Defeasible Deontic Logic for Normative Reasoning

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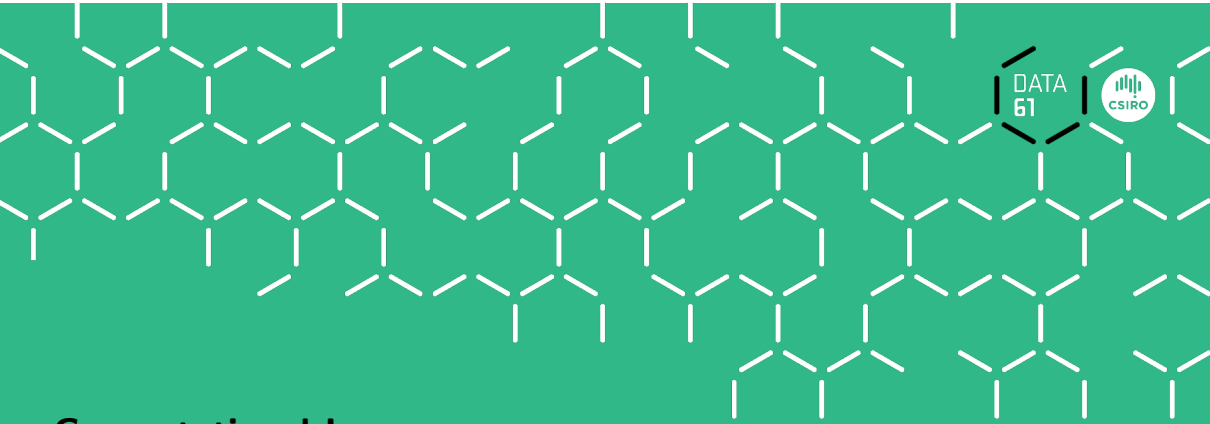
6 September 2020



Computational Law

Aims of Computational Law

To provide formal methods (logic) to:

- formalise a normative system
- determine what normative positions are in force
- determine what norms have been violated or complied with

A Legal Example: License

License for the evaluation of a product

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2. The Licensee must not publish the results of the evaluation of the Product without the approval of the Licensor; the approval must be obtained before the publication. If the Licensee publishes results of the evaluation of the Product without approval from the Licensor, the Licensee has 24 hours to remove the material.
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Background: Normative Systems

Key components of Normative Systems

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$$A_1, \ldots, A_n \Rightarrow C$$

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- Prescriptive clauses (norms defining "normative effects")
  - obligations
  - permissions
  - prohibitions
  - violations

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Norms are defeasible (handling exceptions)

Normative Effects

Obligation A situation, an act, or a course of action to which a bearer is legally bound, and if it is not achieved or performed results in a violation.

Prohibition A situation, an act, or a course of action which a bearer should avoid, and if it is achieved results in a violation.

Permission Something is permitted if the prohibition or the obligation to the contrary does not hold.

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- obligation, OBL
- permission, PERM
- prohibition, FORB

Example

Contract fragment

3.1 A “Premium Customer” is a customer who has spent more that $10000 in goods.

3.2 Services marked as “special order” are subject to a 5% surcharge. Premium customers are exempt from special order surcharge.

5.2 The (Supplier) shall on receipt of a purchase order for (Services) make them available within one day.

5.3 If for any reason the conditions stated in 4.1 or 4.2 are not met the (Purchaser) is entitled to charge the (Supplier) the rate of $100 for each hour the (Service) is not delivered.

Why Defeasible Deontic Logic

- Prescriptive and constitutive rules are generally defeasible
- Prescriptive rules prescribe what are the obligations, prohibitions, and permissions in force in given situations, and what are the compensatory measures for their violations.

Defeasiblity: Example 1

TELECOMMUNICATIONS CONSUMER PROTECTIONS CODE (C628:2012)
Section 2.1. Definitions

Complaint means an expression of dissatisfaction made to a Supplier in relation to its Telecommunications Products or the complaints handling process itself, where a response or Resolution is explicitly or implicitly expected by the Consumer.

An initial call to a provider to request a service or information or to request support is not necessarily a Complaint. An initial call to report a fault or service difficulty is not a Complaint. However, if a Customer advises that they want this initial call treated as a Complaint, the Supplier will also treat this initial call as a Complaint.

If a Supplier is uncertain, a Supplier must ask a Customer if they wish to make a Complaint and must rely on the Customer's response.

Defeasiblity: Example 2

NATIONAL CONSUMER CREDIT PROTECTION ACT 2009 (Act No. 134 of 2009)
Section 29

(1) A person must not engage in a credit activity if the person does not hold a licence authorising the person to engage in the credit activity.

(3) For the purposes of subsections (1) and (2), it is a defence if:

- (a) the person engages in the credit activity on behalf of another person (the principal); and
- (b) the person is:
  - (i) an employee or director of the principal or of a related body corporate of the principal; or
  - (ii) a credit representative of the principal; and ...

Modelling Obligations: Deontic Logic

Extension of logic with the deontic operators OBL and PERM.

- $SpecialOrderPrice(x) = Price(x) + 5\%$
- $\text{OBL}_{Supplier}\ MakeGoodsAvailble1Day$
- $\text{PERM}_{Purchaser}\ ChargeSupplier$

Standard Deontic Logic

Extension of classical logic with the modal operators OBL and PERM.

- $\mathsf{OBL}\,\alpha \equiv \neg\,\mathsf{PERM}\,\neg\alpha, \quad \mathsf{PERM}\,\alpha \equiv \neg\,\mathsf{OBL}\,\neg\alpha$
- $\mathsf{OBL}(\alpha \to \beta) \to (\mathsf{OBL}\,\alpha \to \mathsf{OBL}\,\beta)$
- $\mathsf{OBL}\,\alpha \to \mathsf{PERM}\,\alpha$ or $(\mathsf{OBL}\,\alpha \to \neg\,\mathsf{OBL}\,\neg\alpha)$

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Standard Deontic Logic is not able to deal with violations

Violation paradox

Rules for SSA 2020 Lectures

- Guido should not tell lies in his lecture
- If Guido tells a lie then he has to explain why
- It ought to be the case that if Guido does not tell a lie then he does not explain why
- Guido tells lies in his lecture

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- $\text{OBL}\ \neg lie$
- $lie \rightarrow \text{OBL}\ explain$
- $\text{OBL}(\neg lie \rightarrow \neg explain)$
- lie

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- OBL $\neg lie$
- $lie \rightarrow$ OBL $explain$
- OBL$(\neg lie \rightarrow \neg explain)$
- lie

OBL $explain$ and OBL $\neg explain$

Kobayashi Maru

What's the problem?

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$$a \Rightarrow Ob$$
$$\neg b \Rightarrow Oc$$
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A logic of violations

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- Prescriptive clauses cannot be taken in isolation.
- It is possible to have chains of obligations/violations
- New prescriptive clauses can be derived from the given prescriptive clauses

Permission or permissions?

- Weak (or negative) permission: something is weakly permitted by a (legal) code iff it is not prohibited by that code;
- Strong (or positive) permission: something is strongly permitted by a (legal) code if such a code explicitly states that it is permitted.

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- Strong (or positive) permission: something is strongly permitted by a (legal) code if such a code explicitly states that it is permitted.

Strong legal permissions are exceptions to legal prohibitions

Weak permission: Example

Consider a normative system consisting of the following norm:

> *If one lives in Australia for more than 183 consecutive days over a 12-month period, then she is obliged to pay taxes in Australia on her worldwide income.*

Weak permission: Example

Consider a normative system consisting of the following norm:

If one lives in Australia for more than 183 consecutive days over a 12-month period, then she is obliged to pay taxes in Australia on her worldwide income.

Hence, if

you lived in Australia for 60 consecutive days

then

it is permitted for you not to pay your taxes in Australia.

Strong permission: Example

Consider a normative system consisting of the following norm:

> *If one subscribes to an on-line sale agreement accepting to enter her personal data, then it is permitted for the seller to use this information only on the condition that it is used for shipping, and other necessary purposes to communicate with the buyer or deliver the products to her.*

Strong permission: Example

Consider a normative system consisting of the following norm:

> *If one subscribes to an on-line sale agreement accepting to enter her personal data, then it is permitted for the seller to use this information only on the condition that it is used for shipping, and other necessary purposes to communicate with the buyer or deliver the products to her.*

Hence, there are good reasons to assume that

> *It is forbidden for the seller to use this information for other purposes.*

Defeasible Deontic Logic

Recap Defeasible Logic

Rule-based non-monotonic formalism

- Flexible
- Efficient (linear complexity)
- Directly skeptic semantics
- Argumentation semantics
- Constructive proof theory
- Encompasses other formalisms used in AI and Law
- Applied in several fields/optimised implementations
- Extensible
- Not affected by Deontic Logic Paradoxes

Extending the language of Defeasible Logic

- extend the language with the deontic operators OBL, PERM (FORB $=$ OBL $\neg$)
- extend the language with the reparation operator $\otimes$. Permitted only in the head/conclusion of rules.
- two classes of rules:
  - constitutive: $A_1, \ldots, A_n \hookrightarrow B$
  - prescriptive: $A_1, \ldots, A_n \hookrightarrow_{\mathrm{OBL}} B$

Extending the proof mechanism of Defeasible Logic

- To prove OBL p_n from a rule

$$A \Rightarrow_{\text{OBL}} p_1 \otimes \cdots \otimes p_{n-1} \otimes p_n$$

  we have to show that OBL $p_1, \ldots,$ OBL p_{n-1} and $\neg p_1, \ldots, \neg p_{n-1}$ are provable.
- To disprove OBL p_n from a rule

$$A \Rightarrow_{\text{OBL}} p_1 \otimes \cdots \otimes p_{n-1} \otimes p_n$$

  that at least one among OBL $p_1, \ldots,$ OBL p_{n-1} and $p_1, \ldots, p_{n_1}$ is rejected.

Modelling Permissions

Making a U-turn at an intersection with traffic lights

A driver must not make a U-turn at an intersection with traffic lights unless there is a U-turn permitted sign at the intersection.

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General prohibition to U-turn:

$$arr_{40a}\colon AtTrafficLigths \Rightarrow_{\mathrm{OBL}} \neg Uturn.$$

Permission to Uturn if Uturn permitted sign:

$$arr_{40e}\colon UturnPermittedSign \hookrightarrow Uturn.$$

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From definitions to obligations

Can we conclude OBL B

$$A_1, \ldots, A_n \Rightarrow B$$

and

$$\text{OBL}\, A_1, \ldots, \text{OBL}\, A_n$$

What is a breach of the license?

License for the evaluation of a product

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Uncompensable Violation

$$\Rightarrow_{\mathsf{OBL}} A \otimes B \otimes C$$

and $\neg A$, $\neg B$, $\neg C$

DDL Formally

DDL formally

A rule $r \in R[q, j]$ is *body-applicable* iff for all $a_i \in A(r)$:

1. if $a_i = \Box l$ then $+\partial_{\Box} l \in P(1..n)$ with $\Box \in \{\text{OBL}, \text{PERM}, \text{PERM}_w, \text{PERM}_s\}$;
2. if $a_i = \neg\Box l$ then $-\partial_{\Box} l \in P(1..n)$ with $\Box \in \{\text{OBL}, \text{PERM}, \text{PERM}_w, \text{PERM}_s\}$;
3. if $a_i = l \in Lit$ then $+\partial l \in P(1..n)$.

A rule $r \in R[q, j]$ is *body-discarded* iff $\exists a_i \in A(r)$ such that

1. if $a_i = \Box l$ then $-\partial_{\Box} l \in P(1..n)$ with $\Box \in \{\text{OBL}, \text{PERM}, \text{PERM}_w, \text{PERM}_s\}$;
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3. if $a_i = l \in Lit$ then $-\partial l \in P(1..n)$.

DDL formally

A rule $r \in R$ is *body-p-applicable* iff

1. if $r \in R^{\text{OBL}}$ and it is body-applicable; or
2. if $r \in R^{C}$ and, $A(r) \neq \emptyset$, $A(r) \subseteq PLit$ and $\forall a_i \in A(r)$, $+\partial_{\text{OBL}} a_i \in P(1..n)$.

A rule $r \in R$ is *body-p-discarded* iff

1. if $r \in R^{\text{OBL}}$ and it is not body-applicable; or
2. if $r \in R^{C}$ and either $A(r) = \emptyset$ or $A(r) \cap Lit \neq \emptyset$ and $\exists a_i \in A(r)$, $-\partial_{\text{OBL}} a_i \in P(1..n)$.

DDL formally

A rule $r \in R[q, j]$ such that $C(r) = c_1 \otimes \cdots \otimes c_n$ is *applicable* for literal q at index j, with $1 \leq j < n$, in the condition for $\pm\partial_{\mathrm{OBL}}$ iff

1. r is body-p-applicable; and
2. for all $c_k \in C(r)$, $1 \leq k < j$, $+\partial_{\mathrm{OBL}} c_k \in P(1..n)$ and $(-\partial c_i \in P(1..n)$ or $+\partial{\sim}c_i \in P(1..n))$.

DDL formally $+\partial_{\mathrm{OBL}}$

$+\partial_{\mathrm{OBL}}$: If $P(n+1) = +\partial_{\mathrm{OBL}} q$ then
(1) $\exists r \in R_d^{\mathrm{OBL}}[q, i] \cup R_d^C[q]$ such that r is applicable for q, and
(2) $\forall s \in R[\sim q, j]$, either
  (2.1) s is discarded, or
  (2.2) $\exists t \in R[q, k]$ such that t is applicable for q and $s \prec t$

DDL formally $+\partial_{\mathrm{PERM}_s}$

$+\partial_{\mathrm{PERM}_s}$: If $P(n+1) = +\partial_{\mathrm{PERM}_s} q$ then
(1)$+\partial_{\mathrm{OBL}} q \in P(1..n)$ or
(2.1) $\exists r \in R^{\mathrm{OBL}}_{def}[q] \cup R^{C}_{def}[q]$ such that r is body-p-applicable, and
(2.2) $\forall s \in R[\sim q, j]$, either
(2.2.1) s is discarded, or
(2.2.2) $\exists t \in R_{[}q, k]$ such that t is applicable for q and $s \prec t$

DDL formally (other permissions)

$+\partial_{\mathrm{PERM}_w}$: If $P(n+1) = +\partial_{\mathrm{PERM}_w} q$ then
$(1) -\partial_{\mathrm{OBL}} \sim q \in P(1..n)$.

$+\partial_{\mathrm{PERM}}$: If $P(n+1) = +\partial_{\mathrm{PERM}} q$ then
$(1) +\partial_{\mathrm{PERM}_s} q \in P(1..n)$ or
$(2) +\partial_{\mathrm{PERM}_w} q \in P(1..n)$.

DDL formally (proving violation

$+\partial_\perp$: If $P(n+1) = +\partial_\perp$ then
(1)$\exists R_d^{\mathrm{OBL}} \cup R_d^C$ such that
(1.1) r is body-p-applicable and
(1.2) $\forall c_i \in C(r)$ $+\partial_{\mathrm{OBL}} c_i \in P(1..n)$ and
either $-\partial_C c_i \in P(1..n)$ or $+\partial{\sim}c_i \in P(1..n)$.

From Theory to Practice

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Making sense of the license

C0 the use of the product is forbidden;
C1 if a license is granted, then the use of the product is permitted;
C2 the publication of the result of the evaluation is forbidden;
C2c the removal of the illegally published results within the allotted times compensates the illegal publication;
C2e the publication of the results of the evaluation is permitted if approval is obtained before publication;
C3 commenting about the evaluation is forbidden;
C3e commenting about the evaluation is permitted, it publication of the results is permitted;
C4 publication of the results of evaluation is obligatory, if commissioned for an independent evaluation;
C4x the use of product is obligatory, if commissioned for an independent evaluation;
C5 the use of the product is forbidden, if there is a violation of the above conditions.

Formalising the Agreement

$$
\begin{aligned}
r_0 &: \Rightarrow_{\mathrm{OBL}} \neg \mathit{use} \\
r_1 &: \mathit{license} \rightsquigarrow_{\mathrm{OBL}} \mathit{use} \\
r_2 &: \Rightarrow_{\mathrm{OBL}} \neg \mathit{publish} \otimes \mathit{remove} \\
r_{2e} &: \mathit{approval} \rightsquigarrow_{\mathrm{OBL}} \mathit{publish} \\
r_3 &: \Rightarrow_{\mathrm{OBL}} \neg \mathit{comment} \\
r_{3e} &: \mathrm{PERM}\ \mathit{publish} \rightsquigarrow_{\mathrm{OBL}} \mathit{comment} \\
r_4 &: \mathit{commission} \Rightarrow_{\mathrm{OBL}} \mathit{publish} \\
r_{4x} &: \mathit{commission} \Rightarrow_{\mathrm{OBL}} \mathit{use} \\
r_5 &: \bot \Rightarrow_{\mathrm{OBL}} \neg \mathit{use}
\end{aligned}
$$

where $r_0 \prec r_1$, $r_0 \prec r_{4x}$, $r_1 \prec r_5$, $r_{4x} \prec r_5$ $r_2 \prec r_{2e}$, $r_3 \prec r_{3e}$.

Readings

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Applications I

Business Process Compliance

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Spent Conviction

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Applications II

Contracts/Smart Comtracts

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