B) \land (A \Rightarrow_s C)) & \rightarrow (A \Rightarrow_s (B \land C)) \\
((A \Rightarrow_s B) \land (C \Rightarrow_s B)) & \rightarrow ((A \lor C) \Rightarrow_s B) \\
(A \Rightarrow_s B) & \rightarrow ((B \Rightarrow_s C) \rightarrow (A \Rightarrow_s C))
\end{align*}
\]

(2.2.3) (2.2.4) (2.2.5)

In addition, Jones and Sergot’s analysis is integrated by introducing the normal KD modality \( D_s \), such that \( D_s A \) means that \( A \) is a “constraint on the institution \( s \)”. More precisely, this is suggested to capture all (logical, causal, deontic, etc.) constraints on \( s \) which include the counts-as connection. Accordingly, a formula like \( D_s (A \rightarrow B) \) means “it is a constraint of (operative in) institution \( s \) that if \( A \) then \( B \)” or “it is incompatible with the constraints operative in \( s \) that \( A \) and not-\( B \)”.

When linked to \( D_s \) through the following schema

\[
(A \Rightarrow_s B) \rightarrow D_s (A \rightarrow B)
\]

(2.2.6)

counts-as links thus express institutional constraints (on \( s \)) to the effect that within \( s \) the realisation of \( A \) (e.g., performing certain acts as a presiding official in a wedding ceremony) counts as a sufficient condition of creating \( B \) (the status of married people).

It is important to note that this approach guarantees a restricted form of detachment of “institutional consequents” from antecedents in the form: if \( A \Rightarrow_s B \) holds and it is the case that \( A \), then it is the case in \( s \) that \( D_s B \) according to the constraints operative in \( s \). This is done by adopting also the following schema:

\[
(A \Rightarrow_s B) \rightarrow (A \Rightarrow D_s A).
\]

(2.2.7)

### 2.2.3.2 Counts-as Link as a Classificatory Relation

Following (21), we can argue that the counts-as link—in Searle’s sense—is a normative classificatory relation involving institutional facts. As such, it enjoys, among others, Reflexivity: if \( \Rightarrow_s \) is a classificatory relation, how can we reject that some \( A \) holds as itself in a given institution (i.e., \( A \Rightarrow_s A \))? If so, there is at least another way to model counts-as relations:

- let us introduce a generic, normative, and classificatory, conditionality \( \Rightarrow; \); in other words, any expression \( A \Rightarrow B \) means that \( A \) is normatively falling within type \( B \); and
- let us use a non-normal “institutional” modality \( D_s \), to strictly denote the domain of institutional facts. More precisely, an expression such as \( D_s A \) is to be read as “it is an institutional fact within \( s \) that \( A \)”.

---

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The machinery reframes the counts-as link as follows:

\[(A \Rightarrow_s B) =_{\text{def}} (A \Rightarrow D_s B) \land (D_s A \Rightarrow D_s B)\]  \hspace{1cm} (2.2.8)

This statement accounts for the structuring of institutional facts, with regard to an institution \(s\), in a hierarchy of counts-as relations linking (a) brute facts with institutional facts (\(s\)-facts) and (b) \(s\)-facts with other \(s\)-facts.

The formal theory of the counts-as conditional is provided by a logic corresponding at least to (23)’s system of nonmonotonic cumulative logic.

The axiomatisation adopted for ‘\(\Rightarrow\)’ is as follows:

\[A \Rightarrow A\]  \hspace{1cm} (2.2.9)

\[(A \Rightarrow B) \land (A \land B \Rightarrow C) \rightarrow (A \Rightarrow C)\]  \hspace{1cm} (2.2.10)

\[(A \Rightarrow B) \land (A \Rightarrow C) \rightarrow (A \land B) \Rightarrow C\]  \hspace{1cm} (2.2.11)

As expected, the logic for \(\Rightarrow\) is closed under RCEA and RCK (24). In addition, it is possible to add

\[(A \Rightarrow C) \land (B \Rightarrow C) \rightarrow (A \lor B) \Rightarrow C\]  \hspace{1cm} (2.2.12)

Finally, the logic for \(D_s\) is closed under logical equivalence and contains the following schemata:

\[D_s A \rightarrow \neg D_s \neg A\]  \hspace{1cm} (2.2.13)

\[(D_s A \land D_s B) \rightarrow D_s (A \land B)\]  \hspace{1cm} (2.2.14)

Since this modality is meant to strictly represent the institutional facts holding within \(s\), the necessitation rule is not adopted. In fact, it would sound strange that \(\top\) may be viewed as an institutional fact for any institution \(s\).

2.2.3.3 Discussion

Jones and Sergot are clearly inspired by Goldman’s theory of action generation. As is well-known, the action generation may be characterised as a kind of conditionality where the occurrence of the antecedent \(A\), which corresponds, typically, to an action description, generates the occurrence of a different action description \(B\), if some background conditions are satisfied. In particular, \(A\) and \(B\) are modelled as simultaneous and \(A\) is not strictly part of doing \(B\). (20, 25ff.) considers, among other things, a specific case where the consequent \(B\) is generated by \(A\) by convention. This type is quite close to the idea of “counts as”, since we may speak of conventional generation exactly when, for example, we state that a chess player wins the game by checkmating her opponent. 

(19)’s connective \(\Rightarrow_s\) is standing for a peculiar kind of conventional generation. In fact, such a connective is stated to be non-reflexive and transitive, two properties that, among others, are typically assigned to characterise any conditionality expressing forms of causality or generation (25). In particular, rejecting or adopting reflexivity of counts-as relations constitutes perhaps one of the most decisive aspects that seem to differentiate the two logical approaches recalled in above. As noted by Jones and colleagues, with regard to the counts-as link, “it is precisely the property of non-reflexiveness that distinguishes a generation relation as such”. Reflexivity affects the meaning
ascribed to the counts-as link. First of all, as is well-known, if ‘A counts as A’ holds we clearly cannot argue in favour of transitivity since its presence plus reflexivity imply monotonicity (23). The problem is then to decide whether reflexivity must prevail over transitivity or the other way around. This inevitable choice cannot be avoided insofar as non-monotonicity is a crucial feature of counts-as conditionals:

**Example 1.** Suppose that in an auction if the agent x raises one hand, this may count as making a bid. It is clear that this does not hold if x raises one hand and scratches his own head. If ‘x scratches his own head’ is true, there are good reasons to conclude that x does not make any bid.

Whether normative relations enjoy reflexivity can be a thorny question (26). For example, arguments against reflexivity are quite serious when we deal with dyadic obligations (27). On the other hand, one may tend to view a normative conditional by integrating a generic connective ⇒ with suitable monadic operators and, especially, with a suitable institutional classificatory operator. According to Gelati et al., a formula like A ⇒ A simply states the systematic claim that any formula A is a consequence of itself. Also, notice that this view, according to (2.2.8), does not lead to full reflexivity, but only to Ds A ⇒ Ds A, which means nothing but that an institutional fact is an institutional fact.

In fact, if the counts-as link means that “A is to be classified as B within s”, rejecting reflexivity may be problematic: Defeasible classificatory relations, such as typicality, normally enjoy reflexivity. Actually, counts-as rules are not only regulative; they are primarily constitutive insofar as they express the constitutive elements of institutional reality. As we have seen, this is not only a well-known thesis developed by Searle, but seems to correspond to the idea that such rules may encode as well classificatory relations between categories within any institution.

Of course there are sound arguments to accept transitivity (instead of reflexivity). If we know that raising one hand counts as making a bid, and bidding counts as buying a good, then raising one hand counts as buying a good. This is basically Jones and Sergot’s perspective, which is based on the idea that the occurrence of the antecedent of a counts-as relation is a (defeasible) sufficient reason for getting the consequent. But, as in the case of causality, some pathological examples may be put forward. In Jones and Sergot’s view, counts-as sufficient conditions are defeasible. If so, given a rule such as r₁: X ⇒ₚ Y, we may say that X is sufficient to imply Y if some implicit background conditions S₁ are satisfied. Each rule of this kind is conceptually linked to a number of implicit conditions. Now imagine we have another rule r₂: Y ⇒ₚ Z where the background conditions are S₂. The acceptability of r₃: X ⇒ₚ Z depends on the compatibility of S₁ ∪ S₂ ∪ X with respect to Z. In fact, when S₁ and S₂ are made explicit conjunctively in the corresponding antecedents, we have X ∧ S₁ ⇒ₚ Y and Y ∧ S₂ ⇒ₚ Z. If so, since ’⇒ₚ’ is defeasible, nothing prevents us from having that S₁ ∪ S₂ ∪ {X} ⇒ₚ ¬Z. In a different perspective, when S₁ ∪ S₂ is inconsistent, we would get the disruptive conclusion to infer trivially any formula. To be sure, these are a logical possibilities that may in theory jeopardise the adoption of full transitivity for counts-as relation. Let’s see an example. Consider the following rules:

\[
\begin{align*}
r₁ &: \text{x’s electronic signature counts as x’s handwritten signature} \\
r₂ &: \text{x’s handwritten signature counts as evidence of x’s handwriting.}
\end{align*}
\]

Of course, we cannot conclude that
r_3: x’s electronic signature counts as evidence of x’s handwriting.

The intuitive background presuppositions behind rules r_1 and r_2 are clearly and conjunctively incompatible with regard to Z. So, if counts-as is applied to fact-descriptions, full transitivity cannot in general be accepted.

If the argument above is correct, what we can do is just to drop Jones and Sergot’s (2.2.5) and adopt at most restricted transitivity (cumulativity), namely (2.2.10).

2.2.3.4 Conclusions

The previous discussion has shown that the counts-as relation can be logically viewed as a conventional type of NS. In particular, to sum up:

- **Option 1:**
  - If the counts-as link does not enjoy reflexivity, then
    - it is a generative (dynamic) relation;
    - it is a form of conventional NS, which semantically refers to the best normative worlds specific given institutions.

- **Option 2:**
  - If we do not drop reflexivity and transitivity, then
    - we validate the following schema:
      \[(A \Rightarrow B) \rightarrow ((A \land C) \Rightarrow B)\]  
      (Strengthening of the antecedent)
    - Thus, the counts-as relation amounts in fact to classical implication (classificatory, non-generative/non-dynamic, based on subset inclusion), and so it is not NS (see Section 2.1).

- **Option 3:**
  - If we drop transitivity but not reflexivity, then
    - we obtain a defeasible classificatory (non-generative, non-dynamic) institutional relation;
    - the counts-as only partially meet the formal requirements of weak supervenience.

2.3 Conclusions and Research Challenges

Further research perspectives need to be explored. In particular,

**Research Challenge 1** (Legal and Ordinary Language; NLP). Explore the following issues:

- **Legal and ordinary language**—the language of the law is not only based on constitutive legal norms: terms can be legal or ordinary depending on whether the legal system provides a definition of them or it just refers to their ordinary understanding;

- **Relation with NLP**—what’s the relation between this research line and those falling within NLP domain?
3 Temporalising Legal Norms

In the first year of MIREL research we have recalled and reframed results developed in (2). Subsequent work, in particular, was finalised at the beginning of MIREL project to systematise our previous effort and integrate it with deontic operators (28). The following section reports on our further effort, which was meant in the second year to show to address an open challenge, i.e. (cf. Deliverable D1.1, chap. 3),

• to cover different temporal mechanisms in the law (such as the law of inertia);
• to reconcile intuitions from (28) and techniques from belief and base revision.

We were interested in the formalisation of a belief revision operator applied to an epistemic model that considers rules and time. We enriched a simple logic language with an interval-based model of time, to represent validity and effectiveness of a norm. The revision operator could remove rules when needed or adapt intervals of time when newer, contradictory norms are introduced in the system.

Full results have been presented in (29).

3.1 An Example

Let us first of all present a concrete example that will serve to motivate the main ideas of our proposal.

Example 2. Consider the following pieces of information regarding a legislative attempt to ease tax pressure for people that have been unemployed.

• A citizen was unemployed from 1980 to 1985.
• If unemployed from 1980 to 1983, then a tax exemption applies from 1984 to 1986, in order to increase individual savings.
• New authorities in government revoke tax exemption for years 1985 and 1986.
• Tax exemption reinstated for the year 1985 due to agreements with labor unions.

However, later on the legislators approved a new normative establishing that finally there is no tax-exemption for all citizens for the years 1985 and 1986.

The previous situation seems to establish that, at the end, a tax exemption applies only for year 1985 for a while, before being revoked.

3.2 Legal System as Temporalised Belief Base

The problem of representing temporal knowledge and temporal reasoning arises in many disciplines, including Artificial Intelligence. A usual way to do this is to determine a primitive to represent time, and its corresponding metric relations. There are in the literature two traditional approaches to
reasoning with and about time: a point based approach, as in (2), and an interval based approach as in (30; 31). In the first case, the emphasis is put on instants of time (e.g., timestamps) and a relation of precedence among them. In the second case, time is represented as continuous sets of instants in which something relevant occurs. These intervals are identified by the starting and ending instants of time.

Here, time intervals (like in (32; 31)) are considered. This design decision has been taken because it simplifies the construction of an revision operator which will be introduced below. That is, following the semantics of the temporalised rules proposed in (2) and explained in Section 3.2 (an adapted version), the revision operator in many cases only consists in modifying the intervals to maintain the consistency.

Besides, different temporal dimensions will be taken into account. That is, as it is mentioned in (2), in a normative system, norms have different temporal dimensions: the time of validity of a norm (when the norm enters in the normative system) and the time of effectiveness (when the norm can produce legal effects). Thus, if one wants to model norm modifications, then normative systems must be modelled by more complicated structures. In particular, a normative system is not just the set of norms valid in it, but it should also consider the normative systems where the norms are effective.

3.2.1 Preliminaries and Notation

We will adopt a propositional language $L$ with a complete set of boolean connectives: $\neg$, $\land$, $\lor$, $\rightarrow$, $\leftrightarrow$. Each formula in $L$ will be denoted by lowercase Greek characters: $\alpha, \beta, \delta, \ldots, \omega$. We will say that $\alpha$ is the complement of $\neg \alpha$ and vice versa. The characters $\sigma$ will be reserved to represent cut function for a change operator. We also use a consequence operator, denoted $Cn(\cdot)$, that takes sets of sentences in $L$ and produces new sets of sentences. This operator $Cn(\cdot)$ satisfies inclusion ($A \subseteq Cn(A)$), idempotence ($Cn(A) = Cn(Cn(A))$), and monotony (if $A \subseteq B$ then $Cn(A) \subseteq Cn(B)$). We will assume that the consequence operator includes classical consequences and verifies the standard properties of supraclassicality (if $\alpha$ can be derived from $A$ by deduction in classical logic, then $\alpha \in Cn(A)$), deduction ($\beta \in Cn(A \cup \{\alpha\}$ if and only if ($\alpha \rightarrow \beta \in Cn(A)$) and compactness (if $\alpha \in Cn(A)$ then $\alpha \in Cn(A')$ for some finite subset $A'$ of $A$). In general, we will write $\alpha \in Cn(A)$ as $A \vdash \alpha$. Note that the AGM model (33) represents epistemic states by means of belief sets, that is, sets of sentences closed under logical consequence. Other models use belief bases; i.e., arbitrary sets of sentences (34; 35). Our epistemic model is based on an adapted version of belief bases which have additional information (time intervals). The use of belief bases makes the representation of the legal system state more natural and computationally tractable. That is, following (36, p. 24), we considered that legal systems’ sentences could be represented by a limited number of sentences that correspond to the explicit beliefs of the legal system.

3.2.2 Time Interval

We will consider a universal finite set of time labels $\mathbb{T} = \{t_1, \ldots, t_n\}$ strictly ordered; each time label will represent an unique time instant. Simplifying the notation, we assume that $t_i - 1$ is the immediately previous instant to the instant $t_i$ and $t_i + 1$ is the immediately posterior instant to the instant $t_i$.

Like in (5) we propose temporalised literals, however, we use intervals. We will consider an interval like finite ordered sequence of time labels $t_i, \ldots, t_j$ where $i, j$ are natural numbers ($i \leq j$)
and \( t_i, \ldots, t_j \in \mathbb{T}\) denoting instances of time or timepoints. Thus we have expressions of the type \( \alpha \) interval, where interval can be as follow:

- \([t_i, t_j]\): meaning that \( \alpha \) holds at time \( t_i \). Following (2) \( \alpha \) is transient (holding at precisely one instant of time). For simplicity \([t_i, t_j]\) = \([t_i]\).
- \([t_i, \infty]\): meaning that \( \alpha \) holds from \( t_i \). Following (2) \( \alpha \) is persistent from \( t_i \).
- \([t_i, \infty]\): meaning that \( \alpha \) holds from time \( t_i \) to \( t_j \) with \( t_i < t_j \).

Then we will consider a set of time intervals \( \mathbb{I} \) which contains intervals as those described previously. Thus, for simplicity, we can have expressions like \( \alpha^J \) where \( J \in \mathbb{I} \). Intervals in \( \mathbb{I} \) will be denoted by uppercase Latin characters: \( A, B, C, \ldots, Z \). Two intervals may not be disjoint, as defined next.

**Definition 6.** Contained interval. Let \( R, S \in \mathbb{I} \) be two intervals. We say that \( R \) is contained in \( S \), denoted \( R \subseteq S \) if and only if for all \( t_i \in R \) it holds that \( t_i \in S \).

**Definition 7.** Overlapped interval. Let \( R, S \in \mathbb{I} \) be two intervals. We say that \( R \) and \( S \) are overlapped, denoted \( R \approx S \) if and only if there exists \( t_i \in R \) such that \( t_i \in S \).

**Example 3.** Let \( R, S, V \in \mathbb{I} \) where \( R = [t_3, t_7], S = [t_4, t_6] \) and \( V = [t_5, t_9] \) with \( t_3, t_4, t_5, t_6, t_7, t_9 \in \mathbb{T} \). Then \( S \subseteq R \), \( R \approx V \) and \( S \approx V \).

### 3.2.3 Temporalised Belief Base

As rules are part of the knowledge, they are subject of temporal validity too: the time of force of a rule, i.e., the time when a rule can be used to derive a conclusion given a set of premises. In this perspective we can have expressions like

\[
(\alpha^{[t_a, t_b]} \rightarrow \beta^{[t_e, t_f]})
\]

meaning that the rule is in force from timepoint \( t_e \) to \( t_f \), or in other words, we can use the rule to derive the conclusion at time from time \( t_e \) to \( t_f \). The full semantics of this expression is that from time \( t_e \) to \( t_f \) we can derive that \( \beta \) holds from time \( t_e \) to \( t_f \) if we can prove that \( \alpha \) holds from time \( t_a \) to \( t_b \). But now we are doing a derivation from time \( t_e \) to \( t_f \), so the conclusion \( \beta^{[t_e, t_f]} \) is derived from time \( t_e \) to \( t_f \) and the premise \( \alpha^{[t_a, t_b]} \) must be derived from time \( t_e \) to \( t_f \) as well. In the same way a conclusion can persist, this applies as well to rules and then to derivations.

Thus, it is possible to define temporalised belief base which will contain temporalised literal and temporalised rules (see Example 4). This base represents a legal system in which each temporalised sentence defines a norm whose time interval determines the validity and effectiveness time.

**Example 4.** A legal system can be represented by the temporalised belief base \( \mathbb{K} = \{\alpha^{[t_1, t_3]}, \alpha^{[t_4]}, (\alpha^{[t_1, t_3]} \rightarrow \beta^{[t_4, t_6]}), (\alpha^{[t_1, t_3]} \rightarrow \beta^{[t_5, t_6]}), (\alpha^{[t_5, t_6]} \rightarrow \beta^{[t_7, t_8]}), (\alpha^{[t_7, t_8]} \rightarrow \beta^{[t_9, t_9]}), \epsilon^{[t_1, \infty]}\}\} \).

This type of belief base representation implies that a sentence can appear more than once in a temporalised belief base; but from the point of view of the temporalised sentences stored in the temporalised belief base there is no redundancy because each temporalised sentence has different time interval. For instance, consider Example 4, \( \alpha \) appears two times, but with different intervals. In this case, we will say that \( \alpha \) is intermittent and it means that \( \alpha \) is held from \( t_1 \) to \( t_3 \) and it is held in the instant \( t_4 \). Besides, if the intervals of a sentence are overlapped \( (\beta^{[t_5, t_6]}, \beta^{[t_6, t_8]} \) in Example 4), despite that the time interval of the sentence intuitively be only one \( ([t_5, t_8]) \), we decided to maintain all versions because will be more suitable when we will model the dynamics of the legal system.
3.2.4 Temporalised Derivation

Note that a norm can explicitly be in a temporalised belief base, $\alpha^{t_4}$, in Example 4. However, a norm can implicitly be represented in a temporal belief base if some conditions are held. For instance, in Example 4, $\beta$ is implicitly represented with $\omega^{t_3}$, $\omega^{t_3} \rightarrow \beta^{t_3}$, due to the antecedent of the rule is held in $t_4$ by the temporalised sentence $\omega^{t_3}$. Next, temporalised derivation for a sentence are defined to capture this notion. To do this, first we define a temporalised derivation in a time instant and then we give a definition of temporalised derivation in time interval. The last mentioned is based on the previous.

**Definition 8.** Temporalised derivation in a time instant. Let $\mathbb{K}$ be a set of temporalised sentences and $\alpha^{t_1}$ be a temporalised sentence. We say that $\alpha^{t_1}$ is derived from $\mathbb{K}$ (denoted $\mathbb{K} \vdash \alpha^{t_1}$) if and only if:

- $\alpha' \in \mathbb{K}$ and $t_i \in J$, or
- $(\beta^H \rightarrow \alpha^P)^\emptyset \in \mathbb{K}$ and $t_i \in P$ and $\mathbb{K} \vdash \beta^{t_j}$ for all $t_j \in H$.

**Definition 9.** Temporalised derivation in a time interval. Let $\mathbb{K}$ be a set of temporalised sentences and $\alpha^{[t_i, t_j]}$ be a temporalised sentence. We say that $\alpha^{[t_i, t_j]}$ is derived from $\mathbb{K}$ (denoted $\mathbb{K} \vdash^{t_i} \alpha^{[t_i, t_j]}$) if and only if $\mathbb{K} \vdash^{t_i} \alpha^{[t_p]}$ for all $t_p \in [t_i, t_j]$.

To compute the temporalised derivation of a sentence checking each instant of the intervals benefits us in special cases where implicit sentences need temporalised sentences with overlapped intervals as antecedents. To determine the time interval of the implicitly derived temporal sentence, the temporal consequence will be defined below.

**Definition 10.** Temporalised consequence. Let $\mathbb{K}$ be a set of temporalised sentences and $\alpha^{[t_i, t_j]}$ be a temporalised sentence. We say that $\alpha^{[t_i, t_j]}$ is a temporalised consequence of $\mathbb{K}$ ($\alpha^{[t_i, t_j]} \in Cn^I(\mathbb{K})$) if and only if $\mathbb{K} \vdash^{t_i} \alpha^{[t_i, t_j]}$.

**Example 5.** Consider again the temporalised belief base of Example 4. Then, $\mathbb{K} \vdash^{t_i} \beta^{[t_3, \infty]}$, that is, $\beta^{[t_3, \infty]} \in Cn^I(\mathbb{K})$; and $\mathbb{K} \vdash^{t_i} \alpha^{[t_i, t_4]}$, that is, $\alpha^{[t_i, t_4]} \in Cn^I(\mathbb{K})$.

Note that the underlying semantics of this type of derivation (legal system) differs from that in propositional logic when we want to represent the knowledge (31). Note that, following Definition 9, the **interval of an implicitly derived sentence** will be the interval of the consequent of the rule that derives the conclusion of the proof. For instance, suppose that $\mathbb{K} = \{\gamma^{t_3}, (\gamma^{t_3} \rightarrow \epsilon^{t_3})^{[t_3, \infty]}\}$ then the time interval of $\epsilon$ is $[t_3, \infty]$.

In this proposal, a **contradiction** arise when two complementary sentences can be derived with time intervals overlapped. For instance, suppose $\mathbb{K} = \{\alpha^{t_3}, \neg\alpha^{t_3}\}$, in this case there exist a contradiction. However, consider $\mathbb{K} = \{\alpha^{t_3}, \neg\alpha^{t_3}\}$, in this case, we will say that $\mathbb{K}$ does not have contradictions. Moreover, we will say that a temporalised belief base is **temporally consistent** if the base does not have contradictions. The temporalised belief base of Example 4 is temporally consistent.

3.3 Legal Belief Revision

A legal system should be temporally consistent, i.e., it cannot contain contradictory norms at any time. Hence, we propose a **norm prioritised revision operator** that allows to consistently add a temporalised sentence $\alpha^{[t_i, t_j]}$ to a consistent legal system $\mathbb{K}$.
This special revision operator is inspired in the rule semantics explained above in Section 3.2 (an adapted version from that proposed in (2)). Thus, following the concept of consistency proposed in Section 3.2, the revision operator may remove temporalised sentences or, in some cases, may only modify the intervals to maintain consistency.

To incorporate a norm \( \neg \beta^J \) into a legal system, it is necessary to consider all possible contradictions that may arise if the norm is added without checking for consistency. For this, it is necessary to compute all proofs of \( \beta \) considering only those temporalised sentences \( \beta^P \) whose effectiveness time is overlapped with the time interval \( J \), that is, \( J \approx P \). Note that, computing all minimal proofs of a temporal sentence considering only those which time interval is overlapped with the time interval of the input sentence, is an optimized version. Next, a set of minimal proof for a sentence will be defined.

**Definition 11.** Let \( \mathcal{K} \) be a temporalised belief base and \( \alpha^J \) a temporalised sentence. Then, \( \mathcal{H} \) is a minimal proof of \( \alpha^J \) if and only if

1. \( \mathcal{H} \subseteq \mathcal{K} \)
2. \( \alpha^P \in Cn^t(\mathcal{H}) \) with \( J \approx P \), and
3. if \( \mathcal{H}' \subset \mathcal{H} \), then \( \alpha^P \notin Cn^t(\mathcal{H}') \) with \( J \approx P \).

Given a temporalised sentence \( \alpha^J \), the function \( \Pi(\alpha^J, \mathcal{K}) \) returns the set of all the minimal proofs for \( \alpha^J \) from \( \mathcal{K} \).

**Remark 1.** Each set of \( \Pi(\alpha^J, \mathcal{K}) \) derives \( \alpha \) in at least one time instant of \( J \).

**Example 6.** Consider the temporalised belief base of Example 4. Then \( \Pi(\beta^{[t_5\ldots t_6]}, \mathcal{K}) = \{ \mathcal{H}_1, \mathcal{H}_2, \mathcal{H}_3, \mathcal{H}_4 \} \) where:

- \( \mathcal{H}_1 = \{ \alpha^{[t_1\ldots t_3]}, \alpha^{[t_4]} \} \) (\( \alpha^{[t_1\ldots t_4] \rightarrow \beta^{[t_4\ldots t_6]} [t_4\ldots t_6] \})
- \( \mathcal{H}_2 = \{ \beta^{[t_5\ldots t_6]} \} \)
- \( \mathcal{H}_3 = \{ \beta^{[t_6\ldots t_8]} \} \)
- \( \mathcal{H}_4 = \{ \alpha^{[t_5\ldots t_8]}, (\alpha^{[t_4] \rightarrow \beta^{[t_6\ldots t_6]}} [t_2\ldots t_6]) \} \)

Note that \( \mathcal{H}_1 \) is minimal due to \( \alpha \) should be derivable from \( t_1 \) to \( t_4 \) to use the rule \( (\alpha^{[t_1\ldots t_4]} \rightarrow \beta^{[t_4\ldots t_6]} [t_4\ldots t_6]) \) hence, \( \alpha^{[t_1\ldots t_4]} \) and \( \alpha^{[t_4]} \) should be in \( \mathcal{H}_1 \).

Our operator is based on a selection of sentences in the knowledge base that are relevant to derive the sentence to be retracted or modified. In order to perform a revision, following kernel contractions (37), this approach uses incision functions, which select from the minimal subsets entailing the piece of information to be revoked or modified. We adapt this notion of incision function proposed in (37) to our epistemic model. An incision function only selects sentences that can be relevant for \( \alpha \) and at least one element from each \( \Pi(\alpha^J, \mathcal{K}) \), as follows.

**Definition 12.** Incision function. Let \( \mathcal{K} \) be a temporalised belief base, an incision function \( \sigma \) for \( \mathcal{K} \) is a function such that for all \( \alpha^J \in Cn^t(\mathcal{K}) \):

- \( \sigma(\Pi(\alpha^J, \mathcal{K})) \subseteq \bigcup \{\Pi(\alpha^J, \mathcal{K})\} \)
- For each \( \mathcal{H} \in \Pi(\alpha^J, \mathcal{K}) \), \( \mathcal{H} \cap \sigma(\Pi(\alpha^J, \mathcal{K})) \neq \emptyset \).

In Hansson’s work it is not specified how the incision function selects the sentences that will be discarded of each minimal proof. In our approach, this will be solved by considering those sentences that can produce legal effects in favour of a possible contradiction with the new norm.
Thus, if the new norm is $\neg \beta^d$, then the incision function will select the temporalised sentences $\beta^p$ or $(\alpha^Q \rightarrow \beta^F)^\Pi$ of each $\Pi(\beta^j, \mathbb{K})$.

**Definition 13.** Search consequence function. $Sc: \mathbb{L} \times \mathbb{K} \rightarrow \mathbb{K}$, is a function such that for a given sentence $\alpha$ and a given temporalised base $\mathbb{K}$ with $\mathbb{H} \subseteq \mathbb{K}$,

$$Sc(\alpha, \mathbb{H}) = \{\alpha^j : \alpha^j \in \mathbb{H} \} \cup \{(\beta^p \rightarrow \alpha^Q)^R : (\beta^p \rightarrow \alpha^Q)^R \in \mathbb{H} \text{ and } \beta \in \mathbb{L}\}$$

**Definition 14.** Consequence incision function. Given a set of minimal proofs $\Pi(\alpha^j, \mathbb{K})$, $\sigma^\epsilon$ is a consequence incision function if it is an incision function for $\mathbb{K}$ such that

$$\sigma^\epsilon(\alpha^j, \mathbb{K}) = \bigcup_{H \in \Pi(\alpha^j, \mathbb{K})} Sc(\alpha, \mathbb{H})$$

**Example 7.** Consider Examples 4 and 6. Then, $Sc(\beta, \mathbb{H}_1) = \{\{\alpha^{[t_1, t_4]} \rightarrow \beta^{[t_2, t_6]}|^{[t_4, t_8]}\}$, $Sc(\beta, \mathbb{H}_2) = \{\beta^{[t_5, t_8]}\}$, $Sc(\beta, \mathbb{H}_3) = \{\beta^{[t_5, t_8]}\}$, and $Sc(\beta, \mathbb{H}_4) = \{\{\alpha^{[t_1, t_4]} \rightarrow \beta^{[t_4, t_8]}|^{[t_2, t_22]}\}$. Thus, $\sigma^\epsilon(\beta^{[t_5, t_8]}, \mathbb{K}) = \bigcup_{H \in \Pi(\beta^{[t_5, t_8]}, \mathbb{K})} Sc(\beta, \mathbb{H}) = \{\{\alpha^{[t_1, t_4]} \rightarrow \beta^{[t_4, t_8]}|^{[t_2, t_22]}\}$.

As mentioned before, the revision operator may remove temporalised sentences or, in some cases, may modify the intervals to maintain consistency. Next, a temporal projection will be defined based on a given time interval. The idea here is, given a temporalised belief base $\mathbb{K}$ and given a time interval $[t_i, t_j]$, to return a temporalised belief base $\mathbb{K}'$ containing those sentences from $\mathbb{K}$ whose time intervals be out of $[t_i, t_j]$.

**Definition 15.** Excluding temporal projection. Let $\mathbb{K}$ be a temporalised belief base and let $[t_i, t_j]_{out}$ be a time interval where $t_i, t_j \in \mathbb{T}$. A excluding temporal projection of $\mathbb{K}$ from $t_i$ to $t_j$, denoted $\mathbb{K}^{out}_{t_i, t_j}$, is a subset of $\mathbb{K}$ where for all $\alpha^{[t_p, t_q]} \in \mathbb{K}$, $\mathbb{K}^{out}_{t_i, t_j}$ will contain:

- $\alpha^{[t_p, t_q]}$ if $t_p < t_i$, $t_q \geq t_i$ and $t_q \leq t_j$.
- $\alpha^{[t_i, t_j]}$ if $t_p \geq t_i$, $t_q > t_j$ and $t_p \leq t_j$.
- $\alpha^{[t_p, t_q]}$ and $\alpha^{[t_i, t_j]}$ if $t_p < t_i$, $t_q > t_j$.
- $\alpha^{[t_i, t_j]}$ if $t_q < t_i$ or $t_p > t_j$.

**Remark 2.** Note that the case in which $t_p \geq t_i$ and $t_q \leq t_j$ the temporal sentence it is not considered. In this case, this sentence is erased.

**Example 8.** Consider Example 7 and suppose that $S$ is a temporalised belief base and $S = \sigma^\epsilon(\beta^{[t_5, t_8]}, \mathbb{K})$. Then, $S^{out}_{t_6} = \{\{\alpha^{[t_1, t_4]} \rightarrow \beta^{[t_2, t_6]}|^{[t_4, t_8]}\}, \{\alpha^{[t_1, t_4]} \rightarrow \beta^{[t_5, t_8]}|^{[t_2, t_22]}\}$. Following the notion of excluding temporal projection (Definition 15) a norm prioritized revision operator can be defined. That is, an operator that allows to consistently add temporalised sentences in a temporalised belief base. If a contradiction arises, then the revision operator may remove temporalised sentences or modify the corresponding intervals in order to maintain consistency.

**Definition 16.** Let $\mathbb{K}$ be a temporalised belief base and $\alpha^{[t_i, t_j]}$ be a temporalised sentence. The operator “ $\otimes$ ”, called prioritized revision operator, is defined as follow:

$$\mathbb{K} \otimes \alpha^{[t_i, t_j]} = (\mathbb{K} \setminus S) \cup S^{out}_{t_j} \cup \{\alpha^{[t_i, t_j]}\}$$
Example 9. Consider Example 4 and suppose that a new norm \( \neg \beta_{t_{5},t_{6}} \) it is wished to add. To do this, it is necessary to do \( \mathcal{K} \otimes \neg \beta_{t_{5},t_{6}} \). Consider Examples 6 and 7. Then, \( \mathcal{K} \otimes \neg \beta_{t_{5},t_{6}} \) = \( \{ \alpha_{[t_{1},t_{3}]}, \alpha_{[t_{4}]}, \alpha_{[t_{1},t_{4}]} \rightarrow \beta_{[t_{5}]}, \beta_{[t_{7},t_{8}]}, \beta_{[t_{10}]}, \delta_{[t_{11}]}, (\delta_{[t_{11}]}) \rightarrow \beta_{[t_{15},t_{20}]} \} \). Note that, this new temporalised base is temporally consistent.

The following example shows how our operator works in a particular situation when a legal system undergoes many changes and has rules that complement each other.

Example 10. Consider following temporalised belief base \( \mathcal{K} = \{ \beta_{[t_{1},t_{11}]}, \beta_{[t_{5},t_{6}]} \rightarrow \alpha_{[t_{1},t_{3}]} \} \). Note that, \( \mathcal{K} \vdash_{\alpha_{[t_{1},t_{10}]}} \) because \( \mathcal{K} \vdash_{\alpha_{[t_{1},t_{11}]}} \) for all \( t_{i} \in [t_{1},t_{10}] \). Suppose that it is necessary to adopt \( \neg \alpha_{[t_{1},t_{10}]} \). To do this, it is necessary to compute all the minimal proofs of \( \alpha_{[t_{1},t_{10}]} \) in \( \mathcal{K} \). In this case, \( \Pi(\alpha_{[t_{1},t_{10}]}, \mathcal{K}) = \{ \beta_{[t_{5},t_{6}]} \rightarrow \alpha_{[t_{1},t_{3}]} \} \). Then, \( S = \sigma^{c}(\alpha_{[t_{1},t_{10}]}, \mathcal{K}) = \{ \beta_{[t_{5},t_{6}]} \rightarrow \alpha_{[t_{1},t_{3}]} \} \). Thus, \( S_{t_{10}} = \emptyset \). Therefore, \( \mathcal{K} \otimes \neg \alpha_{[t_{1},t_{10}]} \) = \( \{ \beta_{[t_{5},t_{6}]} \rightarrow \alpha_{[t_{1},t_{3}]} \} \).
4 A Language for Preferences and Value Orderings

As we recalled in Deliverable D1.1 (chap. 4), goals and values play an important role in legal interpretation. Indeed, courts interpret the law and deal with penumbral cases by further developing the content of legal norms: courts act in such a way as to expand or restrict the core of determinate meaning of norms taking into account their goals/purposes and values (38, chap. 7).

More generally, Task 1.2 of WP1 requires to develop standards and languages for modelling values (besides norms and policies).

This first year of research focused on developing general formal methods for modelling several aspects legal knowledge and reasoning. We worked in particular on

- **Legal compliance**—Possible-world semantics for the deontic operator $\otimes$ (39; 40): this contribution was significant for future research on Task 1.3 (WP1) and we also expected that we can offer a theoretical achievement for partners working on Task 3.2 (WP3).

We show here that the work on $\otimes$ can be employed with some adjustment for representing, and reasoning about, values and preferences.

A full discussion is given in (41).

4.1 Introduction

Preliminarily to any useful contribution in this area we need to develop suitable formalisms and reasoning methods to represent and handle agents’ preferences. In the current literature, we can find several approaches to the representation of value and preferences, among which the most remarkable in computational social choice theory are perhaps the following (42):

- conditional preference networks, or CP-nets (43);
- prioritised goals (44; 45).

The second approach uses logical formalisms to describe the goals of the agents whose preferences are modelled as propositional formulae. This allows for a manageable and purely qualitative representation of preferences. Very recently, a new proposal in this perspective has been advanced (46), which presents a modal logic where a binary operator is meant to syntactically express preference orderings between formulae: Each formula of this logic determines a preference ordering over alternatives based on the priorities over properties that the formula express. Accordingly, such types of formalisms are in fact capable of representing not just orderings over alternatives but the reasons that lead to the preferences (47). The formalism is then interestingly used in (46) to originally treat the problem of collective choice in MAS as aggregation of logical formulae. The logic in (46) is clearly inspired by the work in (48), which in turn has a number of similarities with a system that was independently developed in (49) and where a Gentzen system was proposed in a different but related area—deontic logic—to reason about orderings on obligations. The idea that reasoning about preferences is crucial in deontic logic was introduced in semantic settings long time ago (50). However, (49) is based on the syntactic introduction of the new non-classical operator $\otimes$: The reading of an expression like $a \otimes b \otimes c$ is that $a$ is the primary obligation, but if
this obligation is violated, the secondary obligation is \( b \), and, if the secondary (contrary-to-duty) obligation \( b \) is violated as well, then \( c \) is obligatory. These constructions can be used as well to reason about preferences. Thus, following the approach in (49), an expression like

\[
\text{Resident} \rightarrow \neg \text{Pay\_Taxes} \otimes \neg \text{Pay\_Interest} \otimes \text{Pay\_Minimum}
\]  

(4.1.1)

can be intuitively viewed as a conditional preference statement meaning the following:

1. if I’m resident in Italy, i.e., if Resident is the case, then not paying taxes is my actual preference, but,
2. if it happens that I pay taxes, then my actual preference is rather not to pay any interest, but
3. if I pay any interest, then my actual preference is pay a minimum.

The advantage of this formalism is that we can offer a compact representation of reasons explaining preferences, and thus we can also develop intuitive logical tools for reasoning about individual choices. As it has been recently recalled by (46) in the context choice theory, modal logics are a natural way of modelling reason-based preferences. Indeed, preferences among propositional formulae correspond semantically to ideality or orderings on possible worlds. Very recently, we have devised a new semantics for \( \otimes \) deontic logics, which extends neighbourhood models with sequences of truth sets (40; 51). In this paper we extend our previous work and offer new results for a novel preference logic. More precisely, we addressed in our research the following research questions:

- **What is the minimal axiomatisation for modelling reason-based preferences using \( \otimes \)?** We will see that the minimal system \( E \otimes \) just extends classical modal systems (22) even though some additional schemata can be proposed to grasp reasonable properties of preferences.

- **How to semantically characterise the idea of reason-based preference?** We will argue that the intuition of (40; 51) can be applied to preference logic: the idea is that an expression like \( a \otimes b \) is semantically reflected in the sequence \( \langle \|a\|_V, \|b\|_V \rangle \) of truth sets. Specific soundness and completeness results will be proved for preference logics.

- **How to relate the formalism with well-known properties of preferences studied in rational choice theory?** We will discuss how to express two basic social choice principles (contraction and expansion) in the \( \otimes \)-logic.

### 4.2 Language

In Deliverable D1.1 (chap. 5, sec. 5.1.1) a language for \( \otimes \) was presented with the purpose of modelling deontic reasoning and compliance (39; 40). Here we adapt the language for representing preferences.

The language consists of a countable set of atomic formulae. Well-formed-formulae are then defined using the usual Boolean connectives and the \( n \)-ary connective \( \otimes \), which is intended to syntactically formalise a preference ordering among reasons. The language also includes the modal operator \( \text{Pr} \) denoting the actual preferred reason or state of affairs: in other words, \( \text{Pr} p \) means that \( p \) is actually preferred.

The interpretation of an expression \( a \otimes b \) is that \( a \) is the most preferred reason or state of affairs, but, if \( a \) is not the case then \( b \) is preferred.
Let \( \mathcal{L} \) be a language consisting of a countable set of propositional letters \( \text{Prop} = \{ p_1, p_2, \ldots \} \), the propositional constant \( \perp \), round brackets, the Boolean connective \( \rightarrow \), the unary operator \( \text{Pr} \), and a set of \( n \)-ary operators \( \otimes^n \) for \( n \in \mathbb{N}, n > 0 \). We will refer to the \( \otimes^n \) operators and \( \text{Pr} \) as preference operators.

The main motivation for having a family of \( \otimes^n \) operators instead of a single binary operator plus commutativity, i.e., \( a \otimes (b \otimes c) \equiv (a \otimes b) \otimes c \), is to prevent nested preference expressions. With this option one would conflate preferences and “meta-preferences” in the same reading, and it will establish preferences over formulae representing concepts of different types, e.g., \( (a \otimes b) \) and \( c \).

Furthermore, as we have alluded to above, given the expression (or as we will call it \( \otimes \)-chain) \( A \otimes c \) we form the preference \( c \), if \( A \) does not hold. But, if \( A = (a \otimes b) \), what does it mean that it does not hold. Is it that \( a \) is not preferred to \( b \) or there is no preference between \( a \) and \( b \), or \( a \) is preferred to \( \neg b \). While there are no particular technical problems to adapt the development to a binary operator, we refrain to do that until we have a clear conceptual reading of nested \( \otimes \)-chain expressions.

**Definition 17 (Well Formed Formulae).** Well formed formulae (wffs) are defined as follows:

- Any propositional letter \( p \in \text{Prop} \) and \( \perp \) are wffs;
- If \( a \) and \( b \) are wffs, then \( a \rightarrow b \) is a wff;
- If \( a \) is a wff and no preference operator occurs in \( a \), then \( \text{Pr}a \) is a wff;
- If \( a_1, \ldots, a_n \) are wffs and no preference operator occurs in any of the \( a_i \), \( 1 \leq i \leq n \), then \( a_1 \otimes^n \cdots \otimes^n a_n \) is a wff, where \( 1 \leq n \);
- Nothing else is a wff.

We use \( \text{WFF} \) to denote the set of well formed formulae.

Other Boolean operators are defined in the standard way, in particular \( \neg a =_{\text{def}} a \rightarrow \perp \) and \( \top =_{\text{def}} \perp \rightarrow \perp \).

We say that any formula \( a_1 \otimes^n \cdots \otimes^n a_n \) is an \( \otimes \)-chain of length \( n \); also the negation of an \( \otimes \)-chain is an \( \otimes \)-chain. The formation rules allow us to have \( \otimes \)-chain of any (finite) length, and the arity of the operator is equal to number of elements in the chain; accordingly, we drop the index \( m \) from \( \otimes^m \). Moreover, we will often use the prefix notation \( \bigotimes_{i=0}^n a_i \) for \( a_1 \otimes \cdots \otimes a_n \); however, since the arity of the operator can be deduced by the number of arguments, we shall henceforth drop the index. In addition we use the following notation: \( \bigotimes_{i=j}^n a_i \otimes b \otimes \bigotimes_{k=l}^m c_k \), where \( j, l \in \{0, 1\} \). The “\( a \)” part and “\( c \)” part are optional, i.e., they are empty when \( i = 0 \) or \( k = 0 \), respectively. Otherwise the expression stands for the following chain of \( n + 1 + m \) elements: \( a_1 \otimes \cdots \otimes a_n \otimes b \otimes c_1 \otimes \cdots \otimes c_m \).

### 4.3 Axioms

In this section we are going to examine which basic axioms can be chosen for a logic intended to model ordered preferences. We assume that any such logic is based on a suitable axiomatisation of classical propositional logic.

---

\(^1\)We will use the prefix form \( \otimes^1 a \) for the case of \( n = 1 \).
4.3.1 Minimal System $E^\otimes$

The first axiom we consider is the following:

$$\bigotimes_{i=1}^{n} a_i \equiv \left( \bigotimes_{i=1}^{k-1} a_i \right) \otimes \left( \bigotimes_{i=k+1}^{n} a_i \right)$$  (where $a_j \equiv a_k$, for some $j < k$)  \hspace{1cm} (\otimes\text{-shortening})

This axiom allows us to remove (introduce) duplicate formulae (or equivalent formulae) from the left. Thus, given the $\otimes$-chain

$$a \otimes b \otimes a \otimes c$$  \hspace{1cm} (4.3.1)

we can derive the equivalent formula

$$a \otimes b \otimes c$$  \hspace{1cm} (4.3.2)

The intuition is as follows: As we have seen in Section 4.1 the meaning of $\otimes$-chain in (4.3.1) is that $a$ is the most preferred option, but if that is not possible, then the formula following it, in this case $b$, is the next preferred option, and so on. Specifically, if $b$ does not hold, then $a$ is the new preferred option, but we already know that $a$ does not hold, and then we can move to the successive option, i.e., $c$. Intuitively, if I prefer not to get any damage, but if this happens I prefer to be compensated, and, if the damage is not compensated, then I prefer not to get any damage, this just means that my primary preference is not to get any damage and my secondary preference is to be compensated.

Notice that Axiom $\otimes$-shortening gives us a method to define a normal form for preferences: Given any $\otimes$-chain expression, we can create the shortest $\otimes$-chain where all the elements in it are disjoint. We are going to use this property for the development of the semantics for the logic of $\otimes$-chains.

The next axiom allows us to derive actual preferences (i.e., formulae in the scope of the modal preference operator $\Pr$ from $\otimes$-chains). Thus it provides a form of detachment for deriving actual preferences from $\otimes$-chains, i.e., those preferences that hold in a given context. They reflect the intuitive reading of the $\otimes$ operator. Indeed, if $a \otimes b$, the primary preference should hold, and, if $a$ is factually false ($\neg a$), then $b$ must be preferred, i.e., $\Pr b$:

$$\left( \left( \bigotimes_{i=0}^{n} b_i \right) \otimes c \otimes \left( \bigotimes_{j=0}^{m} d_j \right) \right) \wedge \left( \bigwedge_{i=0}^{n} \neg b_i \right) \rightarrow \Pr c$$  \hspace{1cm} (Pr-detachment)

Notice that when the initial optional prefix is absent, Axiom Pr-detachment can be rewritten as

$$\bigotimes_{i=1}^{n} a_i \rightarrow \Pr a_1$$  \hspace{1cm} (Pr-detachment-1)

Thus, the first element of an $\otimes$-chain is one of our actual preferences.

Let us illustrate how the axiom works with the help on an example. Consider the formula (4.1.1) where I reside in Italy and I have paid my taxes. This means that Resident holds, from which, by modus ponens, we obtain

$$\neg \text{Pay\_Taxes} \otimes \neg \text{Pay\_Interest} \otimes \text{Pay\_Minimum}$$

\footnote{Please, remember the convention that if the subscript starts with 0, then that part of the sequence is optional.}
and then by Pr-detachment (or Pr-detachment-1) we can conclude Pr¬Pay_Taxes. If I am a good citizen, and I pay my taxes (against my preference), i.e., Pay_Taxes holds, then Pr-detachment allows me to infer the not paying interest is now one of my preferences, that is we derive Pr¬Pay_Interest. Finally, the minimal system $E^\otimes$ is equipped with the following two inference rules, that permit replacement of equivalent formulae in the context of $\otimes$ and Pr.

$$\wedge_{i=1}^{n} (a_i \equiv b_i) \quad (\otimes\text{-RE})$$

$$a \equiv b \quad \frac{Pr a \equiv Pr b}{Pr a \equiv Pr b}$$

### 4.3.2 Additional Axioms

The minimal logic does not allow us to determine whether the preferences of an agent are consistent, and it does not provide mechanisms to derive (new) preferences from existing ones. In this section we present some additional axioms establishing consistency principles for preferences, and a mechanism to generate new preferences from existing ones. These axioms can be used to extend the minimal logic $E^\otimes$. In Section 4.5 we are going to examine what axioms are needed to represent some social choice principles.

We begin with an axiom ($\otimes$-I) that allows us to derive new preference orderings by combining existing preference orderings (thus it corresponds to a peculiar introduction rule for $\otimes$).

$$\left(\left(\bigotimes_{k=0}^{p} a_k \otimes \bigotimes_{i=1}^{n} b_i \otimes \bigotimes_{l=0}^{q} c_l\right) \wedge \left(\bigotimes_{i=1}^{n} \neg b_i \rightarrow \bigotimes_{j=1}^{m} d_j\right)\right) \rightarrow \bigotimes_{k=0}^{p} a_k \otimes \bigotimes_{i=1}^{n} b_i \otimes \bigotimes_{j=1}^{m} d_j \quad (\otimes\text{-I})$$

Let us illustrate ($\otimes$-I) by considering a simple instance of it as applied to a concrete example:

$$\neg Pay_Taxes \otimes \neg Pay_Interest \quad (4.3.3)$$

$$Pay_Taxes \wedge Pay_Interest \rightarrow \otimes^1 Pay_Minimum \quad (4.3.4)$$

The formula in (4.3.3) states that my primary preference is not to pay taxes, but if this happens then my preference is not pay any interest (for example, by paying them in due time without delay). The expression in (4.3.4) specifies that, if I pay taxes and pay with interest (e.g., because I was late), then my preference is to pay the minimum amount. Hence, ($\otimes$-I) states that there is a chain of preferences dealing iteratively with the fact that my primary preference (not to pay any taxes) is not satisfied.

The next two axioms can be used to guarantee that preferences are consistent.

$$Pr a \rightarrow \neg Pr \neg a \quad (Pr\text{-D})$$

Axiom Pr-D is the standard D axiom of modal logic (22) and it represents the principle of internal consistency of actual preferences. Thus, when the axiom is assumed, it is not possible to have that an agent prefers at the same time $a$ and its opposite $\neg a$. “External consistency” of preferences is
Clearly, given that we use classical propositional logic as the underlying logic, it is not possible that an $\otimes$-chain and its negation hold at the same time. However, without axiom $\otimes \bot$, it is possible to have that $\otimes$-chains like $a \otimes b \otimes c$ and $\neg(a \otimes b)$ hold. The first $\otimes$-chain states that $a$ is preferred, the second best preference is $b$, and the third best preferred one is $c$. But $\neg(a \otimes b)$ assert that $b$ is not the second best preference with respect to $a$. This case is subsumed by $a \otimes b \otimes c$, thus $a \otimes b \otimes c$ and $\neg(a \otimes b)$ (or $\neg \otimes^1 a$) should result in a contradiction. Thus axiom $\otimes \bot$ ensures this effect by establishing that if an agent subscribes to a particular preference ordering, then the agent subscribes to (derives) all the initial (starting from the leftmost element) sub-orderings (sub-chains) of an existing $\otimes$-chain. For example, if

$$\neg \text{Pay}_\text{Taxes} \otimes \neg \text{Pay}_\text{Interest} \otimes \text{Pay}_\text{Minimum}$$

holds, then we can conclude that the following hold, too:

$$\neg \text{Pay}_\text{Taxes} \otimes \neg \text{Pay}_\text{Interest} \otimes \text{Pay}_\text{Minimum}$$

or $\neg \otimes^1 \text{Pay}_\text{Taxes}$.

### 4.4 Sequence Semantics and Results

In Deliverable D1.1 (chap. 5, sec. 5.1.2) a sequence semantics for $\otimes$ was presented (39; 40). A few changes should be made for representing preferences. We omit the details and entirely refer to (41). Some results should be mentioned here, however.

**Lemma 1.** $\otimes$-RE, Pr-RE, $\otimes$-contraction, Pr-detachment are valid in the class of all sequence frames.

**Definition 18** (Extended Frames). A sequence frame is extended when the following holds. For any world $w$ if there is a sequence $\langle A_0, \ldots, A_i, B_1, \ldots, B_k, C_0, \ldots, C_j \rangle \in C_w$ such that $w \not\in B_l$ for $1 \leq l \leq k$ implies $\langle D_1, \ldots, D_m \rangle \in C_w$, then $\langle A_0, \ldots, A_i, B_1, \ldots, B_k, D_1, \ldots, D_m \rangle \in C_w$.

**Definition 19** (Serial Frames). A sequence frame is serial if the following holds. Given any world $w$, if $\langle A_0, \ldots, A_i, C_1, \ldots, C_k \rangle \in C_w$ and $w \not\in A_l$ for $0 \leq l \leq i$, then for any sequence $\langle D_0, \ldots, D_m \rangle$ such that for $0 \leq l \leq m$, $w \not\in D_l$, it holds that $\langle D_0, \ldots, D_m, W - C_1 \rangle \notin C_w$.

**Definition 20** ($\otimes$-Serial Frames). A sequence frame is $\otimes$-serial iff for any world $w$, if $\langle A_1, \ldots, A_n \rangle \in C_w$ and $n \geq 2$, then $\langle A_1, \ldots, A_{n-1} \rangle \in C_w$.

**Lemma 2.**

1. Schema $(\otimes$I) is valid in the class of extended frames.
2. Schema $(\text{Pr-D})$, is valid in the class of serial frames.
3. Schema $(\otimes \bot)$ is valid in the class of $\otimes$-serial frames.

**Corollary 1.** The system $E^\otimes$ is sound and complete with respect to the class of sequence frames.
Theorem 1. 

1. The system $E\otimes(\otimes-I)$ is sound and complete w.r.t. the class of extended frames.

2. The system $E\otimes(\otimes-D)$ is sound and complete w.r.t. the class of serial frames.

3. The system $E\otimes(\otimes-\bot)$ is sound and complete w.r.t. the class of $\otimes$-serial frames.

Corollary 2. The system $E\otimes(\otimes-I) \oplus (\Pr-D) \oplus (\otimes-\bot)$ is sound and complete w.r.t. the class of extended, serial, and $\otimes$-serial frames.

4.5 Choice Consistency: Contraction and Expansion

It is almost standard in social choice theory to assume two rationality conditions of choice (which are related with the fact that a choice function is rationalisable) (52): contraction consistency and expansion consistency. The former one “is concerned with keeping a chosen alternative choosable as the set is expanded by adding alternatives dominated [...] in other choices”, while the latter one “is concerned with keeping a chosen alternative choosable as the set is contracted by dropping other alternatives” (53, page 65). More precisely, contraction consistency states that if an agent chooses some alternative from a set $S$ of alternatives and such alternative remains available in a subset $S'$ of $S$, then the agent chooses it from $S'$. Expansion consistency somehow works in the opposite direction and requires that, given two sets $S$ and $S'$ of alternatives such that $S \subseteq S'$, for all pairs of alternatives in $S$, if one agent chooses two alternatives from $S$, then the agent still chooses both of them from $S'$, or does not choose any of them (52). Although it has been argued that in order to avoid Arrow’s impossibility one possibility, among others, is precisely to relax one of the aforementioned principles (52; 42), these two principles are usually taken as basic standards of rationality in choice theory.

We believe that there are at least two possible ways to interpret the above social choice principles in our framework. The first option is to consider the sets of options $S$ and $S'$ as description of the situations. In such case contraction consistency can be represented by the classical concatenation:

$$
a \rightarrow b \quad b \rightarrow \bigotimes_{i=1}^{n} c_i
$$

$$
a \rightarrow \bigotimes_{i=1}^{n} c_i
$$

The basic idea is that $b$ is a set of conditions under which the preferences expressed by the $\otimes$-chain $\bigotimes_{i=1}^{n} c_i$ can be formed, and $a \rightarrow b$ means that in every state where $a$ holds $b$ holds as well. Thus, by monotonicity and transitivity of classical propositional logic, we can infer that we can form the preference $\bigotimes_{i=1}^{n} c_i$ given $a$.

Similarly, expansion consistency can be modelled in classical propositional logic as

$$
a \rightarrow \bigotimes_{i=1}^{n} b_i \quad c \rightarrow \bigotimes_{i=1}^{n} b_i
$$

$$
((a \lor d) \rightarrow \bigotimes_{i=1}^{n} b_i) \equiv ((c \lor d) \rightarrow \bigotimes_{i=1}^{n} b_i)
$$

Here, pairs of alternatives (more generally, pairs of sets of alternatives) are selected by assuming the truth of $a$ and $c$ and we state that a certain choice from $\bigotimes_{i=1}^{n} b_i$ is considered in both alternatives. Now, if pick up larger sets (determined by disjunctively adding any arbitrary propositional formula $d$), then either the same choice is preserved, or it is abandoned in both alternatives.

The second alternative, that we are going to examine in details in the remainder of the current section,
is to provide a modal characterisation of the two principles, similarly to what was proposed in the framework of (46), where a simple semantic formulation is advanced, but no syntactic formalisation is given. Our logic can satisfy both conditions under some additional frame conditions, and a simple formalisation is possible.

4.5.1 Contraction

Let us begin by considering contraction, which is exemplified as follows.

Example 11. Let $G = \{Erica, Serena\}$ be the group of girls in a class $T = G \cup B$ consisting of boys and girls, where $B = \{Guido, Nino\}$. If I prefer Serena (it is for me the best element) as the fastest runner over 100m in the whole class, then I prefer Serena as also the fastest runner in $G$.

Within our formalism, choices are ordered via the $\otimes$ operator, while a simple way to select arbitrary sets of alternatives is done by arbitrarily considering propositional formulae. Hence, if we consider Example 11, contraction can be easily represented as follows:

$$
\text{SerenaFastest-T} \rightarrow \text{SerenaFastest-G}
$$

$$(\text{SerenaFastest-T} \otimes \text{EricaFastest-T}) \rightarrow (\text{SerenaFastest-G} \otimes \text{EricaFastest-T})
$$

(4.5.1) Contraction is clearly a generalisation of RM, i.e., the closure of $\otimes$ under logical implication:

$$
\bigwedge_{i=1}^{n} (a_i \rightarrow b_i) \\
(\otimes_{i=1}^{m} a_i) \rightarrow (\otimes_{i=1}^{m} b_i)
$$

(\otimes\text{-RM/}\otimes\text{-expansion})

This inference rule is not valid in general in sequence semantics, but rather in a subclass defined by the following property.

Definition 21. Let $F = \langle W, C \rangle$ be a sequence frame. We say that $F$ is $\otimes$-supplemented iff, for any $w \in W$, if $\langle Y_1 \cap Z_1, \ldots, Y_m \cap Z_m \rangle \in C_w$, then $\langle Y_1, \ldots, Y_m \rangle \in C_w$ and $\langle Z_1, \ldots, Z_m \rangle \in C_w$.

This frame property validates schema $\otimes\text{-M}$ below, which is the generalisation of the standard axiom schema $M$ (22):

$$
\left( \bigotimes_{k=1}^{m} (b_k \land c_k) \right) \rightarrow \left( \left( \bigotimes_{k=1}^{m} b_k \right) \land \left( \bigotimes_{k=1}^{m} c_k \right) \right)
$$

(\otimes\text{-M})

Lemma 3. ($\otimes\text{-M}$) is valid in the class of $\otimes$-supplemented sequence frames.

Notice that $\otimes$-supplementation is canonical, thus completeness is ensured accordingly.

Theorem 2 (Completeness of EM$^\otimes$). EM$^\otimes$ is complete with respect to the class of sequence frames that are $\otimes$-supplemented.

The following result shows that the logic EM$^\otimes$ equals to E$^\otimes$ plus the rule $\otimes$-RM, thus $\otimes$-supplementation characterises $\otimes$-RM/contraction.

Lemma 4. The logic EM$^\otimes$ equals the logic E$^\otimes$ plus the rule $\otimes$-RM.

3Indeed, let us state that SerenaFastest-T $=_{def}$ SerenaFastest-B $\land$ SerenaFastest-G.
4.5.2 Expansion

The formulation of expansion is also quite intuitive. Consider the following example.

Example 12. Let $G = \{Erica, Serena, Anna\}$ be the group of girls in a class $T = G \cup B$ consisting of boys and girls and where $B = \{Guido\}$. If I prefer Erica and Serena (they are for me the best elements) as the fastest runners in the 100m (as part of $G$), then Erica and Serena are the best elements as they are among the fastest runners in the whole class, or none of them is among the fastest ones.

Pairs of alternatives (more generally, pairs of sets of alternatives) can be selected by assuming the truth of pairs of formulae in $\otimes$-chains. Now, if we pick up larger sets (which are determined by disjunctively adding any arbitrary propositional formula), then either the same choice is preserved, or it is abandoned in both alternatives. Formally, we can represent the example as follows:

\[
(Serena\text{Fastest}-G \otimes Anna\text{Fastest}-G) \land (Erica\text{Fastest}-G \otimes Anna\text{Fastest}-G) \rightarrow
\]
\[
((Serena\text{Fastest}-G \lor Serena\text{Fastest}-B) \otimes Anna\text{Fastest}-G) \equiv
\]
\[
(((Erica\text{Fastest}-G \lor Erica\text{Fastest}-B) \otimes Anna\text{Fastest}-G))
\]

Accordingly, expansion can be in general captured by the following axiom schema:

\[
\left( \bigotimes_{i=0}^{m} a_i \otimes a \bigotimes_{j=0}^{n} d_j \land \bigotimes_{i=0}^{m} a_i \otimes b \bigotimes_{j=0}^{n} d_j \right) \rightarrow
\]
\[
\left( \bigotimes_{i=0}^{m} a_i \otimes (a \lor c) \bigotimes_{j=0}^{n} d_j \right) \equiv
\]
\[
\left( \bigotimes_{i=0}^{m} a_i \otimes (b \lor c) \bigotimes_{j=0}^{n} d_j \right)
\]

(\otimes\text{-expansion})

Expansion is characterised by the following frame property.

Definition 22. Let $\mathcal{F} = \langle W, C \rangle$ be a sequence frame. We say that $\mathcal{F}$ is $\otimes$-expanded iff, for any $w \in W$, if $\langle X_0, \ldots, X_m, Y, Z_0, \ldots, Z_n \rangle \in C_w$ and $\langle X_0, \ldots, X_m, Y, Z_0, \ldots, Z_n \rangle \in C_w$, then $\langle X_0, \ldots, X_m, Y \cup P, Z_0, \ldots, Z_n \rangle \in C_w$ iff $\langle X_0, \ldots, X_m, W \cup P, Z_0, \ldots, Z_n \rangle \in C_w$.

Lemma 5. ($\otimes$-expansion) is valid in the class of $\otimes$-expanded sequence frames.

Notice that $\otimes$-expansion is canonical, thus completeness is guaranteed.

Theorem 3 (Completeness of $E^\otimes$ plus $\otimes$-expansion). $E^\otimes$ plus $\otimes$-expansion is complete with respect to the class of sequence frames that are $\otimes$-expanded.

4.6 Conclusions and Research Challenges

The language and logic presented in this chapter offer a powerful qualitative framework to reason about preference orderings (among values). Thus, we expect that they can be extensively employed in standard languages for representing legal knowledge. However, to contribution so far has been mainly abstract and theoretical. The following research challenges are still open for MIREL:
Research Challenge 3 (The language of $\otimes$ for values and preferences in law). Show with examples and cases that the logic for $\otimes$ is suitable for capturing significant aspects reasoning about values and preferences in the legal domain.

Research Challenge 4 (Integration of $\otimes$ in other MIREL frameworks). Integrate the logic of $\otimes$ for preferences and values in other MIREL contexts, such as in the frameworks for modelling legal interpretation (see Deliverable D1.1., chap. 4; see, in this deliverable, chap. 5).
5 Logics for Legal Interpretation

The first year of research focused on developing general formal methods for modelling aspects legal interpretation. In particular, we considered:

- **Qualitative Methods: Normative Goals and Interpretation as Semantic Revision (D1.1, chap. 4, sec. 4.1.1)**—The framework has shown that legal concepts can be holistically and inferentially characterised by arbitrarily large and connected theories of semantic rules, and so, when we expand or restrict the scope of legal concepts we are doing nothing but revising or contracting those theories.

- **Quantitative Methods: Normative Goals and Interpretation as Fuzzy Reasoning (D1.1, chap. 4, sec. 4.1.2)**—The system modelled the interpretation of open-textured norms by taking graded categories into account and by working on the goals associated with norms.

For this second year, we have further developed these ideas and worked on:

- **As for Qualitative Methods**—an argumentative framework for meaning negotiation, which is devised taking into account the role of goals and the operation of meaning contraction and expansion of theories: a full discussion is in (54);

- **As for Quantitative Methods**—a generalisation of the framework that was recalled in D1.1: a full discussion is in (55; 56).

5.1 Meaning Negotiation in the Law

5.1.1 Introduction

Meaning negotiation is a process in which the object of negotiation is the meaning of a set of terms (57, p. 3). When this happens in the law, the object of negotiation is typically the meaning of terms occurring in one or more legal provisions relevant for the parties involved in a dispute: the parties in the interaction may typically have a common interest in achieving at least a partial agreement in regard to the interpretation of a given legal provision, although they also have conflict of interests in other respects. Parties can thus make an attempt to converge into a legal solution, which requires to agree on the same legal definitions. Negotiating the meaning of a set of legal terms basically means to propose definitions and to accept and/or to reject them. This may require parties to revise their own concepts or those that have been anyway adopted in previous steps of the process.

We examine some types of disagreements, which concern the coherence of the interpretation of terms occurring in legal provisions when the goals assigned to such provisions are considered.

In earlier work (9; 10), we developed modal extensions of Modal Defeasible Logic (58) and we conceptually used the well-known distinction of constitutive (or counts-as) and regulative norms. The idea, recalled in Deliverable D1.1, was that interpreting norms may require to revise theories of constitutive rules that characterise the concepts occurring in legal rules. This revision is goal driven: the goals of legal norms and the terms occurring in them must be aligned in order to ensure that the application of norms in fact promote those goals. The revision is based on the idea that legal
concepts can be inferentially characterised by arbitrarily large and connected theories of constitutive rules, and so, when we broaden or narrow the scope of legal concepts we are doing nothing but changing (revising or contracting) those theories. The advantages of this approach are thus that it allows us to make these interpretive arguments more transparent and to show interesting connections with techniques from the domain of revision theory.

We confine our attention to two types of revision: the case when the applicability scope of any legal rule is restricted (contraction) or broadened (expansion) and the negotiation mechanism focuses on such restrictions or broadening.

5.1.2 Meaning Negotiations and Arguments to the Best Theory

Let us informally recall some ideas and concepts from (9; 10; 7), which were reframed in Deliverable D1.1 and which have been recently used in the context of meaning negotiation: a full treatment is offered in (54).

Definition 23 (Extended Normative Theory; informal). An extended normative theory \( \mathcal{A} \) is a structure \( \langle (F, R^c, R^{Obl}, R^{Goal} \rightarrow >), G, G, > \rangle \), where

- \( F \) is a finite set of facts;
- \( R^c \) is a finite set of constitutive norms,
- \( R^{Obl} \) is a finite set of regulative norms,
- \( R^{Goal} \) is a finite set of rules for reasoning about legal goals,
- \( > \) is superiority relation for resolving conflicts between norms and rules,
- \( G \) is a set of goals;
- \( G \) is a function assigning a goal to each regulative norm;
- \( > \) is a partial order over \( G \) defining the relative importance of the rule goals.

Some further concepts and notations (mostly standard in Modal Defeasible Logic):

- For \( X \in \{c, Obl, Goal\} \), strict rules have the form \( \phi_1, \ldots, \phi_n \rightarrow_X \psi \). Defeasible rules have the form \( \phi_1, \ldots, \phi_n \Rightarrow_X \psi \). A rule of the form \( \phi_1, \ldots, \phi_n \Rightarrow_X \psi \) is a defeater. Accordingly, the mode denoted by \( X \) determines the type of conclusion one can obtain, and the three types of rules establish the strength of the relationship. Strict rules provide the most stronger connection between a set of premises and their conclusion: whenever the premises are deemed as indisputable so is the conclusion; then we have defeasible rules: a defeasible rule, given the premises, allows us to derive the conclusion unless there is evidence for its contrary; finally we have defeaters. A defeater suggests that there is a connection between its premises and the conclusion, but this connection is not strong enough to warrant the conclusion on its own; on the other hand a defeater shows that there is some evidence for the conclusion, thus it can be used to defeat rules for the opposite conclusion.

- Given a rule \( r \), \( A(r) \) is the set of antecedents of \( r \), while \( C(r) \) denotes its conclusion.

- If \( X \in \{c, Obl, Goal\} \), given an extended normative theory \( \mathcal{A} \), \( +\Delta^X q \) means that literal \( q \) is provable in \( D \) with the mode \( X \) using only facts and strict rules, \( -\Delta^X q \) means that it has been proved in \( \mathcal{A} \) that \( q \) is not definitely provable in \( \mathcal{A} \) with the mode \( X \), \( +\partial^X q \) means that \( q \) is defeasibly provable in \( \mathcal{A} \) with the mode \( X \), and \( -\partial^X q \) means that it has been proved in
that \( q \) is not defeasibly provable in \( D \) with the mode \( X \). If a literal \( q \) is provable in the extended normative theory \( \mathcal{A} \), then there is an argument for \( q \) in this theory.

- An extended normative theory demotes the goal \( g \) iff
  - there is no successful (i.e., justified) argument for \( \text{Goal} \neg g \) if \( F = \emptyset \);
  - there is at least one successful argument for \( \text{Goal} \neg g \) if \( H \subseteq F \).

- An extended normative theory promotes the goal \( g \) iff
  - there is no successful argument for \( \text{Goal} g \) if \( F = \emptyset \);
  - there is at least one successful argument for \( \text{Goal} g \) if \( F \).

- The contraction and expansions of the applicability conditions of \( r \), in the extended normative theory \( \mathcal{A} \), are revision operations over \( \mathcal{A} \) that are respectively denoted by \( \mathbb{R}^{-} (\mathcal{A}) \) and \( \mathbb{R}^{+} (\mathcal{A}) \) (see, for the details, (54)).

From such theories we can thus build arguments supporting the operations of contraction and expansion for applicability of regulative norms, i.e., arguments for the applicability (typically, expansion) or against the applicability (typically, contraction) of a given regulative norm \( r \): the idea was already presented in D1.1. One important result to be considered is the following:

**Proposition 1.** The operations of contraction and expansion may lead to more than one outcome.

This fact raises the question of how to choose among different theory revisions (see Deliverable D1.1, chap. 4, sec. 4.1.1). This problem can take the form of a dialectical process where an exchange of arguments and counter-arguments are meant to establish which is the best theory supporting or excluding the contraction of the applicability conditions of a given legal rule (59).

In general, some criteria can be proposed, such as inclusiveness, simplicity, minimal change, and theory connectedness (7). Let us just consider two of them.

**Minimal change** In (9; 10; 7) we argued that some AGM criteria of minimal change can be re-framed in our logic setting. Here, minimal change still amounts to minimising the changes of the theory extension. However, since the contraction is made by adding defeaters and by removing rules, one may state that the minimal change should be rather obtained by keeping the set of rules as close as possible to the original one. This idea is well-known in revision theory but is overlooked in defeasible argumentation. Notice that the second option (minimal rule change) is independent of the facts of the normative theory, whereas the other (minimal extension change) is context-dependent, since different facts may fire different rules. Obviously, these two options do not always lead to the same results: suppose the facts includes \( a \) and consider

\[
R^{c} = \{ r : a \Rightarrow b, \ s : b \Rightarrow e, \ t : b \Rightarrow d, \ z : b \Rightarrow e \}
\]

If we want to block \( e \) (we want to restrict the interpretation of a concept), we have two options: add either two defeaters to override respectively \( s \) and \( z \), or only one defeater that overrides \( r \). The first option is better in terms of minimising the change of conclusions (we only drop \( e \)), while the second one is better, as only one defeater is added (but two conclusions are dropped: \( b \) and \( e \)).

**Theory connectedness** This can be roughly measured by the number of links (based on sharing common literals) that connect each concept with the others. Intuitively, this is a desirable property, since it reflects the systematic character of legal systems. Consider, for instance, the
following two sets of rules:

\[ R^c = \{ r_1 : \text{Embryo} \rightarrow_c \text{Alive}, r_2 : \text{Alive} \text{, Kill} \rightarrow_c \text{Homicide}, r_3 : \text{Person} \rightarrow_c \text{Alive} \} \]

\[ R^{\text{Obl}} = \{ r_4 : \text{Homicide} \Rightarrow_{\text{Obl}} \text{Punished} \} \]

What we can do is to remove constitutive norms. Suppose we want to prevent the situation where one is punished because she “killed” an embryo. We have two options here: either (a) remove \( r_1 \) or (b) remove \( r_2 \). Option (b) is less satisfactory in this specific example: the impact on the theory is greater, as rule 2 is more connected to the other rules than \( r_1 \).

We could just notice that an argumentation framework for norm applicability can be based on the following intuitions. Let us assume to work using theory connectedness as the only criterion for preferring theories.

**Definition 24** (Norm argument). Let \( \mathcal{A} \) be any extended normative theory and \( r \) be regulative norm in it: by \( \mathcal{A}_r \) and \( \mathcal{A}_{\neg r} \) we mean, respectively, that \( \exists b \in A(r) \) such that \( \mathcal{A} \vdash \neg \delta^g b \) and that \( \exists b \in A(r) \) we have \( \mathcal{A} \vdash + \delta^g b \). We call \( \mathcal{A}_r \) a norm argument against \( r \) and \( \mathcal{A}_{\neg r} \) a norm argument for \( r \). If \( \mathcal{A}_{\neg r} \) is a norm argument, then \( R_{\neg r}(\mathcal{A}_{\neg r}) \) is a norm argument.

**Definition 25** (Norm attack). A norm argument \( \mathcal{B}_{\neg r} \) attacks a norm argument \( \mathcal{A}_x \) with respect to rule \( r \) iff, either \(^1\)

- \( x = \mp r \), \( \mathcal{A}_{\neg r} \) demotes the goal \( g \), \( \mathcal{B}_{\neg r} = R_{\neg r}(\mathcal{A}_{\neg r}) \), and \( \mathcal{B}_{\neg r} \) promotes the goal \( g \); or
- \( x = \mp r \), \( \mathcal{A}_{\neg r} \) promotes the goal \( g \), \( \mathcal{B}_{\neg r} = R_{\neg r}(\mathcal{A}_{\neg r}) \), \( \mathcal{B}_{\neg r} \) promotes the goal \( g \), and \( \mathcal{B}_{\neg r} \) is at least theory connected as \( \mathcal{A}_{\neg r} \); or
- \( x = \mp r \), \( \mathcal{A}_{\neg r} \) promotes the goal \( g \), \( \mathcal{B}_{\neg r} = R_{\neg r}(\mathcal{A}_{\neg r}) \), \( \mathcal{B}_{\neg r} \) promotes the goal \( g \), and \( \mathcal{B}_{\neg r} \) is more theory connected than \( \mathcal{A}_{\neg r} \).

Let us now move to meaning negotiations. Following (60; 61), these negotiations can be viewed as dialogues involving two parties that run according to a general negotiation protocol. Such a protocol can be rather complex, but if meaning negotiations are concerned, it is in fact identical to the one formulated for any other type of negotiations: what is distinctive is rather the object of the dialogue moves. For this reason, we will not present an explicit and complete definition of the protocol: the interested reader is referred, e.g., to (61, Definitions 1, 3, and 4).

For our purposes, it is enough to work on the basic intuition behind the idea of meaning negotiation. A meaning negotiation takes place between two players, one of whom starts with either an offer or a request, given an initial set of norm arguments based on a given extended normative theory (see Definition 24), which is shared by both players. The players then take turns after each utterance, selecting their replies as intuitively specified in Definition 26 below. The initial move is the request of one player, the proponent, to make applicable (or inapplicable) a certain norm \( r \) in the extended normative theory if \( r \) is initially inapplicable (resp., applicable) in the theory. The other player, the opponent, can reply by offering a solution, i.e., by presenting a norm argument supporting the request. Then, the negotiation carries on by using the initial set of norm arguments shared by the players or by revising norm arguments used in the previous steps of the dialogues. As the definition below states, a negotiation terminates when an agent accepts an offer or withdraws from the negotiation. Finally, moves may not be repeated by the same player (61, p. 3).

\(^1\)Notice that \( R_{\neg r} \) can denote any contraction operation among those outlined in (54).
Definition 26 (Speech acts and replies in meaning negotiations). The following are the acts and the corresponding replies or effects for any step \( n \) in a meaning negotiation dialogue. Let \( 1 \leq j \leq n \) and \( \mathcal{A}_{sr_j} \) be a norm argument belonging to the initial set of norm arguments shared by the players or anyway occurring in at least one previous step \( n - m (1 < m < n) \) of the dialogue:

<table>
<thead>
<tr>
<th>Acts at step ( n - 1 )</th>
<th>Replies at step ( n )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( n - 1 = \text{request}(\mathcal{A}'_{sr_j}) )</td>
<td>( n = \text{offer}(\mathcal{R}<em>{sr_j}(\mathcal{A}</em>{sr_j})) )</td>
</tr>
<tr>
<td>( n - 1 = \text{offer}(\mathcal{R}<em>{sr_j}(\mathcal{A}</em>{sr_j})) )</td>
<td>( n = \text{offer}(\mathcal{R}'<em>{sr_j}(\mathcal{A}</em>{sr_j})) : )</td>
</tr>
<tr>
<td></td>
<td>( \mathcal{R}'<em>{sr_j}(\mathcal{A}</em>{sr_j}) ) attacks ( \mathcal{R}<em>{sr_j}(\mathcal{A}</em>{sr_j}) ), or</td>
</tr>
<tr>
<td></td>
<td>( n = \text{accept}(\mathcal{R}<em>{sr_j}(\mathcal{A}</em>{sr_j})) ), or</td>
</tr>
<tr>
<td></td>
<td>( n = \text{reject}(\mathcal{R}<em>{sr_j}(\mathcal{A}</em>{sr_j})) ) if ( \exists n - m : )</td>
</tr>
<tr>
<td></td>
<td>( n - m = \mathcal{A} ) and ( \mathcal{A} ) attacks ( \mathcal{R}<em>{sr_j}(\mathcal{A}</em>{sr_j}) ), or</td>
</tr>
<tr>
<td></td>
<td>( n = \text{withdraw} )</td>
</tr>
<tr>
<td>( n - 1 = \text{reject}(\mathcal{A}_{sr_j}) )</td>
<td>( n = \text{offer}(\mathcal{R}'<em>{sr_j}(\mathcal{A}</em>{sr_j})) : \forall n - m = \mathcal{B} ) where</td>
</tr>
<tr>
<td></td>
<td>( \mathcal{B} ) attacks ( \mathcal{A}<em>{sr_j}, \mathcal{R}'</em>{sr_j}(\mathcal{A}_{sr_j}) ) attacks ( \mathcal{B} ) or</td>
</tr>
<tr>
<td></td>
<td>( \mathcal{A}_{sr_j} ) denotes the goal of ( r_j ), or</td>
</tr>
<tr>
<td></td>
<td>( n = \text{withdraw} )</td>
</tr>
<tr>
<td>( n - 1 = \text{accept}(\mathcal{A}_{sr_j}) )</td>
<td>( n = \text{end of negotiation} )</td>
</tr>
<tr>
<td>( n - 1 = \text{withdraw} )</td>
<td>( n = \text{end of negotiation} )</td>
</tr>
</tbody>
</table>

As recalled in (61, p. 3), in order “to ensure that the offers exchanged during a negotiation and its outcome are related to an initial request”, it is required to add the following rule to the protocol:

- If \( \text{request}(\mathcal{A}'_{sr_j}) \) is the initial request of a dialogue then for any move \( \text{offer}(\mathcal{B}) \) in the dialogue \( \mathcal{B} = \mathcal{A}_{sr_j} \).

Example 13. Suppose we consider an extended normative theory \( \mathcal{A} \) where the set of of facts and rules is the following:

\[
F = \{\text{Embryo, Kill}\}\\
R^c = \{r_1 : \text{Embryo} \rightarrow_c \text{Alive}, r_2 : \text{Alive}, \text{Kill} \rightarrow_c \text{Homicide}, r_3 : \text{Person} \rightarrow_c \text{Alive}\}\\
R^\text{Obl} = \{r_4 : \text{Homicide} \Rightarrow_{\text{Obl}} \text{Punished}\}
\]

For the sake of illustration, assume for simplicity that the goal assigned to \( r_4 \) is human well-being. Clearly, we have the following justified constitutive argument in \( \mathcal{A} \):

\[
\text{Embryo} \rightarrow \text{AliveAlive}, \text{Kill} \rightarrow \text{Homicide}
\]

Hence, the players share this set of initial norm argument: \( \{\mathcal{A}_{sr_4}\} \). Assume that the extended theory, which thus makes \( r_4 \) applicable, denotes the goal well-being. The proponent’s first move is:

1. \( \text{request}(\mathcal{A}'_{sr_4}) \)

The opponent replies as follows:

2. \( \text{offer}(\mathcal{R}_{sr_2}(\mathcal{A}_{sr_4})) \)

which removes from \( R^c \) the rule \( r_2 \). Assume that the resulting theory denotes the goal well-being, hence the proponent reply is
3. \textit{reject}(R_{-r_4}(A_{+r_4}))

The opponent now offers the following:

4. \textit{offer}(R'_{-r_4}(A_{+r_4}))

which removes $r_1$ thus promoting the goal well-being and obtaining a more connected theory. The proponent thus

5. \textit{accept}(R'_{-r_4}(A_{+r_4}))

and so the negotiation ends.

\section*{5.2 Normative Goals and Interpretation as Fuzzy Reasoning}

In Deliverable D1.1, an alternative approach to model the interpretation of open-textured norms was described by taking graded categories into account. The technical option was to use fuzzy logic: indeed, this logic is a suitable tool to capture the imprecision related to legal categories. More precisely, a category may be represented as a fuzzy set: the membership of an element to a category is a graded concept.

In addition to taking graded categories into account, we recalled again that a norm is always associated with a goal (or set of goals). The idea was then to capture the fact that, when a legislator writes a norm, (s)he has in mind a state of affairs to be reached thanks to the compliance to that norm. With that in mind, the degree to which a concept in the rule belongs to a category would also depend on the goal associated with the norm.

The model has been for second year generalised and designed to be applied in normative multi-agent systems (NormMAS): the full presentation is in (56). In particular, we worked on how to combine the view mentioned above with various types of argumentation systems suitable for NormMAS.

Formal argumentation has been in fact used to enrich and analyse NormMAS in various ways. In (56), given the contribution of (55), we discussed three examples from the literature of handling norms by means of formal argumentation. First, we discussed how existing ways to resolve conflicts among norms using priorities can be represented in formal argumentation, by showing that the so-called Greedy and Reduction approaches can be represented using the weakest and the last link principles respectively. Based on such representation results, formal argumentation can be used to explain the detachment of obligations and permissions from hierarchical normative systems in a new way.

Second, we discussed how formal argumentation can be used as a general theory for developing new approaches for normative reasoning, using a dynamic ASPIC-based legal argumentation theory. We have shown how existing logics of normative systems can be used to analyse such new argumentation systems.

Third, we argued how argumentation (as discussed above) can be used to reason about other challenges in the area of NormMAS as well, by discussing a model for arguing about legal interpretation.

The intuition of this approach already introduced with some details in Deliverable D1.1: for all the technicalities (in addition to the previous deliverable), we refer entirely to (56; 55).
5.3 Conclusions and Research Challenges

The above sections still indicate the following research challenges for MIREL (if compared to D1.1):

**Research Challenge 5** (Interpreting Legal Provision: Goals, Qualitative vs Quantitative Methods). *Once you have defined formal models for semantic holism, and have explored qualitative and quantitative methods for modelling legal interpretation where values and goals are decisive, clearly identify pros and cons for all approaches.*

**Research Challenge 6** (Integrating Interpretive Models). *Define formal methods that integrate qualitative or quantitative models of interpretation with argumentation systems (e.g., about interpretive canons: see D1.1, chap. 4, sec. 4.2).*

We made a significant with respect to the first year in regard to Task 1.3 of WP1. However, we should also note that most of the research challenges of D1.1 are still open and must be explored in the remainder of the project activities.
6 Conclusions

This document reported on the second year of research activities conducted in MIREL for WP1. In Deliverable D1.1 (Introduction), we have summarised the main aspects and topics in law that are of interest for MIREL WP1. For this second year of activities, we have focused on the following ones (among those listed in Deliverable D1.1, Introduction):

**Reification (1).** Norms are objects with properties, such as

- **Temporal properties (2).** Norms usually are qualified by temporal properties, such as:
  1. the time when the legal provision and the corresponding norm is in force and/or has been enacted;
  2. the time when the norm can produce legal effects (when the norm is applicable and supports the derivation of legal effects);
  3. the time when the normative effects hold.

**Defeasibility (1; 3; 4).** When the antecedent of a norm is satisfied by the facts of a case, the conclusion of the norm presumably holds, but is not necessarily true. In particular, we worked on:

- **Conflicts (3).** Norms can conflict, namely, they may lead to incompatible legal effects. Conceptually, conflicts can be of different types, according to whether two conflicting norms
  - are such that one is an exception of the other (i.e., one is more specific than the other);
  - have a different ranking status;
  - have been enacted at different times;

- **Norm validity (2).** Norms can be invalid or become invalid. Deleting invalid norms is not an option when it is necessary to reason retroactively with norms which were valid at various times over a course of events. For instance:
  1. The *annulment* of a norm is usually seen as a kind of repeal which invalidates the norm and removes it from the legal system as if it had never been enacted. The effect of an annulment applies *ex tunc*: annulled norms are prevented from producing any legal effects, also for past events.
  2. An *abrogation* on the other hand operates *ex nunc*: The norm continues to apply for events which occurred before the norm was abrogated.

- **Normative effects.** There are many normative effects that follow from applying norms, such as obligations, permissions, prohibitions and also more articulated effects such as those introduced, e.g., by Hohfeld (see (4)). In particular,
  - **Evaluative**, which indicate that something is good or bad, is a value to be optimised or an evil to be minimised. For example, “Human dignity is valuable”, “Participation ought to be promoted”;
**Qualificatory**, which ascribe a legal quality to a person or an object. For example, “x is a citizen”;

**Definitional**, which specify the meaning of a term. For example, “Tolling agreement means any agreement to put a specified amount of raw material per period through a particular processing facility”;

**Persistence of normative effects (5)**. Some normative effects persist over time unless some other and subsequent event terminate them. For example: “If one causes damage, one has to provide compensation.”. Other effects hold on the condition and only while the antecedent conditions of the norms hold. For example: “If one is in a public office, one is forbidden to smoke”.

**Values and goals (6)**. Usually, some values and goals are promoted by the legal norms. Modelling norms sometimes needs to support the representation of values and value preferences (and of of goals and goal preferences), which can play also the role of meta-criteria for solving norm conflicts. (Given two conflicting norms r₁ and r₂, value/goal v₁, promoted by r₁, is preferred to value/goal v₂, promoted by r₂, and so r₁ overrides r₂.)

In particular, we worked on:

- **Task 1.1 Transdisciplinary Research and Conceptual Models for Legal Knowledge Representation and Reasoning**: by offering further results in completing the analysis presented in Deliverable D1.1, especially regarding constitutive norms and legal supervenience (relevant for concept holism in law). In this regard, the relevant topics were:
  - **Normative effects**: Qualificatory and Definitional.
- **Task 1.2 Formal Languages for Representing Norms, Policies, and Values in the Law**: by extending the logical model of norm change reported on in Deliverable D1.1, by developing a complete formalism for modelling preferences and value orderings. In this regard, the relevant topics were:
  - **Reification**. Among others:
    - Jurisdiction,
    - Authority,
    - Temporal properties.
  - **Defeasibility**. In particular, we worked on Conflicts.
  - **Legal procedures**.
  - **Normative effects**.
- **Task 1.3 Logics for Modelling the Interpretation of Legal Provisions** by further developing fuzzy logic for legal interpretation; devising an argumentative system for meaning negotiation in the law that operates within the framework of Deliverable D1.1. In this regard, the relevant topics were:
  - **Defeasibility**.
  - **Values and goals**.

Several research challenges for MIREL have been formulated: see the list before Chapter 2.
References


D1.2 - Part I
Legal knowledge in legal texts, concept holism in the legal domain


[34] A. Fuhrmann, “Theory contraction through base contraction,” Journal of Philosophical Logic,


The MIREL project

21/01/2018

MIREL-D1.2 - Part I

Horizon 2020
D1.2 – Part II

Report and tutorial materials on new formal techniques for modelling the representation of embedded legal knowledge in legal texts, concept holism in the legal domain

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Report and tutorial materials on new formal techniques for modelling the representation of embedded legal knowledge in legal texts, concept holism in the legal domain

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Report and tutorial materials on new formal techniques for modelling the representation of embedded legal knowledge in legal texts, concept holism in the legal domain

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List of Acronyms

LIME- The Language Independent Markup Editor.
LKIF - Legal Knowledge Interchange Format
OASIS - Organization for the Advancement of Structured Information Standards
RAWE - Rules Advanced Web. Editor
RIF - Rule Interchange Format
RuleML - Rule Markup Language
SWRL - Semantic Web Rule Language

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Executive Summary

This document is the second part of Deliverable D1.2, which reports the second year of research activities conducted in MIREL for WP1.

This part II of the D1.2 describes LegalRuleML XML standard that is capable to model all the legal requirements presented in the D1.1 and D.1.2 Part I. This deliverable aims also to describe in details the methodology adopted for modelling legal knowledge from textual provisions, passing to legal rules, connecting also legal ontology. For modelling those legal resources we use tools developed by CIRSFID, University of Bologna (e.g., LIME, RAWE).

Part II of D1.2 copes with the following tasks of the WP1:

1. **Task 1.2** Formal Languages for representing norms, policies, and values in context: LegalRuleML provides a formal language in XML for modelling all the legal features;

2. **Task 1.3** Logics for modelling the interpretation of legal provisions: LegalRuleML includes mechanism for modelling different interpretation of the same legal provisions.

The deliverable D.1.2 Part II is organized as follow: chapter 1 introduces LegalRuleML; chapter 2 presents the LegalRuleML metadata part; chapter 3 presents the LegalRuleML ontology and its extension; chapter 4 presents a temporal modelization of LegalRuleML; chapter 5 shows the special editors and software tools for modelling LegalRuleML and also the connected ontology and metadata; chapter 6 shows the evaluation survey for validating the methodology of legal modelling.

Finally the annexes present tutorial materials and the evaluation survey of the legal norms modelling methodology.
1 LegalRuleML Introduction

The LegalRuleML is an XML standard (https://www.oasis-open.org/committees/legalruleml/) defined inside of OASIS international standardization body (www.oasis-open.org) that aims to produce a rule interchange language for modelling legal norms [43]. It is an extension of a particular module of RuleML families, Consumer RuleML (http://wiki.ruleml.org/index.php/Specification_of_Consumer_RuleML_1.02). Consumer RuleML was designed to uniform Deliberation RuleML and Reaction RuleML families and so to provide a consistent language good for the Semantic Web applications. LegalRuleML reuses some structures of Deliberation RuleML (e.g., Atom, Rule) and others from Reaction RuleML (e.g., Data, Interval). The figure below show the relationship of LegalRuleML with the RuleML families.

LegalRuleML intends to provide XML structures to model in formal manner the legal norms. It is designed for Semantic Web applications (e.g., legal ontology of relationship between norms, for permitting SPARQL queries) or for logic reasoning (e.g., compliance checking) according with the legal logic theories described in the D1.1 of WP1 and in the Chapters above in this D1.2, including deontic, defeasibility, temporal reasoning. In the last decade, several Legal XML standards have been proposed to represent legal texts [30] with XML-based rules (RuleML, SWRL, RIF, LKIF, etc.) [16, 18]. At the same time, the Semantic Web, in particular Legal Ontology research combined with semantic norm extraction based on Natural Language Processing (NLP) [15], has given a strong impetus to the modeling of legal concepts [8, 10, 11]. However in the state of the art does not exist a uniform and consistent XML rule language for modelling legal norms. Based on this, the work of the LegalRuleML focuses the design on three specific needs:

1. To close the gap between legal texts, which are expressed in natural language, and semantic norm modeling. The authentic legal documents (e.g., official gazette) are available
more and more in digital format on the Web and the logic representation of the norms has to be connected with the fragment of texts that generate the modelization. The tractability between text and legal rules is fundamental for preserving the authenticity, the integrity, the legal validity of the logic assertions, and so to create trust and confidence in the legal operators (e.g., judges) about the legal reasoning process.

2. To provide an expressive XML standard for modeling normative rules that satisfies legal domain requirements. The requirements include deontic operators, defeasible structure, temporal parameters, metadata mechanisms.

3. To apply the Linked Open Data [9] approach to model raw data in the law (acts, contracts, court files, judgments, etc.) and to extend it to legal concepts and rules along with their functionality and usage. Legal concepts need to be integrated with legal rules and LegalRuleML permits this connection without conflict [36] with legal ontologies.

### 1.1 LegalRuleML principles

LegalRuleML is designed following some main principles.

**Multiple Semantic Annotations:** A legal rule may have multiple semantic annotations, where these annotations represent different legal interpretations. Each such annotation appears in a separate annotation collection using metadata that provide the interpretation with respect to provenance (agent and role), applicable jurisdiction, logical interpretation of the rule, additional sources that support this interpretation.

**Tracking the LegalRuleML Creators:** As part of the provenance information, a LegalRuleML document or any of its fragments can be associated with its creators. This is important to establish the authority and trust of the knowledge base and annotations.

**Linking Rules and Provisions:** LegalRuleML includes a mechanism, based on IRI, that allows many to many (N:M) relationships among the rules and the textual provisions. Multiple rules are embedded in the same provision, several provisions contribute to define the same rule. This mechanism may be managed in the metadata collections avoiding redundancy in the IRI definition.

**Temporal Management:** Textual provisions and legal rules change in time according to at least three temporal legal axis: time of enter into force of the textual provisions, time of commencement of operational of the norms, the time of application of the norms to the facts. LegalRuleML represents these temporal issues using special metadata. In particular, the rules can be associated to temporal parameters which can vary over time. In this way we can produce all the elements necessary for implementing the temporal reasoning theory described in the D1.1.

**Formal Ontology Reference:** LegalRuleML is independent from any legal ontology and logic framework. However it includes a mechanism, based on IRIs, for pointing to reusable classes of a specified external ontology. In this manner any <Rel> element is associated to a predicate defined in the legal domain ontology. Also the different type of deontic operators (e.g., [OM]: maintenance, [OP]: puntuale, [OAPP]: achievement preemptive persistent, [OAPNP]: achievement preemptive non-persistent, [OANPP]: achievement nonpreemptive, persistent, [OANPNP]: achievement, non preemptive, non-persistent see [40][42]). LegalRuleML legal knowledge is also mappable to RDF triples for Linked Data reuse using a RDFS metamodel.
1.2 LegalRuleML functionalities

The features that LegalRuleML is capable to manage are the following:
- defeasibility of rules and defeasible logic [13, 31, 34];
- deontic operators (e.g., obligations, permissions, prohibitions, rights);
- semantic management of negation;
- temporal management of rules and temporality in rules [21, 22, 29];
- classification of norms (i.e., constitutive, prescriptive);
- jurisdiction of norms;
- isomorphism between rules and natural language normative provisions [7];
- identification of parts of the norms (e.g., bearer, conditions);
- authorial tracking of rules.

1.3 LegalRuleML vocabulary

LegalRuleML vocabulary is designed for modelling three main blocks:
- Rules: where the legal norms are modelled in logic formalism;
- Metadata: where the fundamental data concerning the norms are stored. In this block we find IRI of the authentic legal documents, temporal parameters, jurisdiction declaration, information about agents, locations, or roles played by the agents;
- Context: that is a bridge between rules and metadata in order to minimize the redundancy and for permitting n-ary relations between rules and metadata.

The following figure shows the organization of a LegalRuleML XML document following the abovementioned blocks.

Figure 2 – LegalRuleML main blocks.
1.3.1 Constitutive and Prescriptive Norms

In LegalRuleML, legal rules are captured by the broader class of Statement and the hasTemplate property links a prescriptive or constitutive statement to its template, a fragment of RuleML syntax with root ruleml:Rule that denotes a class of rules. In Legal Theory norms are classified mostly in two main categories: constitutive norms and prescriptive norms. Constitutive norms usually provide definition of the terms and legal concepts used in a given jurisdiction. The function of constitutive norms is to define and create so called institutional facts [36], where an institutional fact is how a particular concept is understood in a specific institution.

The conclusion (head) of a constitutive rule cannot be a deontic formula, nor can it be a compound formula that contains a deontic formula.

```
<lrml:ConstitutiveStatement key="cs1">
  <ruleml:Rule key=":key1">
    <lrml:hasStrength>
      strength of the rule
    </lrml:hasStrength>
    <ruleml:if>
      formula, including deontic formula
    </ruleml:if>
    <ruleml:then>
      non-deontic formula
    </ruleml:then>
  </ruleml:Rule>
</lrml:ConstitutiveStatement>
```

Table 1 – Constitutive Statement in LegalRuleML

Prescriptive norms command obligations, prohibitions, permissions, etc. of a legal system, along with the conditions under which the obligations, prohibitions, permissions, etc. hold.

LegalRuleML uses deontic operators to capture such notions. Deontic operators are meant to qualify formulas. The head of a prescriptive rule is a list of deontic formulas which is called a suborder list and represented in LegalRuleML by the <lrml:Suborder> element.

```
<lrml:PrescriptiveStatement key="ps1">
  <ruleml:Rule key=":key1">
    <lrml:hasStrength>
      strength of the rule
    </lrml:hasStrength>
    <ruleml:if>
      formula, including deontic formula
    </ruleml:if>
    <ruleml:then>
      <lrml:SuborderList>
        list of deontic formulas
      </lrml:SuborderList>
    </ruleml:then>
  </ruleml:Rule>
</lrml:PrescriptiveStatement>
```

Table 2 – Prescriptive Statement in LegalRuleML

1.3.2 Deontic Structures

Standard deontic logic assumes the following relationships between the operators:

\[
\text{[OBL]}\neg p \equiv \neg \text{[PERM]}\neg p
\]
If \( p \) is obligatory, then its opposite, \( \neg p \), is not permitted.

\[
[\text{PRO}]p \equiv [\text{OBL}]\neg p
\]

If \( p \) is prohibited, then its opposite is Obligatory. Alternatively, a Prohibition (PRO) of \( p \) can be understood as Obligation (OBL) of the negation of \( p \).

The operators of Obligation, Prohibition and Permission are typically considered the basic ones, but further refinements are possible, for example, two types of permissions have been discussed in the literature on deontic logic: weak permission (or negative permission) and strong permission (or positive permission).

Weak permission corresponds to the idea that some \( A \) is permitted if \( \neg A \) is not provable as mandatory. In other words, something is allowed by a legal norm only when it is not prohibited by that legal norm [38]. The concept of strong permission is more complicated, as it amounts to the idea that some \( A \) is permitted by a legal norm if and only if such a legal norm explicitly states that \( A \) is permitted, typically as an exception to the prohibition of \( A \) or the obligation of its contrary, i.e., \( \neg A \).

It follows that a strong permission is not derived from the absence of a prohibition, but is explicitly formulated in a permissive (prescriptive) norm [2]. An example of an explicit positive permission is manifested by a “U-turn permitted” sign exposed at a traffic light, which derogates the (general) prohibition to U-turn at traffic lights.

Refinements of the concept of obligation have been proposed as well. For example it is possible to distinguish between achievement and maintenance obligations, where an achievement obligation is an obligation that is fulfilled if what the obligation prescribes holds at least once in the period when the obligation holds, while a maintenance obligation must be obeyed for all the instants when it holds (see [18] for a classification of obligations).

LegalRuleML is neutral about the different subclasses of the deontic operators and it permits to declare an IRI to a proper ontology.

```xml
<lrml:Obligation key="oblig1" iri="http://example.org/deontic/vocab#achievementobligation">
  ...
</lrml:Obligation>
```

*Table 3 – Obligation in LegalRuleML with pointer to specific ontology definition*

The second method is to use an Association to link a Deontic Specification to its meaning using the applyModality element, namely:

```xml
<lrml:Association>
  <lrml:appliesModality iri="http://example.org/deontic/vocab#maintenancemaintenanceobligation"/>
  <lrml:toTarget keyref="#oblig101"/>
</lrml:Association>
```

*Table 4 – Association in LegalRuleML with pointer to specific ontology definition*

Furthermore, Obligations, Prohibitions and Permissions in LegalRuleML are directed operators [24], thus they have parties (e.g. Bearer), specifying, for example, who is the subject of an Obligation or who is the beneficiary of a Permission.

```xml
<lrml:Obligation iri="http://example.org/deontic/vocab#ob1t1">
  <ruleml:slot>
    <lrml:Bear iri="http://example.org/deontic/vocab#ob1Bearer"/>
  </lrml:slot>
  <ruleml:Ind>Y</ruleml:Ind>
</lrml:Obligation>
```

---

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1.3.3 Violation, Suborder, Penalty and Reparation.

Obligations can be violated. A violation is, basically, a situation where we have ([OBL] \( p \)) and \( \neg p \).

One of the characteristics of norms is that having violated them, a penalty can be introduced to compensate for the violation, where a penalty is typically a Deontic Specification. To model this feature of norms and legal reasoning [20] introduced what is called here a suborder list, and [16] showed how to combine them with defeasible reasoning for the modelling of (business) contracts. As we have mentioned above, a suborder list is a list of deontic formulas. Syntactically, a suborder list of one element can be rendered in LegalRuleML as just the element.

Obligations and Prohibitions should not be preceded by Permissions and Rights in a suborder list, for the semantics of suborder lists is such that an element holds in the list only if all the elements that precede it in the list have been violated. It is not possible to have a Violation of a Permission, so it cannot serve a purpose in the suborder list.

For example, given the rules:

\[
\begin{align*}
\text{body} & \Rightarrow [\text{OBL}] A \\
\neg A & \Rightarrow [\text{OBL}] B
\end{align*}
\]

Here the body of the second rule is the negation of the content of the obligation in the head of the first rule. It is possible to merge the two rules above in the following rule:

\[
\text{body} \Rightarrow [\text{OBL}] A, [\text{OBL}] B
\]

obligation of B. This suggests that suborder lists provide a simple and convenient mechanism to model penalties. It is not uncommon for a legal text (e.g., a contract) to include sections about penalties, where one penalty is provided as compensation for many norms. To model this and to maintain the isomorphism between a source and its formalisation, LegalRuleML includes a `<PenaltyStatement>` element, the scope of which is to represent a statement of a penalty as a suborder list (including the trivial non-empty list of a single element).

### Table 5 – Obligation in LegalRuleML with pointer to specific ontology about bearer

<table>
<thead>
<tr>
<th>Rule</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>&lt;ruleml:Atom key=&quot;atom2&quot;&gt;</code></td>
<td></td>
</tr>
<tr>
<td><code>&lt;ruleml:Rel iri=&quot;#rel2&quot;/&gt;</code></td>
<td></td>
</tr>
<tr>
<td><code>&lt;ruleml:Ind X&lt;/ruleml:Ind&gt;</code></td>
<td></td>
</tr>
<tr>
<td><code>&lt;ruleml:Obligation&gt;</code></td>
<td></td>
</tr>
</tbody>
</table>

LegalRuleML not only models penalties, but aims to connect the penalty statement with the corresponding Reparation element:

### Table 6 – Penalty Statement in LegalRuleML

<table>
<thead>
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<th>Rule</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>&lt;lrml:PenaltyStatement key=&quot;pen1&quot;&gt;</code></td>
<td></td>
</tr>
<tr>
<td><code>&lt;lrml:SuborderList&gt;</code></td>
<td>list of deontic formulas</td>
</tr>
<tr>
<td><code>&lt;lrml:PenaltyStatement&gt;</code></td>
<td></td>
</tr>
</tbody>
</table>

### Table 7 – Reparation Statement in LegalRuleML

<table>
<thead>
<tr>
<th>Rule</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>&lt;lrml:Reparation key=&quot;rep1&quot;&gt;</code></td>
<td></td>
</tr>
<tr>
<td><code>&lt;lrml:appliesPenalty keyref=&quot;#pen1&quot;/&gt;</code></td>
<td></td>
</tr>
<tr>
<td><code>&lt;lrml:toPrescriptiveStatement keyref=&quot;#ps1&quot;/&gt;</code></td>
<td></td>
</tr>
<tr>
<td><code>&lt;lrml:Reparation&gt;</code></td>
<td></td>
</tr>
</tbody>
</table>
1.3.4 Alternatives

In the legal interpretation theory [37] norms are interpreted by the judges in order to apply them to the concrete cases. Sometimes the legal interpretation theories conflict and diverge from each other [11,23,33]. Linguistic elements are added to this also for different reasons such as jurisdiction (e.g., national and regional level) or for competences (e.g., civil or criminal court). LegalRuleML endeavours not to account for how different interpretations arise, but to provide a mechanism to record and represent them. We have four different templates: i) same textual provision associated to different legal rules; ii) partial textual provision and other different textual fragments associated to different legal rules; iii) one provision associated to set of legal rules; iv) set of provisions associated to set of legal rules.

The element <lrml:Alternatives> permits to express all these interpretation templates. The following LegalRuleML fragments illustrate how to represent the four cases above:

**Case 1**
```
<lrml:Alternatives key="alt1">
  <lrml:fromLegalSources>
    <lrml:LegalSources>
      <lrml:hasLegalSource keyref="#ref1"/>
      <lrml:hasLegalSource keyref="#ref2"/>
    </lrml:LegalSources>
  </lrml:fromLegalSources>
  <lrml:hasAlternative keyref="#ps1"/>
  <lrml:hasAlternative keyref="#ps2"/>
</lrml:Alternatives>
```

**Case 2**
```
<lrml:Alternatives key="alt2">
  <lrml:LegalSources>
    <lrml:hasLegalSource keyref="#ref1"/>
    <lrml:hasLegalSource keyref="#ref2"/>
  </lrml:LegalSources>
  <lrml:hasAlternative keyref="#ps1"/>
  <lrml:hasAlternative keyref="#ps2"/>
</lrml:Alternatives>
```

**Case 3**
```
<lrml:Alternatives key="alt3">
  <lrml:LegalSources>
    <lrml:hasLegalSource keyref="#ref1"/>
    <lrml:hasLegalSource keyref="#ss1"/>
    <lrml:hasAlternative keyref="#ss2"/>
  </lrml:LegalSources>
  <lrml:Statements key="ss1">
    <lrml:ConstitutiveStatement keyref="#ps1"/>
    <lrml:ConstitutiveStatement keyref="#ps2"/>
  </lrml:Statements>
  <lrml:Statements key="ss2">
    <lrml:ConstitutiveStatement keyref="#ps3"/>
  </lrml:Statements>
</lrml:Alternatives>
```

**Case 4**
```
<lrml:Alternatives key="alt3">
  <lrml:LegalSources>
    <lrml:hasLegalSource keyref="#ref1"/>
    <lrml:hasLegalSource keyref="#ref2"/>
  </lrml:LegalSources>
  <lrml:hasAlternative keyref="#ss1"/>
  <lrml:hasAlternative keyref="#ss2"/>
  <lrml:Statements key="ss1">
    <lrml:ConstitutiveStatement keyref="#ps1"/>
    <lrml:ConstitutiveStatement keyref="#ps2"/>
  </lrml:Statements>
</lrml:Alternatives>
```
2 LegalRuleML metadata

LegalRuleML includes a block for modelling metadata in order to qualify the legal rules, like the legal sources, jurisdiction, temporal parameters. Those metadata can be imported to other XML standards like Akoma Ntoso or Metalex/CEN.

2.1 Sources and Isomorphism

<lrml:References> is the collection dedicated to record non-IRI based identifier sources, and the attribute refIDSystemName is able to annotate the naming convention used. In the following example we refer to the Akoma Ntoso relative IRI of the section 8 of the GDPR, following the naming convention of the XML-schema in Akoma Ntoso:
Report and tutorial materials on new formal techniques for modelling the representation of embedded legal knowledge in legal texts, concept holism in the legal domain

---

Part II

### Table 9 – References to legal provision using relative IRI

<table>
<thead>
<tr>
<th><img src=".Attachment" alt="Image" /></th>
<th><img src="Attachment" alt="Image" /></th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="Attachment" alt="Image" /></td>
<td><img src="Attachment" alt="Image" /></td>
</tr>
</tbody>
</table>

The following example defines the source of the IRI of the European Regulation on Privacy, GDPR, using ELI Naming convention:

```xml
<lrml:LegalSource>
  <lrml:LegalSource key="ref2" sameAs="http://eur-lex.europa.eu/eli/reg/2016/679/oj"
                   refIDSystemName="AkomaNtosso3.0-2017-06-06"/>
</lrml:LegalSource>
```

---

### Table 10 – References to legal provision using absolute IRI

The list of the resources connected with the legal rules that are modelled in a LegalRuleML document are defined once using `<lrml:References>` and `<lrml:LegalSource>`, this minimizes redundant definitions of the resources and avoids errors. The `<lrml:Association>` construct links LegalSources and References with rules (or fragment of rule), thus implementing the N:M relationship.

---

#### 2.2 Jurisdiction and Authority

The **jurisdiction** is a legal concept that represents the geographic area (e.g., international, supranational, national, regional, etc.) or the subject-matter (e.g., criminal law, public law, etc.) over which an authority applies its legal power. In LegalRuleML we have Jurisdiction element that annotates this concept.

```xml
<lrml:Jurisdictions>
  <lrml:Jurisdiction key="eu" sameAs="http://example.org/jurisdiction#europeanUnion"/>
</lrml:Jurisdictions>
```

---

### Table 11 – Jurisdiction modelling in LegalRuleML for geographic area

We can use Jurisdiction also to specify a limited subject-matter, for instance, legal rules which are applicable only to the European Patent Office

```xml
<lrml:Jurisdictions>
  <lrml:Jurisdiction key="epo" sameAs="http://example.org/jurisdiction#europeanPatentOffice"/>
</lrml:Jurisdictions>
```

---

### Table 12 – Jurisdiction modelling in LegalRuleML for competence

Similarly, authority qualifies the rules with respect to the authenticity of the provenance of the formal model. Authority is a person or organization with the power to create, endorse, or enforce Legal Norms.

```xml
<lrml:Authorities>
  <lrml:Authority key="euParliament" sameAs="eu:organization.owl#europeanParliament"/>
    <lrml:hasType iri="lrmlv:Legislature"/>
</lrml:Authority>
</lrml:Authorities>
```

---

### Table 13 – Authority modelling in LegalRuleML
2.3 Agent, Figure, Role

An Agent is an entity that acts or has the capability to act. An Agent could be a physical person, a database, or a bot; for this reason we have the sub-element <lrml:hasType> that expresses the category of agent.

```
<lrml:Agents>
  <lrml:Agent key="at" sameAs="http://example.org/agents#AntonioTajani">
    <lrml:hasType iri="http://example.org/types#Person"/>
  </lrml:Agent>
</lrml:Agents>
```

Table 14 – Agent modelling in LegalRuleML

The Agent usually is the author of the legal rules model and he/she/it can act in a particular function (e.g., as European Parliament President). A Figure in LegalRuleML is an instantiation of a function.

```
<lrml:Figures>
  <lrml:hasMemberType iri="http://example.org/figure-types#LegislativeFigure"/>
  <lrml:Figure key="eupp">
    <lrml:hasFunction iri="http://example.org/functions#europenParliamentPresident"/>
    <lrml:hasActor keyref="#at"/>
  </lrml:Figure>
</lrml:Figures>
```

Table 15 – Figure modelling in LegalRuleML

In the end we associate the Actor that fills a Role (using <lrml:filledBy>) for a particular rule.

```
<lrml:Roles>
  <lrml:Role key="role1" iri="http://example.org/roles#author">
    <lrml:filledBy keyref="#at"/>
    <lrml:forExpression keyref="#rule1_a"/>
  </lrml:Role>
</lrml:Roles>
```

Table 16 – Role modelling in LegalRuleML

Using this mechanism we can filter all the rules modelled by a particular Actor when he/she/it acts as a particular figure.

2.4 Time and Events

Legal texts are often amended as a society or judicial system evolves. Norms and rules are valid in a particular interval of time and with respect to three main legal axes: when they come into force (entry or enforceability), when they effect the intended or desired result (efficacy or commencement), and when they apply (applicability).

The temporal dimensions of the complex events that are the content of the textual provision (e.g., when a person is to present a tax application) are modelled using the normal rules, but for the external temporal parameters that governs the rule itself, LegalRuleML provides a special mechanism for representing temporal situations. We model the intervals and temporal parameters that define the period of enter into force or efficacy or applicability of the rules. Secondly it is fundamental to link link the temporal parameters to any part of a rule (e.g., Atom, Rel, Ind, if, then, etc.) with a very fine granularity. The following fragment shows the definition of the instant time using the <ruleml:Time> element wrapped by the <lrml:Times> collection elements. The first time is the enter into force of the original version of the Italian Privacy Law (196/2003 Act); the second date is the date of efficacy of the second amended and updated version of the same Act:

```
<lrml:Times>
  <ruleml:Time iri="http://example.org/times#privacyLawEnterIntoForce">
    <lrml:TimePoint keyref="#at"/>
    <lrml:forRule keyref="#privacyLaw"/>
  </ruleml:Time>
  <ruleml:Time iri="http://example.org/times#privacyLawEfficacy">
    <lrml:TimePoint keyref="#at"/>
    <lrml:forRule keyref="#privacyLawUpdated"/>
  </ruleml:Time>
</lrml:Times>
```
2.1 Association and Context

To avoid redundancy, we have the element `<Association>` which can be used to group meta information referring to several rules or portions of them. In the following example we have two associations inside of the collection element `<Associations>`.

The first `<Association>` applies the temporal parameters of `tblock1` to the prescriptive statements 1 and 2. In the second one authority and jurisdiction properties are applied to prescriptive statements 1 and 2:

```
<lrml:Associations key="sourceBlock1">
  <lrml:Association>
    <lrml:appliesTemporalCharacteristics keyref="#tblock1"/>
    <lrml:toTarget keyref="#ps1"/>
    <lrml:toTarget keyref="#ps2"/>
  </lrml:Association>
  <lrml:Association>
    <lrml:appliesAuthority keyref="ex:#euParliamentPresident"/>
    <lrml:appliesJurisdiction keyref="ex:#eu"/>
    <lrml:toTarget keyref="#ps1"/>
    <lrml:toTarget keyref="#ps2"/>
  </lrml:Association>
</lrml:Associations>
```
The same it is possible with all the metadata of LegalRuleML: Authority, LegalSource, Jurisdiction, Strength, TemporalCharacteristics, etc.

To represent such parameters to the rules, we use the <lrml:Context> element, which permits the description of all the characteristics that are linked to a particular rule (e.g., rule1).

The mechanism combines the relationships and the target rules, and it acts as a bridge between metadata and rules or fragments of them.

```html
<lrml:Context key="ruleInfo4" hasCreationDate="#t1">
  <lrml:appliesSource keyref="#art_8"/>
  <lrml:appliesTemporalCharacteristics keyref="#tblock1"/>
  <lrml:appliesStrength iri="lrmlv:Defeater"/>
  <lrml:appliesAuthority keyref="authorities:euParliamentPresident"/>
  <lrml:appliesJurisdiction keyref="jurisdictions:eu"/>
  <lrml:appliesAssociations keyref="#assoc1"/>
  <lrml:appliesAlternatives keyref="#alt2"/>
  <lrml:inScope keyref="#rule1"/>
</lrml:Context>
```

Table 20 – Context modelling in LegalRuleML

3 LegalRuleML metamodel

LegalRuleML provides also a metadata model for transforming the information stored inside of the XML file in RDF triples. This permits to reuse the legal knowledge included in the legal rules description for different purposes: i) improve information retrieval of the legal documents; ii) filter the legal rules respect some parameters (e.g., jurisdiction, author, time); iii) combine legal knowledge with Linked Open Data Cloud\(^1\) information. RDFS [8] is used to define the LegalRuleML metamodel, and graphs of the RDFS schemas.

3.1 LegalRuleML RDFS

LegalRuleML has an RDFS model for transforming the metadata in RDF triples\(^2\). The most important parts are related to the qualification of the legal statement (ConstitutiveStatement and PrescriptiveStatement) and to the deontic operators (Obligation, Right, Permission, Prohibition, Compliance, etc.). The PrescriptiveStatement is disjoined with ConstitutiveStatement, ReparationStatement is disjoined with PenaltyStatement and FactualStatement and in general LogicalFormulaStatement is disjoined with RulesStatement.

\(^1\) http://lod-cloud.net/

\(^2\) https://tools.oasis-open.org/version-control/browse/wsvn/legalruleml/trunk/diagrams/#_trunk_diagrams

https://tools.oasis-open.org/version-control/browse/wsvn/legalruleml/trunk/rdfs/#_trunk_rdfs_
Figure 4 – Metamodel of the Statement qualifications.

Figure 5 – Metamodel of the deontic operators.

One limitation of this metamodel is the plain relationships representation between deontic operators. There is lack of axioms on relationships, no disjoined axiom for the is-a relationship, no existential quantifier restrictions.

3.2 An Extension of LegalRuleML metamodel

The current LegaRuleML metamodel is very elementary and oriented to design the LegalRuleML
constructs. However it is a good starting point for developing extensions good for other different goals like compliance checking. The figure below shows an extension of the LegalRuleML metamodel including relationships between deontic operators, disjoint classes axiom, better modelling of the reparation, violation and penalty.

Figure 6 – Extension of LegalRuleML metamodel.

<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>&lt;owl:ObjectProperty rdf:about=&quot;<a href="https://w3id.org/ontology/pronto#hasHeld">https://w3id.org/ontology/pronto#hasHeld</a>&quot; rdf:domain rdf:resource=&quot;<a href="http://docs.oasis-open.org/legalruleml/ns/v1.0/metamodel#DeonticSpecification%22/%3E">http://docs.oasis-open.org/legalruleml/ns/v1.0/metamodel#DeonticSpecification&quot;/&gt;</a></td>
</tr>
</tbody>
</table>
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| Relationship between obligation and permission | <rdfs:range rdf:resource="https://w3id.org/ontology/pronto#Compliance"/> |
| Relationship between prohibition and obligation | <rdfs:range rdf:resource="https://w3id.org/ontology/pronto#Violation"/> |
| Right as a subclass of Permission | <owl:Class rdf:about="http://docs.oasis-open.org/legalruleml/ns/v1.0/metamodel#Right"> |
| Relationship between obligation and permission | <owl:ObjectProperty rdf:about="https://w3id.org/ontology/pronto#implies"> |
| Relationship between prohibition and obligation | <owl:ObjectProperty rdf:about="https://w3id.org/ontology/pronto#isAKindOf"> |
| isFulfilledBy | <owl:ObjectProperty rdf:about="https://w3id.org/ontology/pronto#isFulfilledBy"> |
| Repparation | <owl:ObjectProperty rdf:about="https://w3id.org/ontology/pronto#repairs"> |
| isViolatedBy it defines the relationship between | <owl:ObjectProperty rdf:about="https://w3id.org/ontology/pronto#isViolatedBy"> |
| Relationship between obligation and permission | <owl:ObjectProperty rdf:about="https://w3id.org/ontology/pronto#implies"> |
| Relationship between prohibition and obligation | <owl:ObjectProperty rdf:about="https://w3id.org/ontology/pronto#isAKindOf"> |
| Right as a subclass of Permission | <owl:Class rdf:about="http://docs.oasis-open.org/legalruleml/ns/v1.0/metamodel#Right"> |
| Relationship between prohibition and obligation | <owl:ObjectProperty rdf:about="https://w3id.org/ontology/pronto#isAKindOf"> |
| Right as a subclass of Permission | <owl:Class rdf:about="http://docs.oasis-open.org/legalruleml/ns/v1.0/metamodel#Right"> |
Report and tutorial materials on new formal techniques for modelling the representation of embedded legal knowledge in legal texts, concept holism in the legal domain

| Restriction: Obligation hasHeld CounterParty generated by a Right | <owl:Class rdf:about="http://docs.oasis-open.org/legalruleml/ns/v1.0/metamodel#Permission"/>
|<rdfs:range rdf:resource="http://docs.oasis-open.org/legalruleml/ns/v1.0/metamodel#Obligation"/>
|<rdfs:range rdf:resource="http://docs.oasis-open.org/legalruleml/ns/v1.0/metamodel#Prohibition"/>
|<rdfs:range>
|<owl:intersectionOf rdf:parseType="Collection">
|<owl:Class rdf:about="http://docs.oasis-open.org/legalruleml/ns/v1.0/metamodel#Obligation"/>
|<owl:Restriction>
|<owl:onProperty rdf:resource="https://w3id.org/ontology/pronto#hasHeld"/>
|<owl:someValuesFrom rdf:resource="https://w3id.org/ontology/pronto#CounterParty"/>
|<owl:Restriction>
|<owl:intersectionOf>
|<owl:ObjectProperty>

Table 21 – Some axioms of the extension of the LegalRuleML ontology

4 Temporal Model in LegalRuleML

The temporal model in LegalRuleML permits to filter the rules according to a given event (e.g., the crime to evaluate), to deduct the rules modified when legal texts are changed over time, to make temporal legal reasoning using those information.

The following case is fundamental for understanding the Temporal Model in LegalRuleML. We take the Article 162 of Italian Privacy Code n. 196/2003\(^3\). It is modified

<table>
<thead>
<tr>
<th>196/2003 IRIs /akn/it/act/legislative decree/2003-06-30/196!main!art_162</th>
<th>Enter into efficacy</th>
<th>Modifications of the sanction</th>
<th>IRIs o Modificatory Acts</th>
</tr>
</thead>
</table>

---

### Table 22 – Fragment of legal provisions and temporal legal analysis

First of all we model the text in all the three versions in Akoma Ntoso multiversioning XML with the necessary modifications metadata and temporal information.
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<akomaNtoso xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xsi:schemaLocation="http://www.w3.org/2001/XMLSchema-instance"
xmlns:frbr="http://www.w3.org/ns/frbrcaps"
xmlns:fao="http://www.fao.org/ns/akn30"
xmlns:fo="urn:oasis:names:tc:opendocument:xmlns:xsl-fo-compatible:1.0"
xmlns:frbr4un="http://un.org/metadata"
xmlns:un="http://un.org/schema">

<act name="act">
  <meta>
    <identification source="#source">
      <FRBRWork>
        <FRBRthis value="/akn/it/act/legislativedecree/2003-06-30/196/main"/>
        <FRBRuri value="/akn/it/act/legislativedecree/2003-06-30/196"/>
        <FRBRdate date="2003-06-30"/>
        <FRBRauthor href="#" as="#"/>
        <FRBCountry value="it"/>
      </FRBRWork>
      <FRBRExpression>
        <FRBRthis value="/akn/it/act/legislativedecree/2003-06-30/196/eng@2011-05-13/main"/>
        <FRBRuri value="/akn/it/act/legislativedecree/2003-06-30/196/eng@2011-05-13"/>
        <FRBRdate date="2003-06-30"/>
        <FRBRauthor href="#" as="#"/>
        <FRBLanguage language="eng"/>
      </FRBRExpression>
      <FRBRManifestation>
        <FRBRthis value="/akn/it/act/legislativedecree/2003-06-30/196/eng@2011-05-13/main.xml"/>
        <FRBRuri value="/akn/it/act/legislativedecree/2003-06-30/196/eng@2011-05-13.xml"/>
        <FRBRdate date="2017-12-13"/>
        <FRBRauthor href="#" as="#"/>
      </FRBRManifestation>
    </identification>
    <lifecycle source="#source">
      <eventRef source="#lifecycle0" type="generation" eId="eventRef_1" date="2004-01-01"/>
      <eventRef source="#lifecycle1" type="amendment" eId="eventRef_2" date="2008-12-31"/>
      <eventRef source="#lifecycle1" type="amendment" eId="eventRef_3" date="2009-09-25"/>
    </lifecycle>
    <analysis source="#source">
      <passiveModifications>
        <textualMod eId="pmod_1" type="substitution">
          <source href="/akn/it/act/decree/2008-12-30/207#art_162-para_1__content_ins_1"/>
        </textualMod>
        <textualMod eId="pmod_2" type="substitution">
          <source href="/akn/it/act/decree/2008-12-30/207#art_162-para_2__content_ins_1"/>
        </textualMod>
      </passiveModifications>
    </analysis>
  </meta>
</act>

</akomaNtoso>
Assigning data in breach of Section 16, paragraph 1, letter b), and/or other provisions concerning the processing of personal data shall be punished by a fine consisting in payment of between five thousand and thirty thousand Euro.

Breach of the provision referred to in Section 84(1) shall be punished by a fine consisting in payment of between five hundred and three thousand Euro.
Assigning data in breach of Section 16, paragraph 1, letter b), and/or other provisions concerning the processing of personal data shall be punished by a fine consisting in payment of between ten thousand and sixty thousand Euro.

Breach of the provision referred to in Section 84(1) shall be punished by a fine consisting in payment of between one thousand and six thousand Euro.

If personal data are processed in breach of the measures set forth in section 33 and/or the provisions laid down in section 167, an administrative penalty shall be applied in all cases as consisting in payment of a fine ranging from twenty thousand to one hundred and twenty thousand Euro. Reduction of the applicable fine shall be ruled out in the cases referred to in section 33.
<paragraph eld="art_162-e3__para_2-bis">
  <num>2-bis.</num>
  <content eld="art_162-e3__para_2-bis__content">
    <p>Because personal data are processed in breach of the measures set forth in section 33 and/or the provisions laid down in section 167, an administrative penalty shall be applied in all cases consisting in payment of a fine ranging from ten thousand to one hundred and twenty thousand Euro. Reduction of the applicable fine shall be ruled out in the cases referred to in section 33</p>
  </content>
</paragraph>

Table 23 – Multiversioning Akoma Ntoso XML representation of the legal provisions

<table>
<thead>
<tr>
<th>196/2003 IRIs</th>
<th>Enter into efficacy</th>
<th>LegalRuleML</th>
</tr>
</thead>
<tbody>
<tr>
<td>/akn/it/act/legislativedecree/2003-06-30/196/main#art_162</td>
<td>01-01-2004</td>
<td>PS1: if terminatedProcessingOperations (C,X,Y) Then [OBL] destroy(C,X) OR assign(C,X,K) OR keepForPersonalPurposes(C,X) OR transferForScientificPurposes(C,X,K)</td>
</tr>
<tr>
<td>urn:nir:stato:decreto.legislativo:2003-06-30;196</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Article 16 (Termination of Processing Operations)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Should data processing be terminated, for whatever reason, the data shall be a) destroyed; b) assigned to another data controller, provided they are intended for processing under terms that are compatible with the purposes for which the data have been collected; c) kept for exclusively personal purposes, without being intended for systematic communication or dissemination; or d) kept or assigned to another controller for historical, scientific or statistical purposes, in compliance with laws, regulations, Community legislation and the codes of conduct and professional practice adopted in pursuance of Section 12.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Article 162 (Other Types of Non-Compliance)</td>
<td>01-01-2004</td>
<td>PEN1: [OBL] payBetween (C, 5000, 30000)</td>
</tr>
<tr>
<td>1. Assigning data in breach of Section 16, paragraph 1, letter b), and/or other provisions concerning the processing of personal data shall be punished by a fine consisting in payment of between five thousand and thirty thousand Euro.</td>
<td></td>
<td>PEN2: [OBL] payBetween (C, 500, 3000)</td>
</tr>
<tr>
<td>2. Breach of the provision referred to in Section 84(1) shall be punished by a fine consisting in payment of between five hundred and three thousand Euro.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
**Article 162**
(Other Types of Non-Compliance)
1. Assigning data in breach of Section 16, paragraph 1, letter b), and/or other provisions concerning the processing of personal data shall be punished by a fine consisting in payment of between ten thousand and sixty thousand Euro.
2. Breach of the provision referred to in Section 84(1) shall be punished by a fine consisting in payment of between one thousand and six thousand Euro.
2-bis. If personal data are processed in breach of the measures set forth in section 33 and/or the provisions laid down in section 167, an administrative penalty shall be applied in all cases as consisting in payment of a fine ranging from twenty thousand to one hundred and twenty thousand Euro. Reduction of the applicable fine shall be ruled out in the cases referred to in section 33.

**31-12-2008**
PEN3: [OBL] payBetween (C, 10000, 60000)
PEN4: [OBL] payBetween (C, 1000, 6000)

**25/09/2009**

<table>
<thead>
<tr>
<th>Article 162</th>
<th>31-12-2008</th>
<th>PEN3: [OBL] payBetween (C, 10000, 60000)</th>
<th>PEN4: [OBL] payBetween (C, 1000, 6000)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Other Types of Non-Compliance) 1. Assigning data in breach of Section 16, paragraph 1, letter b), and/or other provisions concerning the processing of personal data shall be punished by a fine consisting in payment of between ten thousand and sixty thousand Euro. 2. Breach of the provision referred to in Section 84(1) shall be punished by a fine consisting in payment of between one thousand and six thousand Euro. 2-bis. If personal data are processed in breach of the measures set forth in section 33 and/or the provisions laid down in section 167, an administrative penalty shall be applied in all cases as consisting in payment of a fine ranging from twenty thousand to one hundred and twenty thousand Euro. Reduction of the applicable fine shall be ruled out in the cases referred to in section 33.</td>
<td>31-12-2008</td>
<td>PEN3: [OBL] payBetween (C, 10000, 60000)</td>
<td>PEN4: [OBL] payBetween (C, 1000, 6000)</td>
</tr>
</tbody>
</table>

Table 24 – Legal rules corresponding to the legal provisions

```xml
<?xml version="1.0" encoding="UTF-8"?>
  <lrml:LegalReferences type="legislative">
    <lrml:LegalReference refersTo="ref1" refID="/akn/it/act/legislativedecree/2003-06-30/196/eng@2009-09-25/main/art_16"
      refIDSystemName="AkomaNtoso3.0-2017-06-08"/>
  </lrml:LegalReferences>
</lrml:LegalRuleML>
```

Definition of the isomorphism information. Legal text IRIs
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<table>
<thead>
<tr>
<th>Ref ID</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ref3</td>
<td>06-30/196/eng@2009-09-25/main#art_162_para_1</td>
</tr>
<tr>
<td>ref4</td>
<td>06-30/196/eng@2009-09-25/main#art_162-e2_para_1</td>
</tr>
<tr>
<td>ref5</td>
<td>06-30/196/eng@2009-09-25/main#art_162-e2_para_2</td>
</tr>
<tr>
<td>ref6</td>
<td>06-30/196/eng@2009-09-25/main#art_162-e2_para_2-bis</td>
</tr>
<tr>
<td>ref7</td>
<td>06-30/196/eng@2009-09-25/main#art_162-e3_para_2-bis</td>
</tr>
<tr>
<td>ref8</td>
<td>Authority that...</td>
</tr>
<tr>
<td>ref9</td>
<td>Authority that...</td>
</tr>
</tbody>
</table>

Temporal information.

Three events.

Three intervals of efficacy.
Report and tutorial materials on new formal techniques for modelling the representation of embedded legal knowledge in legal texts, concept holism in the legal domain.

```xml
<lrml:Authorities>
  <lrml:Authority key="itPar" sameAs="http://example.org/authority#italianParliament"/>
</lrml:Authorities>
<lrml:Jurisdictions>
  <lrml:Jurisdiction key="it" sameAs="http://example.org/jurisdiction#italy"/>
</lrml:Jurisdictions>
<lrml:Associations>
  <lrml:Association key="sourceBlock1">
    <lrml:appliesTemporalCharacteristic keyref="#period1"/>
    <lrml:appliesAuthority keyref="#itPar"/>
    <lrml:appliesSource keyref="#ref1"/>
    <lrml:toTarget keyref="#ps1"/>
  </lrml:Association>
  <lrml:Association key="sourceBlock2">
    <lrml:appliesTemporalCharacteristic keyref="#period1"/>
    <lrml:appliesAuthority keyref="#itPar"/>
    <lrml:appliesSource keyref="#ref2"/>
    <lrml:toTarget keyref="#pen1"/>
  </lrml:Association>
  <lrml:Association key="sourceBlock3">
    <lrml:appliesTemporalCharacteristic keyref="#period2"/>
    <lrml:appliesAuthority keyref="#itPar"/>
    <lrml:appliesSource keyref="#ref4"/>
    <lrml:toTarget keyref="#pen2"/>
  </lrml:Association>
</lrml:Associations>
<lrml:Context key="ruleInfo1">
  <lrml:appliesAssociations keyref="#sourceBlock1"/>
  <lrml:inScope keyref="#ps1"/>
</lrml:Context>
<lrml:Context key="ruleInfo2">
  <lrml:appliesAssociations keyref="#sourceBlock2"/>
  <lrml:inScope keyref="#ps1"/>
</lrml:Context>
<lrml:Context key="ruleInfo3">
  <lrml:appliesAssociations keyref="#sourceBlock3"/>
  <lrml:inScope keyref="#ps1"/>
</lrml:Context>
<lrml:Statements>
  <lrml:PrescriptiveStatement key="ps1">
    <ruleml:Rule key="#rule1" closure="universal">
      <ruleml:If>
        <ruleml:Atom key="#atom6">
          <ruleml:Rel iri="terminateProcessingOperations"/>
          <ruleml:Ind iri="personalData">X</ruleml:Ind>
          <ruleml:Ind iri="dataSubject">Y</ruleml:Ind>
          <ruleml:Ind iri="controller">C</ruleml:Ind>
        </ruleml:Atom>
        <ruleml:Then>
          <lrml:Obligation>
            <ruleml:Or key="#or1">
              <ruleml:Atom key="#atom1">
                <ruleml:Rel iri="destroy"/>
            </ruleml:Atom>
          </lrml:Obligation>
        </ruleml:Then>
      </ruleml:If>
    </ruleml:Rule>
  </lrml:PrescriptiveStatement>
</lrml:Statements>
```

The provided XML code shows the structure of the metadata and the rules associated with it, including the relationships between the authorities, jurisdictions, and context definition, as well as the prescriptive statements that provide the rules for data management and processing.
Report and tutorial materials on new formal techniques for modelling the representation of embedded legal knowledge in legal texts, concept holism in the legal domain

<table>
<thead>
<tr>
<th>RuleML Code</th>
<th>Penalty</th>
<th>Reparation</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;ruleml:Ind iri=&quot;atom2&quot;/&gt;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;ruleml:Ind iri=&quot;atom3&quot;/&gt;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;ruleml:Ind iri=&quot;atom4&quot;/&gt;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;ruleml:Rel iri=&quot;assign&quot;/&gt;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;ruleml:Ind iri=&quot;thirdParty&quot;&gt;K<a href="">ruleml:Ind</a></td>
<td></td>
<td></td>
</tr>
<tr>
<td><a href="">ruleml:Atomic</a></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;ruleml:Atom key=&quot;atom2&quot;/&gt;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;ruleml:Rel iri=&quot;keepForPersonalPurposes&quot;/&gt;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;ruleml:Ind iri=&quot;thirdParty&quot;&gt;K<a href="">ruleml:Ind</a></td>
<td></td>
<td></td>
</tr>
<tr>
<td><a href="">ruleml:Atomic</a></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;ruleml:Atom key=&quot;atom3&quot;/&gt;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;ruleml:Rel iri=&quot;transferForScientificPurposes&quot;/&gt;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;ruleml:Ind iri=&quot;thirdParty&quot;&gt;K<a href="">ruleml:Ind</a></td>
<td></td>
<td></td>
</tr>
<tr>
<td><a href="">ruleml:Atomic</a></td>
<td></td>
<td></td>
</tr>
<tr>
<td><a href="">ruleml:Or</a></td>
<td></td>
<td></td>
</tr>
<tr>
<td><a href="">ruleml:Obligation</a></td>
<td></td>
<td></td>
</tr>
<tr>
<td><a href="">ruleml:then</a></td>
<td></td>
<td></td>
</tr>
<tr>
<td><a href="">lrml:Obligation</a></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;lrml:PenaltyStatement key=&quot;pen1&quot;&gt;</td>
<td></td>
<td></td>
</tr>
<tr>
<td><a href="">lrml:SuborderList</a></td>
<td></td>
<td></td>
</tr>
<tr>
<td><a href="">lrml:Obligation</a></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;lrml:Rel iri=&quot;payBetween&quot;/&gt;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;lrml:Var iri=&quot;euro&quot;&gt;5000<a href="">lrml:Var</a></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;lrml:Ind iri=&quot;euro&quot;&gt;3000<a href="">lrml:Ind</a></td>
<td></td>
<td></td>
</tr>
<tr>
<td><a href="">lrml:Obligation</a></td>
<td></td>
<td></td>
</tr>
<tr>
<td><a href="">lrml:SuborderList</a></td>
<td></td>
<td></td>
</tr>
<tr>
<td><a href="">lrml:Obligation</a></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;lrml:Rel iri=&quot;payBetween&quot;/&gt;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;lrml:Var iri=&quot;euro&quot;&gt;10000<a href="">lrml:Var</a></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;lrml:Ind iri=&quot;euro&quot;&gt;60000<a href="">lrml:Ind</a></td>
<td></td>
<td></td>
</tr>
<tr>
<td><a href="">lrml:Obligation</a></td>
<td></td>
<td></td>
</tr>
<tr>
<td><a href="">lrml:SuborderList</a></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;lrml:PenaltyStatement key=&quot;pen2&quot;&gt;</td>
<td></td>
<td></td>
</tr>
<tr>
<td><a href="">lrml:SuborderList</a></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;lrml:PenaltyStatement key=&quot;rep1&quot;&gt;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;lrml:Reparation key=&quot;assoc1&quot;&gt;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;lrml:appliesPenalty keyref=&quot;#pen1&quot;/&gt;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;lrml:toPrescriptiveStatement keyref=&quot;#ps1&quot;/&gt;</td>
<td></td>
<td></td>
</tr>
<tr>
<td><a href="">lrml:Obligation</a></td>
<td></td>
<td></td>
</tr>
<tr>
<td><a href="">lrml:SuborderList</a></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;lrml:PenaltyStatement key=&quot;rep2&quot;&gt;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;lrml:Reparation key=&quot;assoc2&quot;&gt;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;lrml:appliesPenalty keyref=&quot;#pen2&quot;/&gt;</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Report and tutorial materials on new formal techniques for modelling the representation of embedded legal knowledge in legal texts, concept holism in the legal domain

Table 25 – LegalRuleML modelling of the legal rules

The ps1 is modelled only one time and it is effective starting at e1, but the penalty depends to the temporal versions: pen1 is the penalty effective in the interval \([e1, e2]\) and the pen2 is effective \([e2, \infty)\]. In this manner if we need to define the penalty of a fact in a given time after e2 we will apply pen2, otherwise pen1.

5 Applications and Tools

5.1 Methodology

The application of LegalRuleML is combined with other XML standards following a precise methodology developed by CIRSFID:

1. legal text is marked up using Akoma Ntoso XML standard [39] in order to represent the main structure of the document, the normative references, metadata concerning the legal informative like temporal metadata concerning the time of enter into force;

2. legal text is also analysed by a Legal Ontologist for modelling the legal concepts and for defining the main relationships between the concepts. The relationships are used for assigning the predicates in the rules (e.g., in the Rel element the predicate is specified using the attribute @iri, \(<\text{ruleml:Rel } \text{iri=":personal_data_processing"}/>)

3. legal text is later on modelled by a Legal Knowledge Engineer, who extracts the norms and guidelines, applies models and a theory within a logical framework, and finally represents the norms using the formalism of LegalRuleML.

Using this methodology it is possible to use logic engine like SPINdle for performing legal reasoning [25].
Figure 7 – Semantic Web application of Akoma Ntoso XML standard, Legal ontology and LegalRuleML.

<table>
<thead>
<tr>
<th>Legal Text</th>
<th>XML AKN serialization</th>
</tr>
</thead>
<tbody>
<tr>
<td>Article 8 - Conditions applicable to child's consent in relation to information society services</td>
<td></td>
</tr>
<tr>
<td>1. Where point (a) of Article 6(1) applies, in relation to the offer of information society services directly to a child, the processing of the personal data of a child shall be lawful where the child is at least 16 years old. Where the child is below the age of 16 years, such processing shall be lawful only if and to the extent that consent is given or authorised by the holder of parental responsibility over the child.</td>
<td></td>
</tr>
</tbody>
</table>

```xml
<?xml version="1.0" encoding="UTF-8"?>
<akomaNtos xmlns="http://docs.oasis-open.org/legaldocml/legaldocml/akn/3.0/WD17" xmlns:html="http://www.w3.org/1999/xhtml">
  <act name="act">
    <meta>
      <identification source="#source">
        <FRBRWork>
          <FRBThis value="/akn/Eu/act/regulation/EU/2016-04-27/679/!main"/>
          <FRBRURI value="/akn/Eu/act/regulation/EU/2016-04-27/679"/>
          <FRBRdate date="2016-04-27" name=""/>
          <FRBRauthor href="#" as="#"/>
          <FRBRcountry value="Eu"/>
        </FRBRWork>
        <FRBRExpression>
          <FRBThis value="/akn/Eu/act/regulation/EU/2016-04-27/679/eng@/!main"/>
          <FRBRURI value="/akn/Eu/act/regulation/EU/2016-04-27/679/eng@"/>
          <FRBRdate date="2016-04-27" name=""/>
          <FRBRauthor href="#" as="#"/>
          <FRBRLanguage languages="eng"/>
        </FRBRExpression>
      </identification source="#source">
    </meta>
  </act>
</akomaNtos>
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---

<FRBRuri value="/akn/Eu/act/regulation/EU/2016-04-27/679/eng@.xml"/>
<FRBRdate date="2018-01-05" name=""/>
<FRBRauthor href="#" as="#"/>
</FRBRManifestation>

<references source="#source">
<TLCPerson eId="child" href="/akn/ontology/person/child" showAs="Somebody"/>
<TLCCConcept eId="at_least16years" href="/akn/ontology/concept/at_least16years" showAs="Somebody"/>
<TLCCConcept eId="personal_data_processing" href="/akn/ontology/concept/personal_data_processing" showAs="Somebody"/>
<TLCCConcept eId="information_society_service" href="/akn/ontology/concept/information_society_service" showAs="Somebody"/>
<TLCPerson eId="source" href="/akn/ontology/person/somebody" showAs="Somebody"/>
</references>
</meta>
<preface>
<p>REGULATION (EU) OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 27 April 2016 on the protection of natural persons with regard to the processing of personal data and on the free movement of such data, and repealing Directive 95/46/EC (General Data Protection Regulation)
</p>
<body>
<article eId="art_8">
<num>Article 8</num>
<header eId="art_8__heading">- Conditions applicable to child's consent in relation to information society service</header>
<paragraph eId="art_8__para_1">
<num>1.</num>
<content eId="art_8__para_1__content">
<p>Where point (a) of Article 6(1) applies, in relation to the offer of information society services directly to a child, the processing of the personal data of a child shall be lawful where the child is at least 16 years old. Where the child is below the age of 16 years, such processing shall be lawful only if and to the extent that consent is given or authorised by the holder of parental responsibility over the child.
</p>
</content>
</paragraph>
</article>
</body>
</act>

Legal concepts

- Individual(PRONTO:child type(PRONTO:person))

OWL DL

- SubClassOf(PRONTO: data_controller PRONTO: data)

Axioms

- SubClassOf(PRONTO: personal_data_processing PRONTO: process)
### Part II

Report and tutorial materials on new formal techniques for modelling the representation of embedded legal knowledge in legal texts, concept holism in the legal domain

<table>
<thead>
<tr>
<th>Logic rule modelling</th>
<th>IF:</th>
<th>THEN:</th>
</tr>
</thead>
<tbody>
<tr>
<td>personal_data_processing(d,x) &amp; child(x) &amp; at_least16years(x) &amp; information_society_service(s,d) &amp; data_controller(y,s)</td>
<td>obligation_to_obtain_consent(y,x,s)</td>
<td></td>
</tr>
</tbody>
</table>

#### LegalRuleML XML serialization

```
<lrml:PrescriptiveStatement key="ps1">
  <lrml:Rule key=":ruletemplate2" closure="universal">
    <lrml:Paraphrase>
      If the student is minor and if the student is emancipated, in any case, he/she can provide autonomous consent, if it is considered an action of ordinary administration
    </lrml:Paraphrase>
    <lrml:if>
      <lrml:And key=":and1">
        <lrml:Atom key=":atom1">
          <lrml:Rel iri=":child"/>
          <lrml:Ind>x</lrml:Ind>
        </lrml:Atom>
        <lrml:Atom key=":atom2">
          <lrml:Rel iri=":at_least16years"/>
          <lrml:Ind>X</lrml:Ind>
        </lrml:Atom>
      </lrml:And>
      <lrml:Atom key=":atom3">
        <lrml:Rel iri=":personal_data_processing"/>
        <lrml:Ind>D</lrml:Ind>
        <lrml:Ind>X</lrml:Ind>
      </lrml:Atom>
      <lrml:Atom key=":atom4">
        <lrml:Rel iri=":information_society_service"/>
        <lrml:Ind>D</lrml:Ind>
        <lrml:Ind>S</lrml:Ind>
      </lrml:Atom>
      <lrml:Atom key=":atom5">
        <lrml:Rel iri=":data_controller"/>
        <lrml:Ind>Y</lrml:Ind>
        <lrml:Ind>S</lrml:Ind>
      </lrml:Atom>
    </lrml:if>
    <lrml:then>
      <lrml:Atom key=":atom6">
        <lrml:Rel iri=":obligation_to_obtain_consent"/>
        <lrml:Ind>X</lrml:Ind>
        <lrml:Ind>Y</lrml:Ind>
        <lrml:Ind>S</lrml:Ind>
      </lrml:Atom>
    </lrml:then>
  </lrml:Rule>
</lrml:PrescriptiveStatement>
```
5.2 RAWE Web Editor for LegalRuleML

For modelling the legal rules in LegalRuleML CIRSFI D developed RAWE (Rule Advanced Web Editor [28]). RAWE is a web editor developed using Web technologies. RAWE helps to connect the legal texts with the legal rules, it supports the end-user to model the legal rules using visual graphic blocks, and it synchronizes the metadata of the legal document with the metadata of the legal rules.

We use graphic blocks of Scratch programming for modelling legal rules. The metadata of the text are copied from Akoma Ntoso standard to LegalRuleML standard for guaranteeing harmonization, interoperability, integration, consistency.

Each part of the text is connected with the proper rules. In case of modification of the text, we can detect all the rules affected by the modification.

The button "ontology" permits to link to each part of LegalRuleML the correct predicates using the ontology extended for a specific legal domain (e.g., privacy).
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Figure 10 – Ontology classes and individuals for populating the legal rules.

Figure 11 – RAWE web editor: LegalRuleML XML serialization.

The tool is capable to translate the modelling in LegalRuleML and to call SPIndle for starting the legal reasoning process.
6  Evaluation

One of the most important phase in the standardization language process is the evaluation by the end-user, not in term of syntax, but in term expressiveness, effectiveness, usability.

For this reason CSIRO-Data61 and The University of Rostock produced the survey for testing the “Formal Contract Logic” methodology used for modelling legal rules. The survey is attached in the Annex III.

The survey test is divided in three main blocks:

1. Statements decomposition in logic rules: seven statements coming from contract are modelled with logic rule. The end-user should indicates if there are mistakes and some suggestions are provided.

2. Composition of rules with some predetermined predicates: some statements coming from contract are provided and the end-user should model them in logic rules using some predetermined predicates.

3. Information about skills and data of the end-user: the mathematical basis are tested and non-personal data are collected for statistical reason (e.g., age, education).

The evaluation was conducted inside of the “Law, Science and Technology” PhD class, on December 20, with five doctoral candidates with law background and one doctoral candidate with computer science competences. All the students are Italian. The test was completed in one hour and half. Linguistic barriers influenced the timing.

7  Conclusions

LegalRuleML guarantees to implement all the legal requirements of the legal rule modelling and the operators capable to perform an effective and computable legal reasoning.

LegalRuleML permits also to link semantic ontology to the legal rule modelling and in this way to extract RDF assertions useful for the Linked Open Data.

LegalRuleML is integrated with others Legal XML standards for implementing the semantic web cake layers like Akoma Ntoso.

LegalRuleML can modelled using graphic tools and specialized editor for helping the legal knowledge engineer to combine text, norms, legal rules and legal concepts.
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References

Report and tutorial materials on new formal techniques for modelling the representation of embedded legal knowledge in legal texts, concept holism in the legal domain

43. Athan, Tara; Governatori, Guido; Palmirani, Monica; Paschke, Adrian; Wyner, Adam, LegalRuleML: Design Principles and Foundations, in: Reasoning Web. Web Logic Rules, springer, 2015, Volume 9203, pp. 151 - 188 (atti di: 11th International Summer School 2015, Berlin, Germany, July 31- August 4
Appendix I

Semantic web ecosystem for modelling Legal Knowledge

Monica Palmirani
CIRSFID, University of Bologna
Jurix2017, Luxembourg

14 December 2017
Outline

• Goal: Set of Standards for modelling Legal Knowledge – reuse, interoperability, integration
• Components of the set
  – Legal IRI
  – Legal XML
  – Legal RDF and Ontology
  – LegalRuleML
• A scenario of application: Cloud4EU Project
• Conclusions
Gaol: Set of Standards for modelling Legal Knowledge

• “Fill the gap” between text and formal logic modelling and in future also the interpretation.
• In the legal domain we have different objects to represent:
  – **norms**: abstract mandatory commands concerning rights or duties
  – **legal concepts**: abstract category of concepts (e.g. *good faith*)
  – **textual provisions**: sequences of texts that expresses the norms and concepts
  – **rules**: modelling of the text in logical rules and convert them in a formal representation
  – **interpretation**: additional meta-rules on the top of other rules - *hermeneutics*
«Fill the gap» between disciplines

- Define a robust approach for joining three fields of the legal research:
  - Document Management & Archiving - TEXT
  - Semantic Web – CONCEPT & METADATA
  - AI&Law and Legal – RULES & INTERPRETATION

- Set of technical standards for fostering and integrating valuable AI&Law research results:
  - Legal reasoning including temporal aspects
  - Legal knowledge extraction using NLP
  - Legal ontology and semantic web applications
  - Network Analysis
  - Visualization for the citizen
Legal XML, Semantic Web and AI&Law

• In the last fifteen years several Legal XML standards were arisen for describing the legal text but not all have these characteristics [Metalex/CEN, Akoma Ntoso, USML, Formex 4.0, etc.]

• Also several standards are present in the scenario for representing rules [RuleML, RIF, SWRL, LKIF-rule, etc.]

• Legal Ontology research [e.g. LKIF-core, JusWordNet, ELI ontology, EuroVoc, etc.] combined with the NLP extraction of the semantic has borne a great impulse to the modelling of the legal concepts for the Semantic Web


• Semantic Web community more focused on Linked Open Data [Casanovas, Palmirani, Peroni, van Engers, Vitali: Semantic Web for the Legal Domain: The next step. Semantic Web, 2017]
Set of standards for «Fill the Gap»

- Provide a set of integrated standards for modelling all the Semantic Web cake in legal domain
- Provide an integrated architecture able to take advantage from the integration of all the knowledge and fill the gap between text, ontologies, rules

- LegalRuleML - OASIS
- Metalex CEN ontology - RDF
- LegalDocML – Akoma Ntoso
- LegalCiteM – OASIS
- URN:LEX
- AKN
- ECLI
- ELI

Sartor, 2009
Legal Document, Legal Rules, Legal Ontology

Legal document in XML

Legal Ontology

Logic Rules

Annotation
Crowd-sourcing
Citizen participation
Market applications
Civic media

Linked Open Data

Certified process

Web of things

ENGINE

Rendering for the end-user
Set of standards for what?

- Management *over the time* of the legal sources especially in digital era
- Inclusion of the *legal knowledge*
- Extraction of RDF assertions for populating *Semantic Web/LOD*
- Underpin *linguistic analysis* of the text (NLP) and translation task
- Support *Legal checking compliance* and *Legal reasoning*
- Favour *Visualization* and *network analysis*
- *Interoperability* between different solutions/systems
- *Integration* of research modules inside of commercial applications
Article 4 Definitions
For the purposes of this Regulation:
(1) ‘personal data’ means any information relating to an identified or identifiable natural person (‘data subject’); an identifiable natural person is one who can be identified, directly or indirectly, in particular by reference to an identifier such as a name, an identification number, location data, an online identifier or to one or more factors specific to the physical, physiological, genetic, mental, economic, cultural or social identity of that natural person;

Interpretation: identifiable natural person

Const. Rule: IF X is naturalPerson AND X identifiableWith Y THEN X is a identifiable natural person

Example: Regulation (EU) 2016/679 – GDPR

- Legal, court, business, academic, and technology professionals.
- Collaboration on non-proprietary standards for the legal community.

OASIS LegalXML Member Section – March 2002.

LegalXML

LegalDocML (Akoma Ntoso - 2012)

LegalRuleML (rules - 2012)

LegalCiteM (citations - 2014)
Legal IRI
(Internationalized Resource Identifiers)

«So that certainly the word "nomen" comes from "nomos", or law, given that precisely the "nomination" are given by the men "ad placitum", ie for free and collective convention.»

The Name of the Rose, Umberto Eco
Legal naming convention for identifiers and references

- MetalexCEN (2007)
- Akoma Ntoso (2008)
- ECLI (2011)
- ELI (2012) Council conclusions inviting the introduction of the European Legislation Identifier (ELI) (2012/C 325/02)
- urn:lex (2013)
- Current Akoma Ntoso version (2017)
- LegalCiteM (2018) – metamodel
Characteristics for Legal IRI

1. **MEANINGFULNESS**: the name is a meaningful and logical description of the resource and not of its physical path.
2. **PERMANENCE**: the name must be permanent and stable over time.
3. **INVARIANCE**: the name must derive from invariant properties of the resource so as to provide some degree of certainty in obtaining the same name for the same resource regardless of process, *tool and person.*
IFLA FRBR model

WORK

realizes 1

COMPONENTS

EXPRESSION

embodies 1

COMPONENTS

MANIFESTATION

1

ITEM

exemplifies

ACT 2016/679

English VERSION 2 of the ACT 2016/679

FILE XML of the VERSION 2 of the ACT 2016/679

Specific FILE XML on the server of the VERSION 2 of the ACT 2016/679
Two valid versions at the same $t$

- Multiple versions are possible that are valid at the same time especially in the retroactive modifications

```
<table>
<thead>
<tr>
<th>t0</th>
<th>t1</th>
<th>ti</th>
<th>ti+1</th>
<th>tn+1</th>
<th>tn</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>URI@version_date;view_date</td>
<td>URI@version_date;view_date</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
```

Retroactive repeal
The two versions are equally plausible and the resolver has to retrieve both
FRBR – URI in Akoma Ntoso

/work

expression

man.

manifestation of the expression in force at 2016 but with the view of 2017
FRBR – URI in Akoma Ntoso

QUERY METHODS

/akn/eu/act/2016-04-27/2016-679/:2017-12-12 – all versions close to 12 Dec 2017

/akn/eu/act/2016-04-27/2016-679/eng:2016-12-12->2017-12-12 – all versions included between the two dates

LegalCiteM Mission

• The LegalCiteM TC develops an open standard for machine-readable tagging of legal citations based upon a formalized conceptual model, vocabulary, metadata definitions, and prescribed syntax.

• The idea is to take textual citation and to formalize it in a reference capable to be de-referenced in any other local specific identifier

• **ECLI:EU:C:2014:317**
….Appeal Court of The Hague (judgment 28 November 1968, case-law N.V. Cabolent c. National Iranian Oil Company)…. 
Legal XML standards

«Things should be as simple as possible, but not simpler»
Albert Einstein
Legal XML standards in the world

1997 • EnAct - Tasmania, Australia, New Zealand e Canada
1999 • FORMEX data model - EUR-LEX
2001 • NormeinRete – Italy
2002 • MetaLex and SDU BWB - Netherland
2003 • LexDania – Denmark
2003 • eLaw - Austria
2004 • CHLexML - Swiss
2006 • AKOMA NTOSO - United Nations for Pan-African Parliaments
2008 • Crown XML Schema for Legislation - United Kingdom
2008 • Chile XML
2009 • House of Representatives
2013 • USML schema

2007-2009
Legal XML characteristics

1. **Document oriented** – document is the central
2. **Self-contained and Self-explainable** – document is autonomous
3. **Descriptive** – document is well described also in odd structure
4. **Prescriptive** – document is checked in quality
5. **Separation of concerns** - content, metadata, presentation are separated
6. **Ontology-oriented** – the ontology level is external of the document
7. **Technology Natural** – independent from technology
8. **Persistent over time** – long term preservation for archiving
9. **Workflow-oriented** – document is part of a legislative process
AKOMA NTOSO

• An open XML standard for any legal document used in Parliamentary processes and judiciary systems

• Started in 2004-2005 within the project “Strengthening Parliaments’ Information Systems in Africa”, promoted by the UNITED NATIONS Department for Economics and Social Affairs (UNDESA)

• Akoma Ntoso means “Linked Hearts” and it is a symbol used by the Akan people of West Africa to represent understanding and agreement

• Now in OASIS standardization process: LegalDocML
Akoma Ntoso document types

UNITED NATIONS SYSTEM

Chief Executives Board for Coordination

HIGH-LEVEL COMMITTEE ON MANAGEMENT (HLCM)

Akoma Ntoso for the United Nations System

Guidelines for the mark-up of UN normative, parliamentary and judicial documents
Akoma Ntoso for Transparency, Quality and Efficiency

XML by itself is not a guaranty for transparency. Yet, Akoma Ntoso has explicit features that support it:

- Clear division of metadata from official content
- Explicit lifecycle of the document and tracking of workflow events
- Systematic connection of separate pieces of information to extract new legal knowledge
- Long-term preservation of legal validity (authentic document, integrity)
- Management of multiple linguistic expressions
- Data model for open government data
- Preservation of privacy/liability issues (e.g. in judiciary document according to GDPR)
Common Law example


Civil Law examples


Che cosa è dati.senato.it

Il punto per l'accesso diretto ai dati del Senato della Repubblica. Aggiornamenti quotidiani di informazioni facilmente e liberamente utilizzabili (dati aperti) che riguardano ogni aspetto dell'attività politica e istituzionale: i disegni di legge con il loro iter, le votazioni elettroniche d'Aula, le Commissioni, i Gruppi parlamentari e tante altre informazioni.

Una base informativa messa a disposizione di cittadini, ricercatori, giornalisti e sviluppatori per analizzare e condividere la conoscenza di cosa viene proposto, discusso e votato dai rappresentanti del popolo nella Camera alta del Parlamento italiano.

I dati sono disponibili in formato XML che permette di integrarsi direttamente con le applicazioni di Dati Aperti.
“USLM is designed to be consistent with Akoma Ntoso to the extent practicable. Many of the element and attribute names in USLM match the Akoma Ntoso equivalents. As Akoma Ntoso becomes a standard, and as demand for it emerges, it should be possible to produce an Akoma Ntoso XML rendition of the United States Code through a simple transformation.”

Success stories of Akoma Ntoso

- Senate of Brazil (act, bill, consolidation, point-in-time)
- **European Parliament** (bill and amendments)
- Library of Congress of Chile (bill and debates)
- Senate of Italy (bill publication in open data)
- Parliament of Uruguay (bill workflow)
- US Code Consolidation service (code management)
- State of California (xml standard for document management)
- Hong Kong City State (xml standard for document management)
- Federal Chancellery of Switzerland (publication in gazette)
- High Court of Cassation of Italy (xml standard for document management)
- UK The National Archives
- FAO - UN

South Africa SAFLII [http://www.saflii.org/content/partners](http://www.saflii.org/content/partners)
Akoma Ntoso temporal model

- Each **event** is tracked in metadata
- Each **modification** is annotated using a taxonomy
- Renumbering **mapping** mechanism manages the changes over time
- **Retroactivity** and **multiple versions** are managed
- Sophisticated mechanism of **timing** in the text (e.g., suspension, derogation, prolongation, etc.)
- **Consolidation** elements in the text for managing redlining, consolidation, codification
- **Static** and **dynamic** references
Example 1: COMMISSION REGULATION (EU) No 742/2010 of 17 August 2010

Article 2

This Regulation shall enter into force on the day following its publication in the Official Journal of the European Union.

It shall apply from 1 July 2010.

However, Article 1(2), as regards point B of Part II, Part III, point (a) of Part IV and Part V of Annex I to Regulation (EU) No 1272/2009, shall apply from 1 July 2011.

Date of delivery 17 August 2010
Publication date 18.8.2010
Date of inforce 19 Aug. 2010
Date of efficacy 1 July 2010
Derogation of Date of efficacy 1 July 2011
Example 2 – EU directive VAT special services

Visit the web-site
http://normaxml.cirfid.unibo.it/cassation/

D= date of delivery
F=date of enter into force
E= date of enter into operation
Example 3: Retroactive annulment

Time line

$t_0$ $t_1$ $t_2$ $t_i$ $T_{x-1}$ $t_x$

Normative system

Yesterday

$A_0$ $A_1$ $A_2$ .... $A_{i-1}$ $A_i$ .... $A_{x-1}$ $A_x$

ART. 3 annulled

Annulment by Constitutional court decision

ART. 3 annulled

view of the Legal system in the time $t_2$ with the knowledge of $t_j$

view of the Legal system in the time $t_x$ with the knowledge of $t_j$
### PROYECTO DE LEY

#### Artículo 1º.

- Declarése, por vía interpretativa, a los efectos dispuestos por la Ley Nº 12.091, de 5 de enero de 1954 y por la Ley Nº 13.367, de 27 de abril de 1963, que las embarcaciones deportivas o de recreo, de bandera extranjera, con sus accesorios, que arriben al país navegando por sus propios medios, podrán entrar, permanecer y salir de aguas jurisdiccionales o de puertos o lugares de la República amparadas por su bandera y sin otro requisito que presentar el rol respectivo de la tripulación y la matrícula, sin cumplir con las exigencias aplicables a los buques mercantes, pudiendo ser sus propietarios y/o usuarios, personas físicas o jurídicas, nacionales o extranjeras, radicadas o no en el país.

#### Artículo 2º.

### PROYECTO DE LEY

#### Artículo 1º.

- Declarése, por vía interpretativa, a los efectos dispuestos por la Ley Nº 12.091, de 5 de enero de 1954, que las embarcaciones deportivas o de recreo, de bandera extranjera, con sus accesorios, que arriben al país navegando por sus propios medios, podrán entrar, permanecer sin límites de tiempo y salir de aguas jurisdiccionales o de puertos o lugares de la República, amparadas por su bandera, registrando el rol respectivo de la tripulación y la matrícula ante la Prefectura Naval, pudiendo ser sus propietarios y/o usuarios, personas físicas o jurídicas nacionales o extranjeras radicadas o no en el país.

#### Artículo 2º.
CODEX – FAO portal

1. SCOPE
This standard applies to olive oils and olive pomace oils described in Section 2 presented in a state for human consumption.

2. DESCRIPTION
Olive oil is the oil obtained solely from the fruit of the olive tree (Olea europaea L.), to the exclusion of oils obtained using solvents or re-esterification processes and of any mixture with oils of other kinds. Virgin olive oils are the oils obtained from the fruit of the olive tree solely by mechanical or other physical means under conditions, particularly thermal conditions, that do not lead to alterations in the oil, and which have not undergone any treatment other than washing, decanting, centrifuging and filtration. Olive-pomace oil is the oil obtained by treating olive pomace with solvents other than halogenated solvents or by other physical treatments, to the exclusion of oils obtained by re-esterification processes and of any mixture with oils of other kinds.

8. ESSENTIAL COMPOSITION AND QUALITY FACTORS
Extra virgin olive oil: virgin olive oil with a free acidity, expressed as oleic acid, of not more than 0.8 grams per 100 grams and whose other characteristics correspond to those laid down for this category. Virgin olive oil: virgin olive oil with a free acidity, expressed as oleic acid, of not more than 2.0 grams per 100 grams and whose other characteristics correspond to those laid down for this category. Ordinary virgin olive oil: virgin olive oil with a free acidity, expressed as oleic acid, of not more than 3.3 grams per 100 grams and whose other characteristics correspond to those laid down for this category.2. Refined olive oil: olive oil obtained from virgin olive oils by refining methods which do not lead to alterations in the initial glyceride structure. It has a free acidity, expressed as oleic acid, of not more than 0.3 grams per 100 grams and its other characteristics correspond to those laid down for this category.3. Olive oil: oil consisting of a blend of refined olive oil and virgin olive oils suitable for human consumption. It has a free acidity, expressed as oleic acid, of not more than 1 gram per 100 grams and its other characteristics correspond to those laid down for this category.4. Refined olive-pomace oil: olive-pomace oil obtained from crude olive-pomace oil by refining methods which do not lead to alterations in the initial glyceride structure. It has a free acidity, expressed as oleic acid, of not more than 0.3 grams per 100 grams and its other characteristics correspond to those laid down for this category.5. Olive-pomace oil: oil consisting of a blend of refined olive-pomace oil and virgin olive oils. It has a free acidity, expressed as oleic acid, of not more than 1 gram per 100 grams and its other characteristics correspond to...
Visualization tools
Legal RDF and Ontology

«Excuse me, but what can I do for time and space to be exactly the same thing? That is, I ask someone who is now and he answers me: "6 kilometers". What is this?» (Dobel)

Woody Allen, Anything Else
AKN and semantic web

1. Simple vocabulary
   - Term: Privacy
   - Keyword: protection of privacy

2. Linguistic ontology
   - Term: Privacy

3. Ontology
   - Term: Right to access
   - Keyword: Access
   - TLCTerm: Privacy International
   - TLCCConcept: rightToAccess
UNDO ontology

- [https://unsceb-hlcm.github.io/](https://unsceb-hlcm.github.io/)

Roles and statues
«and they don't seem to have any rules in particular; at least, if there are, nobody attends to them» Alice's Adventures in Wonderland
Lewis Carroll
RuleML Family of Sublanguages

RuleML

LegalRuleML

Deliberation

HOL

FOL

Derivation

Fact

Query

Hornlog

Datalog

Consumer

Reaction

KR

ECAP

CEP

Trigger (EA)

Production (CA)

Extension

subClassOf

Overlaps

Syntactic specialization of
LegalRuleML: Main features

• Different **types of rules:**
  • Constitutive rules (e.g. definitions)
  • Prescriptive rules (e.g. obligation, permission, etc.)
  • Facts
• **Isomorphism** – connecting rules with the text
  * (fill the gap)*
• **Deontic operators**
  – obligation, permission, right, prohibition, compliance, violation, reparation
• **Defeasibility**
• **Temporal parameters**
• **RDF meta model**

*Tara Athan, Guido Governatori, Monica Palmirani, Adrian Paschke, Adam Z. Wyner: LegalRuleML: Design Principles and Foundations. Reasoning Web 2015: 151-188*
LegalRuleML Approach

Judge1

Context of rule1

Judge2

Context of rule2

Multiple rules as (alternative) interpretations of the same text
LegalRuleML Approach

Multiple sources for the same rule

Context 1 of rule3
National

Context 2 of rule3
Regional

Context 3 of rule3
European

Context T2 of rule3-v2

LegalRuleML Approach
LegalRuleML main blocks

Metadata
- Legal Sources
- References
- Agents, Figures
- Authority
- Time Instants
- Temporal Characteristics
- Jurisdiction
- Role

Context association of metadata with statements

Context different author association of metadata with statements

Context different time and jurisdiction association of metadata with rules

Context association of alternative interpretations of the same text

<ruleml:Rule key=":rule1">
  <ruleml:if> ...</ruleml:if>
  <ruleml:then>...</ruleml:then>
</ruleml:Rule>...

<ruleml:Rule key=":rule2">
  <ruleml:if> ...</ruleml:if>
  <ruleml:then>...</ruleml:then>
</ruleml:Rule>...
Cloud4EU Project

Pre-Commercial Procurement
Cloud4EU Project Scenario

• Goal: provide a module (LE) for monitoring the GDPR legal texts and rules over time and for providing compliance checking support during the BPMN design and in execution of eGov services in cloud

Guido Governatori, Mustafa Hashmi, Ho-Pun Lam, Serena Villata, Monica Palmirani: Semantic Business Process Regulatory Compliance Checking Using LegalRuleML. EKAW 2016: 746-761
Example

Legal Text

“Article 8 - Conditions applicable to child’s consent in relation to information society services

1. Where point (a) of Article 6(1) applies, in relation to the offer of information society services directly to a child, the processing of the personal data of a child shall be lawful where the child is at least 16 years old. Where the child is below the age of 16 years, such processing shall be lawful only if and to the extent that consent is given or authorised by the holder of parental responsibility over the child.”

Logic rule

IF

personalDataProcessing(d,x) \( \land \) child(x) \( \land \) at_least16years(x) \( \land \) information_society_service(s,d) \( \land \) data_controller(y,s)

THEN

obligation_to_obtain_consent(y,x,s)
Exercise - http://sinatra.cirsfid.unibo.it/c4eu-rawe/

PrescriptiveStatement

Rule

IF

And 5 atoms

personal_data_processing(d,x) \( \land \)

child(x) \( \land \)

at_least16years(x) \( \land \)

information_society_service(s,d) \( \land \)

data_controller(y,s)

THEN

obligation_to_obtain_consent(y,x,s)

/Rule

/PrescriptiveStatement
LegalRuleML rule modelling

<?xml version="1.0"?>
xmlns:ruleml="http://ruleml.org/spec" xmlns:rulemlmm="http://ruleml.org/1.0/metamodel#"
  <lrml:Comment> GDPR - minor consent </lrml:Comment>
  <lrml:LegalReferences refType="http://example.org/Lrml#LegalSource">
    <lrml:LegalReference refersTo="ref1" refID="/akn/act/regulation/2016-04-27/679/!main#art_8__para_1" refIDSystemName="AkomaNtoso3.0-2017-06"/>
  </lrml:LegalReferences>
  <lrml:LegalSources>
    <lrml:LegalSource key="ls1" sameAs="http://data.europa.eu/eli/reg/2016/679/oj" type="eli"/>
  </lrml:LegalSources>
</lrml:LegalRuleML>
LegalRuleML rule modelling

<lrml:PrescriptiveStatement key="ps1">
  <ruleml:Rule key=":ruletemplate2" closure="universal">
    <ruleml:if>
      <ruleml:And key=":and1">
        <ruleml:Atom key=":atom1">
          <ruleml:Rel iri=":child"/>
          <ruleml:Var>X</ruleml:Ind>
        </ruleml:Atom>
        <ruleml:Atom key=":atom2">
          <ruleml:Rel iri=":at_least16years"/>
          <ruleml:Var>X</ruleml:Ind>
        </ruleml:Atom>
        <ruleml:Atom key=":atom3">
          <ruleml:Rel iri=":personal_data_processing"/>
          <ruleml:Var>D</ruleml:Ind>
          <ruleml:Var>X</ruleml:Ind>
        </ruleml:Atom>
      </ruleml:And>
    </ruleml:if>
  </ruleml:Rule>
</lrml:PrescriptiveStatement>

From the ontology
Usability for end-user: Dashboard

- Legal Text
- Legal Rules
- RuleViewer
- BPMN+Legal Rules= Compliance checking
- Ontology API
Document modelling in AKN
Legal rule modelling
BPMN processing and compliance checking
Conclusions

• **Set of standards** helps consistency, reuse of legal knowledge, temporal model management, robust theoretical approach

• **Akoma Ntoso** is a robust Legal XML standard for legal document representation.

• **LegalRuleML** integrates Akoma Ntoso creating an ecosystem for managing legal norms using formal methods. Provide a computable model for large KB-rules.

• **Other standards** could be integrated using patterns and design principles in favour of Semantic Web and Internet of Things. Reusability and interoperability are guaranteed. Integration of different valuable research results.

• **Applications**: cloud computing, privacy, tax law, labour law, public law, technical normative (transportation, bank, insurance, credit card, etc.).

• **Future**: empowering machine-readable legal knowledge as “source of law”, guaranteeing integrity, **authoritateness**, **authenticity**, persistence over time, codifying **interpretation**.
LuxLogAI
Luxembourg Logic for AI Summit
12-21 Sep 2018, Luxembourg

The Luxembourg Logic for AI Summit (LuxLogAI) will bring together international conferences and workshops covering a wide range of topics in artificial intelligence, rule-based reasoning, decision making, machine learning, machine law, machine regulation and machine ethics.

- GCAI 2018: 17–19 Sep 2018
- RuleML+RR 2018: 18–21 Sep 2018
- DecisionCAMP 2018: 17–19 Sep 2018
- RW Summer School 2018: 12–16 Sep 2018
- eventually further meetings and workshops (e.g. EU Horizon 2020 MIREL network meeting)
- joint panel discussion (e.g. on machine law/ethics)

An overall focus theme of LuxLogAI 2018 is *Methods and Tools for Responsible AI*. Submissions and participation from academia and industry are highly encouraged, and the active involvement of research students will be fostered.

Conference Chairs: Leon van der Torre, Martin Theobald, Xavier Parent (all U Luxembourg)
Organisational Support: Christoph Benzmüller (U Luxembourg & FU Berlin), Geoff Sutcliffe (U Miami)
Publicity Chair: Shohreh Haddadan (U Luxembourg)

RuleML+RR 2018
http://2018.ruleml-rr.org

The International Joint Conference on Rules and Reasoning (RuleML+RR) is the leading international joint conference in the field of rule-based reasoning, and focuses on theoretical advances, novel technologies, as well as innovative applications concerning knowledge representation and reasoning with rules. The event will bring together rigorous researchers and inventive practitioners interested in the foundations and applications of rules and reasoning in academia, industry, engineering, the legal domain (LegalRuleML), business, finance, healthcare, and other application areas. It will provide a forum for stimulating cooperation and cross-fertilization between the many different communities focused on the research, development and applications of rule-based systems.

PC Chairs: Christoph Benzmüller (U Luxembourg & FU Berlin) and Francesco Ricca (U Calabria)
Proceedings: Dumitru Roman (SINTEF/U Oslo)
Industry Track: Silvie Spreeuwenberg (LibRT Amsterdam)
Int’l Rule Challenge: Giovanni De Gasperis (U L’Aquila)
Invited Speakers: Georg Gottlob (University of Oxford), Guido Governatori (Data61/CSIRO),
Paper Submission: 27 April 2018 (preliminary)
References: IRI

• Resolver of Akoma Ntoso http://akresolver.cs.unibo.it/
  http://akresolver.cs.unibo.it/admin/documentation.html

• Akoma Ntoso Naming Convention Version 1.0
  http://docs.oasis-open.org/legaldocml/akn-nc/v1.0/akn-nc-v1.0.html


• ELI http://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1396269218211&uri=CELEX:52012XG1026%2801%29


• LegalCiteM - https://docs.google.com/spreadsheets/d/1e-Uzk4b0ms60oClupAHrkjufFY8f4KMLygOdXLuG9qE/edit#gid=0
References: AKN

• Akoma Ntoso Vocabulary [http://docs.oasis-open.org/legaldocml/akn-core/v1.0/akn-core-v1.0-part1-vocabulary.html](http://docs.oasis-open.org/legaldocml/akn-core/v1.0/akn-core-v1.0-part1-vocabulary.html)

• Akoma Ntoso specifications [http://docs.oasis-open.org/legaldocml/akn-core/v1.0/akn-core-v1.0-part2-specs.html](http://docs.oasis-open.org/legaldocml/akn-core/v1.0/akn-core-v1.0-part2-specs.html)

• AKN4UN [https://unsceb-hlc.github.io/](https://unsceb-hlc.github.io/)

Portal

• [http://sinatra.cirsfid.unibo.it/node/portalfaoabasic/](http://sinatra.cirsfid.unibo.it/node/portalfaoabasic/)

• [http://sinatra.cirsfid.unibo.it/node/portalfaoresolution/](http://sinatra.cirsfid.unibo.it/node/portalfaoresolution/)

Ontology and Linguistic resources

References: LegalRuleML

- Schemas and Examples SVN: https://tools.oasis-open.org/version-control/browse/wsvn/legalruleml/?rev=319&sc=1
- XML schemas: http://docs.oasis-open.org/legalruleml/legalruleml-core-spec/v1.0/csprd02/xsd-schema/
- Documentation of the LegalRuleML TC: https://http://docs.oasis-open.org/legalruleml/legalruleml-core-spec/v1.0/csprd02/legalruleml-core-spec-v1.0-csprd02.html
monica.palmirani@unibo.it
http://sinatra.cirsfid.unibo.it/
http://lime.cirsfid.unibo.it/
Appendix II

Slides presented at Jurix2017, Monica Palmirani, inside of the TeReCom - 1st Workshop on Technologies for Regulatory Compliance, PRONTO: Privacy Ontology for Legal Compliance.
PRONTO: Privacy ontology for legal compliance

Monica Palmirani, Arianna Rossi, Michele Martoni
University of Bologna, CIRSFID

Cesare Bartolini, Livio Robaldo, SnT, The Luxembourg University
General goal of our project
A Deep Dive Into Privacy

A new EU regulation called GDPR is coming into force (25th May 2018) to regulate data protection in the EU and also outside of the EU.

This new regulation imposes new constraints, it defines new rights and obligations, and it encourages consumers/citizens to be more aware about data protection.

The GDPR obliges to document and report the legal compliance in case of audit. E.g., data breach in $t_n$. 
What and Who - Scenario

- Lawfullness
- Fairness
- Transparency
- Porpouse limitation
- Data Minimization
- Accuracy
- Storage limitation
- Integrity
- Confidentiality
- Accountability

To know which data are used by whom for which purposes and how they are processed
Which are the Pillars of the GDPR
Methodology: MeLOn

- Data
- Purposes
- Agents
- Processing
- Rights
Which are the Pillars of the GDPR

- Data
- Purposes
- Processing
- Agents
- Rights

Data are processed
Which are the Pillars of the GDPR

Data

Processes are linked to precise purposes

Data are processed

Purposes

Processing

Agents

Rights
Which are the Pillars of the GDPR

- Purposes
- Data
- Processing
- Agents
- Rights

Data are processed
Processing are linked to precise purposes
Legal basis
Which are the Pillars of the GDPR

- Data
- Purposes
- Processing
- Agents
- Rights

Data are processed
Processing are linked to precise purposes
Has Rights

Legal basis
**Data**

**By typology**
- Personal data
- Sensitive data
  - Genetic data
  - Sexual data
  - Judicial data
  - Biometric data
  - Opinion data
  - Health data

**By process type**
- Original data
- Processed data
- Derived data
Agents

- Controller – e.g., company providing service
- Processor – e.g., company managing data
- Data subject – natural person
- Authority
- Representative
- Recipient
- Third party – e.g., company using data for advertising
- Data protection officer
Processing

- Collect
  - Acquire, Record
- Transform
  - Profiling
  - Automated decision-making
  - Direct marketing process
- Transmit
  - Transfer outside of the EU borders
- Delete
Purposes

• Security/technical
• Statistical/research
• Profiling/direct marketing
• Public interest/judicial
• Health/humanitarian
Rights

• Right to be informed (art. 13)
• **Right of access (art. 15)**
• Right to rectification (art. 16)
• Right to erasure/ right to be forgotten (art. 17)
• Right to restriction of processing (art. 18)
• Right to object to processing (art. 21)
• **Right to data portability (art. 20)**
• Right to withdraw the consent (art. 13)
• Right to lodge a complaint to a supervisory authority (art. 77)
• Right not to be subject to a decision based solely on automated processing (art. 22)
PRONTO: for modelling policy
## Type of data

types of data (art. 4 GDPR)

<table>
<thead>
<tr>
<th>Concept</th>
<th>Simplified definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Genetic data</td>
<td>The personal data concerning the genetic characteristics of a person that reveal information about his/her health (e.g. predisposition to diabetes or heart diseases) and that result from a biological sample (e.g. saliva)</td>
</tr>
<tr>
<td>Sexual data</td>
<td>The personal data about the sex life or sexual orientation of a person</td>
</tr>
<tr>
<td>Health data</td>
<td>The personal data that reveal the physical or mental health status of a person (e.g. disease, disability, clinical treatment, medical history, etc.)</td>
</tr>
<tr>
<td>Biometric data</td>
<td>The personal data that result from the processing of physical or behavioural characteristics of a person and that identify this person uniquely. E.g. fingerprints, facial images, iris recognition, voice</td>
</tr>
</tbody>
</table>
## Type of processing

### Actions related to processing (art. 44 GDPR; art. 22 GDPR)

<table>
<thead>
<tr>
<th>Concept</th>
<th>Simplified definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transfer of data to a country outside the EU</td>
<td>It is the action of transferring data of people in the EU outside the EU (which thus can be processed following different laws)</td>
</tr>
<tr>
<td>Automated decision-making</td>
<td>It is the ability of computers to analyze data and make judgements without human intervention. E.g. a user applies for a loan online and the website uses algorithms and data on credit to give an immediate answer on the application; a factory relies on an algorithm that determines automatically the pay of a worker based on his daily productivity</td>
</tr>
</tbody>
</table>
Transfer outside the EU and Automated decision-making
Type of processing

Actions related to processing
(art. 4 GDPR; FEDMA's Code of practice for the use of personal data approved by Article 29 WP)

<table>
<thead>
<tr>
<th>Concept</th>
<th>Simplified definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Profiling</td>
<td>It is a form of automated processing that evaluates certain aspects of a person to analyse and predict his ability to perform a task, his interests or his behaviour. E.g. predict the performance at work, economic situation, health, personal preferences, interests, reliability, behaviour, location or movements.</td>
</tr>
<tr>
<td>Direct marketing</td>
<td>It is the communication of advertising or marketing material by the marketer itself (or on its behalf) and directed to particular individuals</td>
</tr>
</tbody>
</table>
### Table 1: Data Categories Based on Origin

<table>
<thead>
<tr>
<th>Category</th>
<th>Sub-Category</th>
<th>Example</th>
<th>Level of Individual Awareness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initiated</td>
<td>Applications, Registrations, Public records, Filings, Licenses, Credit card purchases</td>
<td></td>
<td>High</td>
</tr>
<tr>
<td>Provided</td>
<td>Bills paid, Inquiries responded to, Public records, Health, Schools, Courts, Surveys</td>
<td></td>
<td>High</td>
</tr>
<tr>
<td>Transactional</td>
<td>Bills paid, Inquiries responded to, Public records, Health, Schools, Courts, Surveys</td>
<td></td>
<td>High</td>
</tr>
<tr>
<td>Posted</td>
<td>Speeches in public settings, Social network postings, Photo services, Video sites</td>
<td></td>
<td>High</td>
</tr>
<tr>
<td>Engaged</td>
<td>Cookies on a website, Loyalty card, Inhabit location sensors on personal devices</td>
<td></td>
<td>Medium</td>
</tr>
<tr>
<td>Not Anticipated</td>
<td>Data from sensor technology on my Car, Time pushed over a pixel on the screen of a tablet</td>
<td></td>
<td>Low</td>
</tr>
<tr>
<td>Passive</td>
<td>Facial images from CCTV, Obscured web technologies, WiFi readers in buildings that establish location</td>
<td></td>
<td>Low</td>
</tr>
<tr>
<td>Derived</td>
<td>Computational, Notional, Statistical, Advanced Analytical, Credit score, Response score, Fraud scores, Risk of developing a disease based multi-factor analysis, College success score based on multi-variable big data analysis at age 9</td>
<td></td>
<td>Medium to Low</td>
</tr>
</tbody>
</table>
Profiling and Direct marketing

Data subject → Document → WWW → Controller

Authority

Data subject Controller Authority
## Right of access

Group 4: right of access (art. 15 GDPR)

<table>
<thead>
<tr>
<th>Concept</th>
<th>Simplified definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Right of access</td>
<td>The data subject has the right to access the data (original, processed and derived data) that a controller has on him/her and to obtain a copy of that data (original, processed and derived data). E.g. the right to know all the information that your bank has on you and obtain a copy of them, even of the derived data.</td>
</tr>
<tr>
<td>Original data</td>
<td>The personal data provided by the data subject. E.g. the data you give by filling a form when you enter into a contract, but even simply the e-mail address you give when you sign up for a service</td>
</tr>
<tr>
<td>Processed data</td>
<td>The personal data after they have been processed by the controller, thus after they have been stored, organised, structured, modified, combined, etc.</td>
</tr>
<tr>
<td>Derived data</td>
<td>The inferred and derived data generated by the controller from the analysis of the original data e.g. when the controller profiles or classifies a person according to his purchase pattern, assigns him a (credit) score</td>
</tr>
</tbody>
</table>
Right of access

Data subject

Controller

Original data

Processed data

Derived data

Authority

Original data

Processed data

Derived data

Data subject

Controller

Original data

Processed data

Derived data

Authority

Right of access
right to data portability (art. 20 GDPR)

<table>
<thead>
<tr>
<th>Concept</th>
<th>Simplified definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Right to data portability</td>
<td>The data subject has the right to receive in a machine-readable format the personal data (=original data) he/she provided to a certain controller AND to transmit them (=processed data) to another controller. E.g. the right to retrieve the listening history from Spotify and transmit it to Google Play Music</td>
</tr>
<tr>
<td>Original data</td>
<td>The personal data provided by the data subject. E.g. the data you give by filling a form when you enter into a contract, but even simply the e-mail address you use when you sign up for a service</td>
</tr>
<tr>
<td>Processed data</td>
<td>The personal data after they have been processed by the controller, thus after they have been stored, organised, structured, modified, combined, etc.</td>
</tr>
</tbody>
</table>
Right to data portability

Data subject

Controller

Authority

Controller
Reused ontologies: pattern design

- **ALLOT**: this ontology implements the Akoma Ntoso Top Level Classes (TLCs) as a formal OWL 2 DL and permits to connect the data and document classes with FRBR ontology.
- **FRBR**: FRBR is an ontology that implements the FRBR model.
- **LKIF Core**: Action.owl is an ontology that represents actions in general, i.e. processes which are performed by an agent. We use in particular lkif:Agent to model lkif:Organization and lkif:Person.
- **LKIF Core**: Role.owl is an ontology to describe typologies of roles (epistemic roles, functions, person roles, organisation roles). We use in particular lkif:Role.
- **The Publishing Workflow Ontology (PWO)** is a simple ontology written in OWL 2 DL for the characterization of the main stages in the workflow associated with the publication of a document (e.g. being written, under review, XML capture, page design, publication on the Web). We reuse the workflow pattern to model the different types of processing of personal data.
- **Time-indexed Value in Context (TVC)** is an ontology pattern that allows to describe scenarios in which someone (e.g., a person) has a value (e.g., a particular role) during a particular time and for a particular context. We use this portion of ontology to connect the event with value, context and time parameters.
- **Time Interval (TI)** is an ontology design pattern that enables the description of periods of time that are characterised by a starting date and an ending date. We use this ontology to manage the time interval.
Future work

• Populate with individuals
• Testing with policy and concepts
• Evaluate with xqueries
• Evaluate modelling rules using the ontology
• Evaluate checking compliance
• Documenting on web
Thanks for your attention

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– arianna.rossi15@unibo.it
– michele.martoni@unibo.it
– cesare.bartolini@uni.lu
– livio.robaldo@uni.lu
Appendix III

Survey distributed on 20 December to Law, Science and Technology PhD students.
Dear participant,

Thank you very much for participating in our study! You will need approximately 30-45 minutes to complete the task and to fill out the corresponding questionnaire.

Please note:

1. Please answer all questions thoroughly so that the statistical evaluation can be carried out precisely. Do not skip any answers as all information is valuable for us.
2. If you are not able to answer single questions precisely, please give the best possible solution from your point of view.
3. All given information are handled strictly confidential and will only be used for research purposes.

In case you have any questions or uncertainties, you can ask the instructor at any time.

We appreciate your cooperation!
Task  \textit{Formal Contract Logic (FCL)}

Before you begin reading, please give the current time up to-the-minute: \underline{\hspace{2cm}} : \underline{\hspace{2cm}}

In many business areas there are legal requirements to be met. Your task is to model these compliance requirements based on a legal text. Please proceed with the following subtasks one by one:

1) Have a close look at the table on page 3 and 4. It explains the formal notation you will be asked later on to model the requirements. The individual rules are illustrated by examples for opening and maintaining a bank account.

2) Rate the rules on page 5 and 6 according to the formal notation. The rules provide an overview on airport security procedures.

3) Model the compliance requirements on page 7 to 9 according to the formal notation. Use the given table for your solution. You can also skip back to step 1) to have a look at the table. The excerpt of the legal text deals with rules that are imposed on a telephone company for handling consumer complaints.

\textbf{Please note:} During you work on the task you are not allowed to exchange information with your neighbour.
**Notation**

**Formal Contract Logic (FCL)**

<table>
<thead>
<tr>
<th>Notation</th>
<th>Explanation</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>subject</td>
<td>action verb</td>
<td>object</td>
</tr>
<tr>
<td>Use text according to these rules:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• subject – the person, role or organisation performing the action. If it is clear, who performs the action, the subject can be omitted.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• action verb – infinitive or present tense version of the verb that represents the action.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• object – object that the verb is operating on.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• quantifier – additional information about the object such as time specifications.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Subject:</strong> customer</td>
<td><strong>Action verb:</strong> check</td>
<td><strong>Object:</strong> credit worthiness</td>
</tr>
<tr>
<td><strong>if ... then</strong></td>
<td>The condition ‘if ... then’ is used to formulate a compliance requirement with regard to the cause and consequence of an action.</td>
<td>See examples below.</td>
</tr>
<tr>
<td>obligatory</td>
<td>An obligation is a situation, an act, or a course of action to which someone is legally bound, and if it is not achieved or performed, results in a violation. We use the term “obligatory” to define when an obligation enters to force or when it ends. There are several attributes for an obligation which are explained below.</td>
<td>obligatory (achievement, persistent, punctual)</td>
</tr>
<tr>
<td>punctual</td>
<td>Punctual refers to a specific point in time and must be met immediately after the obligation is in force.</td>
<td><strong>Requirement:</strong> Before a new bank account can be opened, staff must proof the customer’s identity. <strong>Rule:</strong> if open new bank account then proof customer identity is obligatory (punctual)</td>
</tr>
<tr>
<td>maintenance</td>
<td>Maintenance refers to a period of time and must be continually met after they are in force.</td>
<td><strong>Requirement:</strong> Staff has to make copies of the customer’s identity documents and keep them as record. <strong>Rule:</strong> if copy identity documents then keep identity documents as record is obligatory (maintenance)</td>
</tr>
<tr>
<td>achievement</td>
<td>Achievement refers to a period of time in which the obligation must be met at least once. There are three different types of achievement obligation, which are explained below.</td>
<td>See examples below.</td>
</tr>
</tbody>
</table>
### Achievement Persistent Pre-emptive

**Persistent obligations** are valid for a specified timeframe.  
**Pre-emptive obligations** can to be fulfilled even before the obligation is in force.

**Requirement:** Staff must obtain the customer’s permission to copy the identity documents.  
**Rule:** If copy identity documents then obtain customer permission is obligatory (achievement, persistent, pre-emptive)

### Requirement Persistent Non-Pre-emptive Perdurant

**Persistent obligations** are valid for a specified timeframe.  
**Non-pre-emptive obligations** cannot be fulfilled before the obligation is in force.  
**Perdurant** means that the obligation persists after being violated.

**Requirement:** If the customer is a natural person of full age, staff must contact market support and ask for a new account number.  
**Rule:** If natural person of full age then ask market support for account number is obligatory (achievement, persistent, non-pre-emptive, perdurant)

### Requirement Persistent Non-Pre-emptive

**Persistent obligations** are valid for a specified timeframe.  
**Non-pre-emptive achievement obligations** cannot be fulfilled before the obligation is in force.

**Requirement:** The customer must pay a monthly interest rate of 10%, if the account balance is negative.  
**Compliance rule:** If account balance < 0 then customer pay interest rate = 10% per month is obligatory (achievement, persistent, non-pre-emptive)

### Permitted

A **permission** is a situation, an act, or a course of action which someone is entitled to, and if it is achieved does not result in a violation.

**Requirement:** With a positive payment experience, the customer can be offered a credit limit of more than 2.000 Euro.  
**Rule:** If then positive payment experience then offer customer credit limit > 2.000 Euro is permitted

### Not Obligatory

A **negation** denotes that an obligation is terminated.

**Requirement:** The customer receives an interest rate of 4% per year as long as the account balance is less than 100.000 Euro.  
**Rule:** If account balance > 100.000 Euro then pay interest rate = 4% per year is not obligatory (persistent, non-pre-emptive)

### And

An **and** is used to link expressions. It can be used for text, obligations or permissions.

**Requirement:** With a positive credit assessment and a positive payment experience, the customer can be offered a credit limit of more than 2.000 Euro.  
**Rule:** If positive credit assessment and positive payment experience then offer customer credit limit > 2.000 Euro is obligatory (punctual)

### Two Obligations

A **compensation** consists of at least two obligations. If one of them is violated, it is replaced with the next following obligation.

**Requirement:** Stockless bank accounts are charged a fee of 5 Euro per year. If this fee is not paid, the bank account is dissolved without customer order.  
**Rule:** If stockless bank account then customer pay fee = 5 Euro per year is obligatory (maintenance) and dissolve bank account is obligatory (achievement, persistent, non-pre-emptive)
Statements

Formal Contract Logic (FCL)

Please rate if the rule represents the given requirement correctly by checking one of the circles. If the rule is wrong, provide the correct solution.

1. **Requirement:** Before I can drop off my luggage at the airport, I have to present a valid passport at the counter.

   **Rule:** if drop luggage then present valid passport is obligatory (maintenance)
   
   O Right
   
   O Wrong, correct rule: ________________________________

   If you selected wrong, please mark what you think is wrong:
   
   O maintenance  O use of text

2. **Requirement:** At the security control, I need to walk through the metal detector before getting access to the gate.

   **Rule:** if walk through metal detector then get gate access is obligatory (achievement, persistent, non-pre-emptive, perdurant)
   
   O Right
   
   O Wrong, correct rule: ________________________________

   If you selected wrong, please mark what you think is wrong:
   
   O achievement  O use of text  O persistent, non-pre-emptive, perdurant

3. **Requirement:** When my passport expires, I need to apply for a new one at the city hall.

   **Rule:** if passport expired then apply new passport is obligatory (achievement, persistent, non-pre-emptive)
   
   O Right
   
   O Wrong, correct rule: ________________________________

   If you selected wrong, please mark what you think is wrong:
   
   O achievement  O use of text  O persistent, non-pre-emptive

4. **Requirement:** Past the security control, I am allowed to carry liquids up to 1 l.

   **Rule:** if enter security control then carry liquids < 1 l is obligatory (achievement, persistent, pre-emptive)
   
   O Right
   
   O Wrong, correct rule: ________________________________

   If you selected wrong, please mark what you think is wrong:
   
   O achievement  O use of text  O persistent, pre-emptive
5. **Requirement:** When exceeding the allowed 20 kilos per luggage, I must reduce the weight before I can drop off my luggage or I have to pay a fee.

   **Rule:** if drop luggage and luggage weight > 20 kg then reduce luggage weight is obligatory (achievement, persistent, pre-emptive) and pay fee is obligatory (achievement, persistent, pre-emptive)

   - Right
   - Wrong, correct rule: __________________________________________________________

     If you selected wrong, please mark what you think is wrong:

     - achievement  ○ use of text  ○ persistent, pre-emptive

6. **Requirement:** When entering non-EU countries an immigration form is distributed at the aircraft that need to be completed before passing the border control.

   **Rule:** if entering non-EU countries then fill out immigration form is obligatory (achievement, persistent, non-pre-emptive)

   - Right
   - Wrong, correct rule: __________________________________________________________

     If you selected wrong, please mark what you think is wrong:

     - achievement  ○ use of text  ○ persistent, non-pre-emptive

7. **Requirement:** While I am staying the airport I must not leave my luggage unattended.

   **Rule:** if staying at airport then watch luggage is obligatory (achievement, persistent, pre-emptive)

   - Right
   - Wrong, correct rule: __________________________________________________________

     If you selected wrong, please mark what you think is wrong:

     - achievement  ○ use of text  ○ persistent, pre-emptive
Solution  **Formal Contract Logic (FCL)**

Before you begin with the modelling task, please give the current time up-to-the-minute:  ____ : ____

| complaint | charge for activity | complaint acknowledgment |
| description complaint process | complaint acknowledgment |
| customer requests escalation | manage resolution |
| **consent disclosure information** | make description complaint process online available |
| customer requests hard copy | send written no contact message |
| complaint | monitor customer process |
| customer requests information | information older > 2 years |
| complaint | send description complaint process |
| description complaint process | customer dissatisfied resolution |
| no contact | **disclose information** |
| charge for activity | consumer complaint activity |
| manage escalation | complaint |
| complaint acknowledgment | offer compensation |

Use the given expressions to formally represent the requirements. All expressions must be used, but every expression can be used only once. An example is given below.

<table>
<thead>
<tr>
<th>Ex.</th>
<th>Suppliers not subject to the requirements of the Privacy Act must ensure personal information concerning a complaint is not disclosed except with the express consent of the consumer.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>if consent disclosure personal information then disclose information is permitted</td>
</tr>
</tbody>
</table>
A supplier must take the following actions:

<table>
<thead>
<tr>
<th>No.</th>
<th>Requirement</th>
<th>Rule</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Implement, operate and comply with a complaint handling process that is free of charge; other than for: the provision of information where a consumer or former customer requests access to information held by the supplier about the consumer or former customer which was collected by the supplier more than 2 years prior to the date of the request.</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Implement, operate and comply with a complaint handling process that requires all complaints to be: A. Resolved in an objective, efficient, and fair manner; or B. escalated and managed under the supplier's internal escalation process if requested by the consumer or a former customer.</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Suppliers must demonstrate, fairness and courtesy, objectivity and efficiency by acknowledging a complaint immediately where the complaint is made in person or by telephone.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>If a consumer or former customer tells the supplier that they are dissatisfied with the progress or resolution of a complaint or asks about their options to pursue a complaint further, the supplier must offer a compensation.</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>If a supplier is unable to contact a consumer to resolve their complaint, or to advise them of the outcome of their complaint, the supplier must write to the consumer at their last known address, state that they were unable to contact the consumer.</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Document its complaint handling process and make it available to staff, consumers and other stakeholders in a summary form that is available in hard copy upon receipt of a request at contact for a single copy from consumers or former customers.</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Document its complaint handling process and make it available to staff, consumers and other stakeholders in a summary form that is available in soft copy, which is in a readily accessible position on the supplier’s website.</td>
<td></td>
</tr>
</tbody>
</table>

After you finished the modelling task, please give the current time up to-the-minute: ___ : ___
Questionnaire

A. Personal details:

Age: _____ years

Gender: O female  O male

In which course of study are you enrolled?

O Bachelor  O Master  _____ Semester

O Business Sciences  O Media Informatics

O Business Mathematics  O Software Engineering

O Informatics  O Information Technology

O Information Systems  Other, please specify: ________________________________

B. Math quick-test:

A bat and a ball cost 1,10 Euro. The bat costs 1,00 Euro more than the ball. How much does the ball cost?

_____ cents

If it takes 5 machines 5 minutes to make 5 widgets, how long would it take 100 machines to make 100 widgets?

_____ minutes

In a lake, there is a small patch of lily pads. Every day, the patch doubles in size. If it takes 48 days for the patch to cover the entire lake, how long would it take for the patch to cover half of the lake?

_____ days

Please answer the following questions by checking one of the circles or boxes. An example is given below.

How easy is the use of this scale?

simple  difficult

How do you feel regarding the use of the scale?

positive or negative
C. Questions regarding the task description:

1. How clear was the task description to you?
   
   unclear  ○○○○○○○○○○○  clear
   
   0  1  2  3  4  5  6  7  8  9

2. How did you get along with the task overall?
   
   very bad  ○○○○○○○○○○○  very good
   
   0  1  2  3  4  5  6  7  8  9

3. How strong was your motivation to reach a good result?
   
   very low  ○○○○○○○○○○○  very high
   
   0  1  2  3  4  5  6  7  8  9

4. How comprehensible was the given information of the task description?
   
   incomprehensible  ○○○○○○○○○○○  comprehensible
   
   0  1  2  3  4  5  6  7  8  9

5. How did you perceive the amount of information of the task description?
   
   very low  ○○○○○○○○○○○  very high
   
   0  1  2  3  4  5  6  7  8  9

6. How did you perceive the level of information complexity of the task description?
   
   very low  ○○○○○○○○○○○  very high
   
   0  1  2  3  4  5  6  7  8  9

D. Questions regarding the modelling task:

1. How good are your general process modelling skills?
   
   very low  ○○○○○○○○○○○  very high
   
   0  1  2  3  4  5  6  7  8  9

2. How good are your process modelling skills with the *Business Process Modell and Notation* (BPMN 2.0)?
   
   very low  ○○○○○○○○○○○  very high
   
   0  1  2  3  4  5  6  7  8  9

3. How good are your process modelling skills with *Event-driven Process Chains* (EPC)?
   
   very low  ○○○○○○○○○○○  very high
   
   0  1  2  3  4  5  6  7  8  9

4. How good are your data modelling skills with *Entity Relationship Model* (ER)?
   
   very low  ○○○○○○○○○○○  very high
   
   0  1  2  3  4  5  6  7  8  9

5. How well did you understand the description of the *Formal Contract Logic* (FCL)?
   
   very bad  ○○○○○○○○○○○  very good
   
   0  1  2  3  4  5  6  7  8  9
6. How difficult was the modelling of the rules using the *Formal Contract Logic* (FCL)?

   ![Difficulty Level]

7. How do you feel regarding the modelling with the *Formal Contract Logic* (FCL)?

   - ![Positive]
   - ![Negative]
   - ![Active]
   - ![Passive]
   - ![Dominated]
   - ![Dominant]

8. If you have any further questions or suggestions please feel free to tell us below. We are looking forward to your feedback:

   ![Feedback Box]

Thank you again for participating!
The MIREL project

21/01/2018

MIREL-D1.2 - Part II

Horizon 2020