

Modeling Legal Dynamics in Defeasible Logic

Antonino Rotolo

CIRSFID, University of Bologna, Italy

Formal Models of Norm Change 2

University of Amsterdam

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Acknowledgements

- ▶ Governatori, G. and A. Rotolo. 2010. Changing Legal Systems: Legal Abrogations and Annulments in Defeasible Logic. *The Logic Journal of IGPL*
- ▶ Riveret, R. and A. Rotolo. 2008. Temporal Deontic Defeasible Logic: An Analytical Approach. *Computable Models of the Law*. Berlin: Springer.
- ▶ Rubino, R. and A. Rotolo. 2009. A Java Implementation of Temporal Defeasible Logic. *Proc. RuleML 2009*. Berlin: Springer.
- ▶ Governatori, G. and A. Rotolo. 2008. Changing Legal Systems: Abrogation and Annulment. Part I: Revision of Defeasible Theories. *Proc. DEON 2008*. Berlin: Springer.
- ▶ Governatori, G. and A. Rotolo. 2008. Changing Legal Systems: Abrogation and Annulment. Part II: Temporalised Defeasible Logic. *Proc. NorMAS 2008*. University of Luxembourg.
- ▶ Governatori, G., M. Palmirani, R. Riveret, A. Rotolo, and G. Sartor. 2007. Back to the Future: Variants of Temporal Defeasible Logic for Modelling Norm Modifications. *Proc. of ICAIL 2007*. New York: ACM Press.
- ▶ Riveret, R., M. Palmirani, and A. Rotolo. 2007. Legal Consolidation Formalised in Defeasible Logic and Based on Agents. *Proc. V Legislative XML Workshop*. Florence: European Press Academic Publishing.
- ▶ Governatori, G., Palmirani, M., Riveret, R., Rotolo, A., and G. Sartor. 2005. Normative Modifications in Defeasible Logic. *Proc. JURIX 05*. Amsterdam: IOS Press.

Layout

- ▶ Explicit vs implicit modifications in the law

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- ▶ Modelling explicit modifications: belief and base revision in rule-based systems (Defeasible Logic, DL)
- ▶ Modelling explicit modifications in Temporal Defeasible Logic (TDL)

Explicit vs Implicit Legal Modifications

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- ▶ **Implicit:** the legal system is revised by introducing new norms which are not specifically meant to modify previous norms, but which change in fact the system because they are incompatible with such existing norms and prevail over them

Types of Explicit Modifications (1)

- ▶ *Textual modifications*: e.g., substitution, which typically replaces some textual components of a provision with other textual components. Example (fictional from the Italian constitution):

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Legislative Act n. 124, 23 July 2008

Art. 1. With the exception of the cases mentioned under the Articles 90 and 96 of the Constitution, criminal proceedings against the President of the Republic, the President of the Senate, the President of the House of Representatives, and the Prime Minister, are suspended for the entire duration of tenure. [. . .]

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Modifying norm (enacted on 10 August 2008):

Legislative Act n. 124, 23 July 2008 will begin to be in force since 20 September 2008.

Defeasible Logic

Natural representation of legal systems.

- ▶ Defeasible Theory
 - ▶ Facts
 - ▶ Strict rules ($A \rightarrow B$)
 - ▶ Defeasible rules ($A \Rightarrow B$)
 - ▶ Defeaters ($A \rightsquigarrow B$)
 - ▶ Superiority relation over rules
- ▶ Derive (plausible) conclusions with the minimum amount of information.
 1. $+\Delta q$, which means that q is strictly provable in D ;
 2. $-\Delta q$, which means that q is not strictly provable in D ;
 3. $+\partial q$, which means that q is defeasibly provable in D ;
 4. $-\partial q$, which means that q is not defeasibly provable in D .
- ▶ Theory extension

$$E(T) = (\Delta^+(T), \Delta^-(T), \partial^+(T), \partial^-(T))$$

Revision in DL: Substitution

Art.3 : Citizen \Rightarrow Equal_Status

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Art.3 : Citizen \Rightarrow *Equal_Status*
↓

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Art.3 : Citizen \Rightarrow Equal_Status



Art.3 : Human \Rightarrow Equal_Status

Revision in DL: Substitution

Art.3 : Citizen \Rightarrow Equal_Status

\downarrow

Art.3 : Human \Rightarrow Equal_Status

$$T_{r:A \Rightarrow B, C/A}^{sub} = \begin{cases} T & \text{if } B \in \partial^+(T) \text{ whenever } C \in \partial^+(T) \\ (F, R', \succ') & \text{otherwise} \end{cases}$$

where

$$R' = R - \{r : A \Rightarrow B\} \cup \{r : C \Rightarrow B\}$$

$$\succ' = \succ$$

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$$T_{r:A \Rightarrow B, C}^{derog} = \begin{cases} T & \text{if } B \notin E(T) \\ (F, R', \succ') & \text{otherwise} \end{cases}$$

$R' = R \cup \{r' : A, C \rightsquigarrow \sim B\}$ and

$\succ' = \succ \cup \{r' \succ r\} \cup \{s \succ r' \mid s \in R[B] - \{r\}\}$.

Revision of Norms: Annulment as Rule Removal

$$T_r^{annul} = (F, R - \{r\}, \succ)$$

Contraction of the rule: simple and close to legal practice!

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Abrogation?

- ▶ Abrogations operate *ex nunc* and so do not cancel the effects that were obtained before the modification (non-retroactivity);
- ▶ Abrogations are not properly norm removals: a norm n , abrogated in 2009, will anyway produce its effects if the facts happened in 2008.

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- ▶ Modifications are parametrized with time
- ▶ Modifications can be conditioned to some preconditions (conditional modifying norms)
- ▶ Conflicts between modifying norms: modifications are defeasible

Retroactive Modifications

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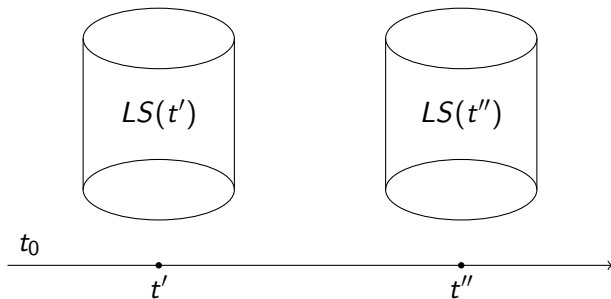
T_2 remove s from T_0 : undo-change-redo. $T_2 = (((((T_0)_r^+)_r^-)_s^-)_r^+)$.

Assuming $(T_r^+)_r^- = T$.

T_0 is just the fact A . T_1 is obtained from T_0 by retroactively adding two rules $A \Rightarrow B$ and $B \Rightarrow C$ and these rules are effective in T_0 . Then the next transformation, leading to T_2 is the removal of $A \Rightarrow B$ from T_0 .

Moving to TDL: Normative Systems

$LS(t_1), LS(t_2), \dots, LS(t_j), \dots$



Rules in TDL

A rule is identified by a unique label and gives conditions to derive a (legal) provision at a particular time.

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$$r1 : (IncomeThreshold^{31Jan} \Rightarrow HighMarginalRate^{(28Feb, \tau)})^{(1Jan, \pi)} @ (31Dec, \pi)$$
$$r2 : (HighMarginalRate^{28Feb} \Rightarrow Pay50\%^{(1March, \pi)})^{(1Jan, \pi)} @ (31Dec, \pi)$$

Meta-Rules in TDL

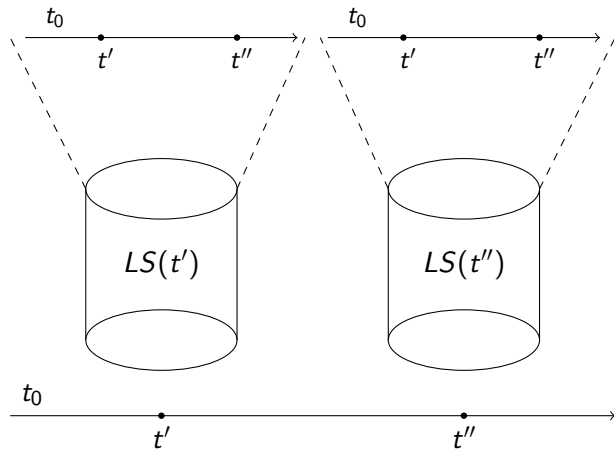
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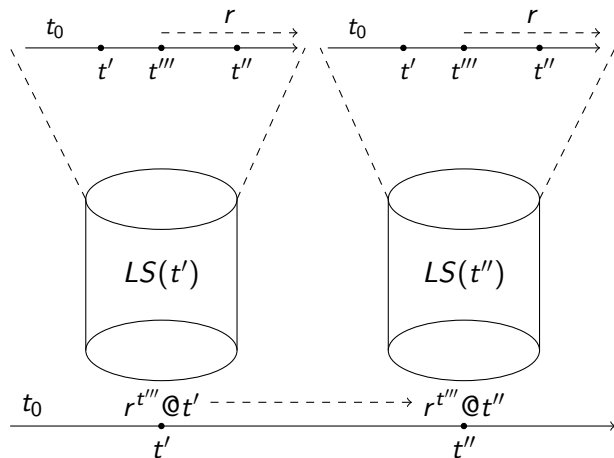
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$$mr : (JoinEU^{21March} \Rightarrow$$
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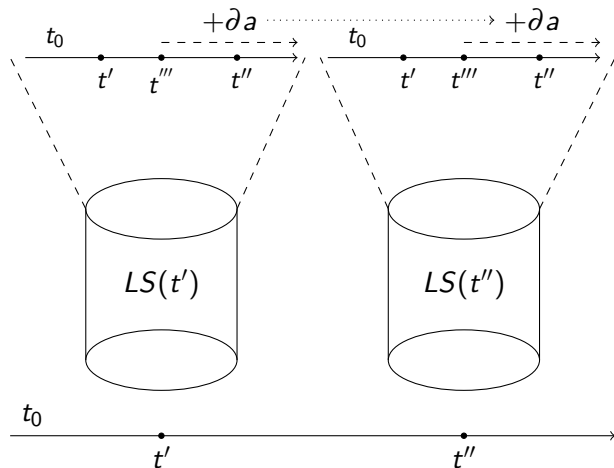
Temporal Model



Rule Persistence



Conclusion Persistence



Persistence in Normative Systems

Given

$$r1 : (a^{10} \Rightarrow b^{(20,\pi)})^{(5,?)@v1}$$

When can we prove b ?

Persistence in Normative Systems

Given

$$r1 : (a^{10} \Rightarrow b^{(20,\pi)})(5,?)@v1$$

When can we prove b ?

1. Can we prove b^{20} from viewpoint 4?

Persistence in Normative Systems

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$$r1 : (a^{10} \Rightarrow b^{(20,\pi)})^{(5,?)@v1}$$

When can we prove b ?

1. Can we prove b^{20} from viewpoint 4? No

Persistence in Normative Systems

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When can we prove b ?

1. Can we prove b^{20} from viewpoint 4? No
2. Can we prove b^{20} from viewpoint 5?

Persistence in Normative Systems

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2. Can we prove b^{20} from viewpoint 5? Yes

Persistence in Normative Systems

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When can we prove b ?

1. Can we prove b^{20} from viewpoint 4? No
2. Can we prove b^{20} from viewpoint 5? Yes
3. Can we prove b^{25} from viewpoint 5?

Persistence in Normative Systems

Given

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When can we prove b ?

1. Can we prove b^{20} from viewpoint 4? No
2. Can we prove b^{20} from viewpoint 5? Yes
3. Can we prove b^{25} from viewpoint 5? Yes

Persistence in Normative Systems

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When can we prove b ?

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2. Can we prove b^{20} from viewpoint 5? Yes
3. Can we prove b^{25} from viewpoint 5? Yes
4. Can we prove b^{20} from viewpoint 10?

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4. Can we prove b^{20} from viewpoint 10? Yes, if ? is " π "
5. What about if $r1$ ceases to be effective at 9? Can we still prove b^{20} from viewpoint 10, and prove it from viewpoint 5?

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5. What about if $r1$ ceases to be effective at 9? Can we still prove b^{20} from viewpoint 10, and prove it from viewpoint 5?
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Persistence in Normative Systems

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4. Can we prove b^{20} from viewpoint 10? Yes, if ? is “ π ”
5. What about if $r1$ ceases to be effective at 9? Can we still prove b^{20} from viewpoint 10, and prove it from viewpoint 5? ???
6. Can we prove b^{20} from viewpoint 5 in a successive version of the normative system ($v2$)? and what about if $v2$ no longer contains $r1$?

Persistence in Normative Systems

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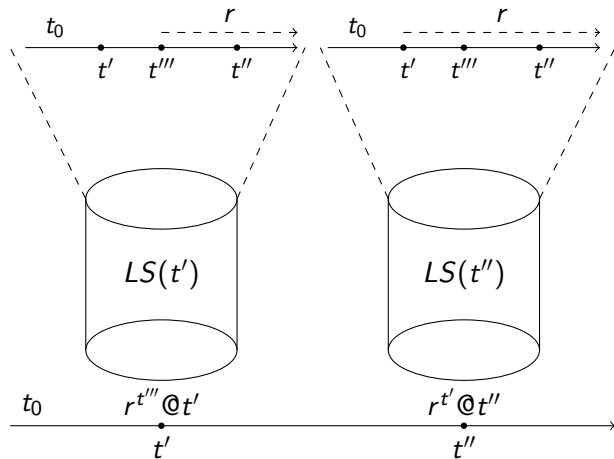
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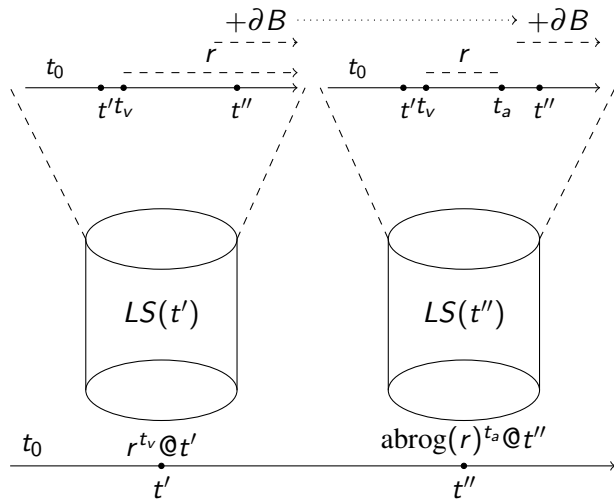
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Temporal Modifications: Time of Force

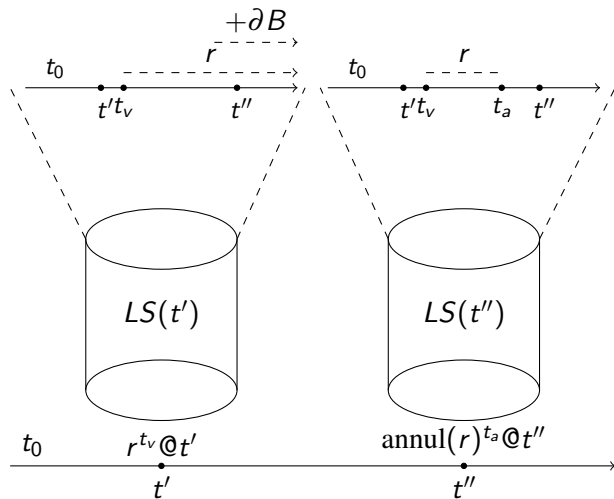
Norm: $r^{t'''} @ t'$
Modifying norm: $(\Rightarrow r^{t'}) @ t''$



Abrogation



Annulment



Conflicts between Modifications

$$r : (A^{t_1} \Rightarrow B^{(t_2, \tau)})^{(t_3, \pi)} @ (t_4, \pi)$$

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- ▶ Indisputable cases of conflict

$$mr_1 : (\Rightarrow r : (C^{t_1} \Rightarrow B^{(t_2, \tau)})^{(t_3, \pi)}) @ (t_5, \pi)$$

$$mr_2 : (\Rightarrow \text{annul}(r)^{(t_3, \pi)}) @ (t_5, \pi)$$

Conflicts between Modifications

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- ▶ Disputable cases of conflict

$$mr_1 : (\Rightarrow r : (C^{t_1} \Rightarrow B^{(t_2, \tau)})^{(t_3, \pi)}) @ (t_5, \pi)$$

$$mr_2 : (\Rightarrow r : (A^{t_1} \Rightarrow Q^{(t_2, \tau)})^{(t_3, \pi)}) @ (t_5, \pi)$$

↓

$$r : (C^{t_1} \Rightarrow Q^{(t_2, \tau)})^{(t_3, \pi)} @ (t_5, \pi)$$

Conclusions

- ▶ Logical model to capture modifications in legal systems
- ▶ It handles retroactivity, time-forking
- ▶ It handles modifications of modifications
- ▶ Experiment with other temporal models (intervals, duration, periodicity), and causality
- ▶ Complexity