

A Model-based Approach to the Automatic Revision of Secondary Legislation

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ABSTRACT

Conflicts between laws can readily arise in situations governed by different laws, a case in point being when the context of an inferior law (or set of regulations) is altered through revision of a superior law. Being able to detect these conflicts automatically and resolve them, for example by proposing revisions to one of the modelled laws or policies, would be highly beneficial for legislators, legal departments of organizations or anybody having to incorporate legal requirements into their own procedures. In this paper we present a model based approach for detecting and finding legal conflicts through a combination of a formal model of legal specifications and a computational model based on answer set programming and inductive logic programming. Given specific scenarios (descriptions of courses of action), our model-based approach can automatically detect whether these scenarios could lead to contradictory outcomes in the different legal specifications. Using these conflicts as use cases, we apply inductive logic programming (ILP) to learn revisions to the legal component that is the source of the conflict. We illustrate our approach using a case-study where a university has to change its studentship programme after the government brings in new immigration regulations.

1. INTRODUCTION

Law is dynamic in the sense that it is constantly changing due to changes in society. It is typically changed by legislators enacting new laws or amending or repealing existing ones. One problem with changing laws is that the subjects of the law need to adapt to the new legislation. This is a problem, because depending on the changes made, their previous ways of acting might no longer be applicable or plain incorrect in the new legal setting, possibly resulting in (unintended) illegal behaviour and fines. To give an example, if employment laws change, organizations which are subject to these laws need to check whether the organization-specific employment rules are still all correct and legal under the new legislation. That is why, when laws are changed, it is essential for actors (such as the above mentioned organizations) to verify whether their existing regulations and actions are still compliant in the context of the revised legislation.

In this paper we start by modelling legal systems with the help of legal specifications. We present the formal specification and a corresponding computational model of a mechanism for automatically detecting conflicts between legal specifications, based on actors' typical course of actions. If conflicts are detected, our mechanism automatically deals with them by proposing ways to update the legal specification precedence. We use a UK immigration law case study to illustrate our approach. We stress that the approach presented is applicable to laws in general, not just the laws in the case-study. The conflict detection and resolution mechanisms are general-purpose techniques.

2. MODELLING OF LEGAL SYSTEMS

The model we use to represent legal systems has been presented in several earlier papers, amongst which the most relevant is [4]. It considers how institutional models, here called legal specifications, may be used for legal reasoning in the context of Japanese contract law. For the sake of completeness of this paper, we summarize its main features.

The approach we take is to use the model to characterize all the traces that can arise from the legally relevant actions of the parties involved in the specification. Thus a trace is a sequence of relevant actions taken by the parties involved. Each of this actions brings about a change in the legal state. Starting from the initial legal state, Δ, a trace brings about a sequence of states that is referred to as the model of the trace.

The design is of an event-driven evolution of an legal state, itself represented by a set of facts (fluents, \( F \)). This state is acted upon through two relations: (i) \( G \), whose function is that of a gatekeeper, in that it determines which physical actions (\( \mathcal{E}_{\text{phys}} \)) are relevant to the legal specification, and conditional upon the current state, maps those to legal actions (\( \mathcal{E}_{\text{legal}} \)), as well as generating any violations (\( \mathcal{E}_{\text{viol}} \)), and (ii) \( C \), which updates the legal state, contingent upon the combination of the set of legal actions from the transitive closure of \( G \) plus any unfulfilled obligations and non-permitted events, and the current state. Also any concluded (satisfied or vio-
lated) obligations are removed. Thus, starting from an initial state \( \Delta \), a trace of physical actions, referred to as exogenous events, generates a sequence of states by means of a state transformer function comprising \( G \) and \( C \) as described above, resulting in a model of the legal specification. The legal specification formally characterized by \( I = (E,F,G,C,\Delta) \), namely events, fluents, the generation relation, the consequence relation and the initial state.

The formal model and its declarative specification language IntStAL become a computational model by translating it to a logic program under the Answer Set semantics \([8]\). In answer set programming, the program is written in AnsProlog as a finite set of rules of the form \( r: \text{consequence} : -\text{condition}, \text{or} \bot : -\text{condition} \). A rule should be read as: “The consequence is supported if all components of condition are true”. A rule with \( \bot \) as the consequence is referred to as an (integrity) constraint. \( \bot \) is always assigned the truth value “false”. The semantics of AnsProlog are defined in terms of answer sets – assignments of true and false to all elements of, called atoms, the program that satisfy the rules in a minimal and consistent fashion. A program has zero or more answer sets, each corresponding to a solution.

The legal specifications are mapped to a set of AnsProlog rules. The rule bodies are conjunctions of literals using negation as failure for negated expressions. These rules are then combined with a set of standard rules that handle housekeeping tasks (fluent inertia, violation generation) and a set of rules for time predicates, which are generated on demand, based on the provided trace length.

Provided with a trace, the program will result in exactly one answer set containing the corresponding model of the trace. Otherwise, the program returns all traces and their corresponding models as answer sets. The program can be augmented with constraints to obtain specific traces and their models.

### 2.1 Modelling of Case Study

Our case study is set against the background of changes in UK immigration legislation with a particular focus on changes to student visa regulations announced on March 22nd, 2011 by the UK Home Secretary\(^1\).

As part of these changes, the regulations concerning the permitted working hours (during studies) for international students were reduced\(^2\). What is vital for our case study, which for presentation purposes only concentrates on one aspect of the resulting implications, is that the reduction of international student working hours might result in conflicts with existing policies such as those for university studentships. Thus, our case study concerns the tensions between on the one hand, the regulations associated with the visa of an international student studying at a university, the limitations on how much work a student is obliged to undertake and on the other hand, the regulations associated with the studentship awarded to the student, in particular the minimum number of teaching hours that the student must deliver. In the scenario we consider here, the government reduces the number of hours that are permitted to twenty, thirty hours or full-time. This information is directly encoded as part of the initial state. Figure 1 provides an AnsProlog code fragment of each legal specification that includes the rules that are causing the conflict. Given the supremacy of the immigration law, it is the rules from the university specification that need to be revised.

### 3. LEGAL CONFLICT DETECTION

Having described how legal specifications can be used to model laws and legal systems, this section turns the focus to detecting conflicts between two legal specifications. The definition of conflicts and the mechanism for conflict detection have initially been presented in our previous work \([9]\). Based on that, in this paper we extend the definition to distinguish between weak and strong conflicts depending on the nature of the conflicts.

#### 3.1 Preliminary Definitions

In order to detect the disparities among a set of individual legal systems or laws, we model them as legal specifications using the approach of Section 2. Together they form a so-called composite legal specification, denoted as \( C \).

We assume that there is a shared legal ontology within \( C \). If the original specifications did not use the same legal ontology, they would have been semantically aligned before they were put together as a composite.

In other words, the same concept (e.g., an action or a piece of domain information) is denoted by the same AnsProlog represen-

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\(^1\)The changes we are concerned with in this paper in particular concern §57–62 of UK Immigration Law (as of February 2011).

\(^2\)A detailed list of these changes with the respective legal texts as well as a statement of intent can be found on the UK Home Office website under http://www.ukba.homeoffice.gov.uk/sitecontent/documents/news/sop4.pdf.
Table 1: The visa and university laws and procedures with respect to working hours of students

<table>
<thead>
<tr>
<th>Visa Regulations</th>
<th>University Policy</th>
</tr>
</thead>
<tbody>
<tr>
<td>$L_1 = { \langle Student, applyStudentVisa \rangle }$</td>
<td>$L_1 = { \langle Student, applyToStudy \rangle }$</td>
</tr>
<tr>
<td>$\ldots$</td>
<td>$\ldots$</td>
</tr>
<tr>
<td>$C^*(X, E) = \emptyset$</td>
<td>$C^*(X, E) = \emptyset$</td>
</tr>
</tbody>
</table>

3.1.1 Composite Traces

Having formed a composite legal specification $C_L$ from a set of legal specifications, we can now continue with the conflict analysis within $C_L$. For this purpose, the composite specification will be analysed by event traces specified by the user containing the actions of the stakeholders in order to ascertain whether the system is conflict-free or not. These traces are referred to as composite traces (CTR) and are formed by exogenous events from any individual specification in $C_L$. This implies that each event can be recognized by one or more individual specifications, but not necessarily by all of them.

**Definition 1.** Given a composite legal specification $C_L$, a composite trace, denoted as CTR, is a sequence $e_i$ (1 ≤ i ≤ m) such that $\forall e_i$, 1 ≤ i ≤ m, $\exists L_i \in C_L$ denoted as CTR.

From the definition, composite traces can describe all possible scenarios in the context of a $C_L$, which enables (i) a comprehensive and general analysis of all potential conflicts between specifications in $C_L$ by generating all composite traces of $C_L$, and (ii) a user-lead conflict analysis, by selecting those composite traces that are most relevant with respect to the stakeholders. Use cases can also cover these case specified by the designer. Full coverage can be achieved, although possible computationally expensive, by not providing the system with a use case. The system will then compute all conflict traces of a certain specified length.

3.1.2 Synchronization with Null Events

Given a composite trace CTR of $C_L$, the state transition of each legal specification in $C_L$ is driven by the events appearing in the CTR. Since not every exogenous event is necessarily recognized by each individual specification, they can become desynchronized making comparison difficult. To solve this problem technically, we add a special event, called null event ($e_{null}^i$) to progress the state transition of individual specification $L_i$, at time t if the occurred event in the CTR at time t is unknown to $L_i$. It should be noted that null events only increase the legal state counter, but do not cause any change to the state itself.

**Definition 2.** Given a composite legal specification $C_L$ with $C_L = \{L_1, \ldots, L_n\}$, a composite trace CTR = $\langle e_1, \ldots, e_l \rangle$ for $C_L$. The event sequence $\langle a_1, \ldots, a_l \rangle$ is a synchronized trace, for $L_i \in C_L$ if $a_k = e_k$ when $e_k \in E_{null}$ or $a_k = e_{null}$ otherwise.

With synchronized traces, we can generate a composite model for $C_L$, as a set of models corresponding to the synchronized traces of the individual specifications $L_i$, denoted as $M_i$.

3.2 Legal Conflicts and Conflict Traces

Legal conflicts are detected by comparing the states of each individual specification at a given time instant. The composite traces which result in legal conflicts are referred to as conflict traces.

We distinguish between two types of legal conflicts: weak and strong conflicts. A weak conflict between two laws is defined as the existence of a common fluent between any pair of individual specifications that is true in one but false in the other. For instance, a weak conflict can be identified when the permission fluent concerning working in the UK holds true in one legal specification but is false in another one at the same time.

**Definition 3.** Given a composite trace CTR for a composite legal specification $C_L$, the CTR is a weak conflict trace if:

- $\exists L_i, L_j \in C_L$ with synchronized models $M_i = \{S_0^{i_0}, \ldots, S_t^{i_t}\}$ and $M_j = \{S_0^{j_0}, \ldots, S_t^{j_t}\}$ such that
- $\exists f \in (F^i \cap F^j)$ such that
- $\exists k, 0 \leq k \leq t$ such that
- $f \in S_k^i$ and $f \not\in S_k^j$

We have a strong conflict when there is simultaneously an event that is not permitted in one specification while in another there is an obligation for the event.

**Definition 4.** Given a composite trace CTR for a composite legal specification $C_L$, a CTR is a strong conflict trace if:

- $\exists L_i, L_j \in C_L$ with synchronized models $M_i = \{S_0^{i_0}, \ldots, S_t^{i_t}\}$ and $M_j = \{S_0^{j_0}, \ldots, S_t^{j_t}\}$ such that
- $\exists e \in E^i \cup E^j$.
- $p \in P^i$, $p = \text{perm}(e)$ such that
- $\exists o \in O^j$, $o = \text{obl}(e, d, v)$ such that
- $\exists k, 0 \leq k \leq t$ such that
- $o \in S_k^i$ and $o \not\in S_k^j$

A composite legal specification is conflict-free if it does not admit either weak or strong conflict traces.

3.3 Automatic Conflict Detection

Having presented the theoretical side of conflicts, we now turn to the computational side. With the help of legal specification, conflicts can be detected automatically by comparing the inconsistent states among their models $M$ for any synchronized event traces at any given time. The brute force method of combining the Answer-Set Programming programs of legal specifications together with the rules.

$\text{holdsat}(F, T)$, not $\text{holdsat}(F, T)$, and $\text{not conflict}$ cannot give any result, as the body is contradictory.
Since the problem is caused by the syntactic identity of F, it can be resolved by a systematic renaming of literals, as long as we remember what has been renamed as what. Thus, we add rename(F, FX, X) for each event and fluent in the individual legal specification of C_L, where rename/3 indicates that an event or a fluent F is renamed FX in the legal specification X. We now present the main parts of detection program P_{C_L}:

**Weak Conflicts:**
\[
\text{conflict}(FX, FY, I) : \neg \text{holds}(FX, I), \neg \text{holds}(FY, I), \text{rename}(F,FX), \text{rename}(F,FY), \text{instant}(FY), \text{instant}(I), \text{instant}(X,Y).
\]

**Strong Conflicts:**
\[
\text{conflict}(FX, FY, I) : \neg \text{obl}(FX, D,V), \text{instant}(FY), \text{instant}(I), \text{instant}(X,Y).
\]

**Conflict Selection:**
\[
\text{conflict} : \neg \text{conflict}(FX, FY, I).
\]

Combining this with a program P_I that specifies the conditions for what makes a trace of a certain length, we obtain all conflict traces and models as answer sets. If we have a trace CTR, we can create the program P_{CTR} containing the facts that stipulate that these events have been observed and include the necessary time atoms. Combining this with P_{C_L}(the AnsProlog program of a C_L), we obtain a single answer set if the trace is a conflict trace.

4. LEGAL CONFLICT RESOLUTION

4.1 Conflict Resolution via Inductive Learning

Having determined (weak and strong) conflict traces in a composite legal specification C_L and obtained the literals conflict/3 capturing the information about the detected conflicts, we can now move on to resolve these conflicts. We propose to do so by revising inferior laws. We take the basic ILP mechanism set out in \cite{3} and extend this technique to composite legal specification – instead of just one – and to synthesize the use cases for the learning specification automatically – instead of manually – following conflict detection. In consequence, a partial solution is the revision of the detection program FXfications, and is guaranteed not to lead to the conflict. Thus, we add rename/3 indicates that an event or a fluent F is renamed FX in the legal specification X. We now present the main parts of detection program P_{C_L}:

**Weak Conflicts:**
\[
\text{conflict}(FX, FY, I) : \neg \text{holds}(FX, I), \neg \text{holds}(FY, I), \text{rename}(F,FX), \text{rename}(F,FY), \text{instant}(FY), \text{instant}(I), \text{instant}(X,Y).
\]

**Strong Conflicts:**
\[
\text{conflict}(FX, FY, I) : \neg \text{obl}(FX, D,V), \text{instant}(FY), \text{instant}(I), \text{instant}(X,Y).
\]

**Conflict Selection:**
\[
\text{conflict} : \neg \text{conflict}(FX, FY, I).
\]

Combining this with a program P_I that specifies the conditions for what makes a trace of a certain length, we obtain all conflict traces and models as answer sets. If we have a trace CTR, we can create the program P_{CTR} containing the facts that stipulate that these events have been observed and include the necessary time atoms. Combining this with P_{C_L}(the AnsProlog program of a C_L), we obtain a single answer set if the trace is a conflict trace.

4. LEGAL CONFLICT RESOLUTION

4.2 Conflict Resolution in Case Study

We now resolve the conflicts detected in the case study by means of LC-RES. The input is a composite legal specification and a set of use cases. For simplicity, we associate a distance cost with addition and deletion to the Cost argument in revision tuples, but this can be adjusted to give different outcomes, via the optimization mechanism discussed above. By having the precedence of Visa Regulation higher than University Policy, the optimal solution obtained is as below, which implies a revision to University Policy in order to be...
compliant with Visa Regulation:

\[
\begin{align*}
\text{rev} & (\text{university}, 3, r(h\text{INIT}3, b\text{HO3}, 1(0)), 1) \\
\text{rev} & (\text{university}, 2, r(h\text{INIT}2, b\text{HO3}, 1(0)), 1)
\end{align*}
\]

The result suggests a revision to the rule 3 and rule 2 by adding the domain fluent \text{person(\text{Student, overseas})} with mode declaration id b\text{HO3}, then rule 3 and 2 become:

\[
\begin{align*}
\text{initiated}(\text{perm(workUNI(\text{Student, thirty}), I)}, I) & : - \\
\text{occurred}(\text{askStudentShipUNI(\text{Student}, I)}, I), \\
\text{holdsat} & (\text{availabilityUNI}, I), \\
\text{not holdsat} & (\text{person(\text{Student, overseas}), I}).
\end{align*}
\]

\[
\begin{align*}
\text{initiated}(\text{obl(workUNI(\text{Student, thirty}), endOfStudyUNI, I)}, I) & : - \\
\text{occurred}(\text{askStudentShipUNI(\text{Student}, I)}, I), \\
\text{holdsat} & (\text{availabilityUNI}, I), \\
\text{not holdsat} & (\text{person(\text{Student, overseas}), I}).
\end{align*}
\]

Therefore, the university regulation should revise the rule as: for all non-overseas students, the permission and the obligation to work thirty hours per week are initiated.

5. RELATED WORK

Detecting and resolving legal conflicts are not new issues and have been investigated for several decades (a comprehensive discussion is provided in [10]). [11] addresses both detection and resolution of normative conflicts by means of static comparison using \textit{first-order unification} to obtain overlapping substitution values to the variables appearing in a pair of norms/rules with contradictory normative positions, e.g. permission and prohibition, obligation and prohibition. In contrast to their work, the conflicts we address, shift attention to a broader level of legal specifications, which implies that they may occur implicitly and cannot be observed easily by the static comparison of legal rules. Therefore, we detect the legal conflicts through interacting with a sequence of events (i.e. composite traces) and continuous comparison of the changing legal states and consequences, which makes the approach more comprehensive and of practical use. [5] and [10] present a formal definition and analysis of conflicts, but no computational mechanisms are provided. Moreover, their work also assume that all conflicts are known a priori. However, it is very likely that individuals do not have sufficient legal knowledge to be aware of potential conflicts arising from their cases. So our approach works both for specific traces but can also detect conflicts without them.

Regarding the mechanism for conflict resolution, Vasconcelos et al. annotate each rule with an \textit{undesirable set} containing values that cause conflicts, then the rule with lower precedence has to avoid being assigned these values. An alternative method is provided by [10], where either a belief change function or a non-monotonic reasoning approach is applied with regards to classic ordering strategies over laws. García-Camino et al. achieve conflict resolution by removing laws with lower precedence. Contrasted to the existing work above, there are two novel contributions in our resolution mechanism: (i) our strategy is to apply a minimum revision to the legal specification with lower priority, making it consistent with the others, rather than ignoring or deleting them, and (ii) the LC-RES tool is fully implemented under \textit{AnsProlog} and supported by ASP solver \textit{CLINGO}, providing an automated revision mechanism.

6. CONCLUSIONS AND FUTURE PLAN

Conflicts of law might occur between legal systems from different jurisdictions (e.g. different countries), or also might be caused unintentionally between new legislation and existing laws (e.g. as in the scenario described in the case study). It is of great importance for individuals on the one hand, to be able to foresee potential conflicts as consequence of a sequence of events, and on the other hand, for legislators and rule makers to know how to prevent the occurrences of conflicts when revising current laws. In this paper, we first presented a formal and computational approach supporting legal modelling and reasoning. Based on that, we then introduced an approach for automatically detecting conflicts between different legal systems, which is able to not only detect conflicts at a general level of a composite legal specification, but also to identify conflicts that are caused by specific cases (i.e. traces of exogenous events). Furthermore, in order to resolve the conflicts, we implement an automatic mechanism based on \textit{inductive learning} to produce revision suggestions with minimum cost to the current legal systems.

For the future work, we outline several issues and extensions to the current approach: (i) establish a legal ontological framework to relax the assumption of semantic alignment within a composite legal specification. (ii) extend the method to handle multiple traces and even all possible traces by giving each trace separate unrelated state instances. (iii) investigate further the complete solution to resolve all conflicts.

7. REFERENCES


