Computational Logic and Legal Reasoning

The British Nationality Act

The University of Michigan Lease Termination Clause

The World Health and UNICEF Annual Estimates of National Infant Immunisation Coverage
British Nationality
Act 1981

1981 CHAPTER 61

An Act to make fresh provision about citizenship and nationality, and to amend the Immigration Act 1971 as regards the right of abode in the United Kingdom.

[30th October 1981]

BE IT ENACTED by the Queen's most Excellent Majesty, by and with the advice and consent of the Lords Spiritual and Temporal, and Commons, in this present Parliament assembled, and by the authority of the same, as follows:—

PART I

BRITISH CITIZENSHIP

Acquisition after commencement

1.—(1) A person born in the United Kingdom after commencement shall be a British citizen if at the time of the birth by birth or adoption—

(a) a British citizen; or

(b) settled in the United Kingdom.

(2) A new-born infant who, after commencement, is found abandoned in the United Kingdom shall, unless the contrary is shown, be deemed for the purposes of subsection (1)—

(a) to have been born in the United Kingdom after commencement; and

(b) to have been born to a parent who at the time of the birth was a British citizen or settled in the United Kingdom.
British Nationality Act
Acquisition at Birth

English

1.- (1) A person born in the United Kingdom after commencement shall be a British citizen if at the time of the birth his father or mother is
(a) a British citizen; or
(b) settled in the United Kingdom.

Logic Program

\[
X \text{ acquires british citizenship by subsection 1.1 at time } T \\
\text{if } X \text{ is born in the uk at time } T \\
\text{and } T \text{ is after commencement} \\
\text{and } Y \text{ is father of } X \quad \text{or} \\
\quad Y \text{ is mother of } X \\
\text{and } Y \text{ is a british citizen at time } T \quad \text{or} \\
Y \text{ is settled in the uk at time } T
\]
40.- (2) The Secretary of State may by order deprive a person of a citizenship status if the Secretary of State is satisfied that deprivation is conducive to the public good.

40.- (4) The Secretary of State may not make an order under subsection (2) if he is satisfied that the order would make the person stateless.
Rule and exception

The Secretary of State may by order deprive a person of a citizenship status if the Secretary of State is satisfied that deprivation is conducive to the public good.

Logic program combining the rule and exception into one rule

The Secretary of State may by order deprive a person of a citizenship status if the Secretary of State is satisfied that deprivation is conducive to the public good and the Secretary of State is not satisfied that the order would make the person stateless.
The relationship between rules and exceptions and argumentation

Rule and exception

The Secretary of State may by order deprive a person of a citizenship status if the Secretary of State is satisfied that deprivation is conducive to the public good.

The Secretary of State may not deprive a person of a citizenship status if the Secretary of State is satisfied that the order would make the person stateless.

Argumentation

An argument based on

The Secretary of State may by order deprive a person of a citizenship status if the Secretary of State is satisfied that deprivation is conducive to the public good.

is attacked and defeated by an argument based on

The Secretary of State may not deprive a person of a citizenship status if the Secretary of State is satisfied that the order would make the person stateless.
British Nationality Act - Acquisition by Abandonment – another case of rules and exceptions

English

1.-(2) A new-born infant who, after commencement, is found abandoned in the United Kingdom shall, unless the contrary is shown, be deemed for the purposes of subsection (1)-

(a) to have been born in the United Kingdom after commencement; and

(b) to have been born to a parent who at the time of the birth was a British citizen or settled in the United Kingdom.

Logic Programming

The conclusion of 1.1 holds for a person if the person is found newborn abandoned in the uk after commencement and it is not shown that the contrary of the conditions of 1.1 hold for the person.
Hierarchies of rules and exceptions

Rule 1: All thieves should be punished.
Rule 2: Thieves who are minors should not be punished.
Rule 3: Any thief who is violent should be punished.

The intended meaning:

\begin{align*}
\text{a person should be punished} \\
\text{if the person is a thief and the person is not a minor.}
\end{align*}

\begin{align*}
\text{a person should be punished} \\
\text{if the person is a thief and the person is a minor} \\
\text{and the person is violent.}
\end{align*}

If these are the only conditions under which a person who is a thief should be punished, then it goes without saying that:

\begin{align*}
\text{a person should not be punished if the person is a thief} \\
\text{and the person is a minor and the person is not violent}
\end{align*}
A “higher-level” representation

a person should be punished
if the person is a thief
and it is not the case that
the person is an exception to the punishment rule.

a person is an exception to the punishment rule
if the person is a minor
and it is not the case that
the person is an exception to the exception to the punishment rule.

a person is an exception to the exception to the punishment rule
if the person is violent.
Rules and exceptions

We commonly say:

As a general rule: *a conclusion holds if conditions hold.*

Exception: *the conclusion does not hold if other conditions hold.*

What we really mean is:

*a conclusion holds if conditions hold and other conditions do not hold.*
The University may terminate this lease when the Lessee, having made application and executed this lease in advance of enrolment, is not eligible to enrol or fails to enrol in the University or leaves the University at any time prior to the expiration of this lease, or for violation of any provisions of this lease, or for violation of any University regulations relative to residence or for health reasons, by providing the student with written notice of termination 30 days prior to the effective time of termination,

unless life, limb or property would be jeopardised, the Lessee engages in the sale or purchase of controlled substances in violation of Federal, state, or local law, or the Lessee is no longer enrolled as a student, or the Lessee engages in the use of firearms, explosives, inflammable liquids, fireworks or other dangerous weapons within the building or turns in a false alarm in which case a maximum of 24 hours notice would be sufficient.
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The University may terminate this lease by providing the student with written notice of termination 30 days prior to the effective time of termination if

- the Lessee has made application and executed this lease in advance of enrolment and
- [the Lessee is not eligible to enrol or the Lessee fails to enrol in the University]

or

- the Lessee leaves the University at any time prior to the expiration of this lease
- the Lessee violates any provisions of this lease
- the Lessee violates University regulations regarding residence
- there are health reasons

and the University may not terminate this lease with a maximum of 24 hours notice of termination.
The University may terminate this lease with maximum 24 hours notice if

- life, limb or property would be jeopardised
- the Lessee engages in the sale or purchase of controlled substances in violation of Federal, state, or local law
- the Lessee is no longer enrolled as a student
- the Lessee engages in the use of firearms, explosives, inflammable liquids, fireworks or other dangerous weapons within the building
- the Lessee turns in a false alarm.

Perhaps the condition “it is not the case that the University may terminate this lease with a maximum of 24 hours notice of termination” was not intended.

Why would the University want to restrict itself?

Better to use parallel syntax to express parallel ideas:
The University may terminate this lease by providing 24 hour notice.
Computational Logic and Legal Reasoning

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The World Health and UNICEF Annual Estimates of National Infant Immunisation Coverage
WUENIC – A Case Study in Rule-based Knowledge Representation and Reasoning (two papers on my webpage)

Anthony Burton\textsuperscript{1*}, Robert Kowalski\textsuperscript{2}, Marta Gacic-Dobo\textsuperscript{1}, Rouslan Karimov\textsuperscript{3}, David Brown\textsuperscript{3}

Informal rules (until ~ 2009)

Attempt to formalise the rules (from ~2007 - 2009)

Formal rules and Prolog implementation (from ~ 2009)

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Yearly Official Infant Immunization Coverage Estimates produced by WHO/UNICEF
Relationship with Legal Reasoning

No simple, independent way to assess the truth, in this case the real immunisation coverage.

There is a need for a systematic way to make decisions, which are rigorous, transparent, and consistent, but also flexible.
Inconsistent data
BCG,DTP1,DTP3,Pol3, MCV, HepB3, Hib3, 1980-2006 by countries

Government reported data

- data points 54497
- (27 years, 194 countries)
- To UNICEF: 17900 records
- To WHO: 19481 records
- Administrative coverage: 8313 records
- Official coverage estimates: 8803 records

National and international survey data

- Data points 13017
- From 132 countries
- cohort coverage 1980 to 2005
  - DHS survey (194)
  - MICS survey (211)
  - EPI cluster survey (147)
  - Other surveys (185)

WHO/UNICEF estimates:
24539 data points from 194 countries and 27 years
Nationally reported data = Numerator/Denominator

Numerator = Number of children immunised
Denominator = Target population of children

Numerator problems:

Missing immunization data
Ad hoc adjustment for missing data

Denominator problems:

Inaccurate population data for denominator
Private / NGO sector not included
Survey data measures percentage directly (no numerator/denominator problems)

Problems with survey data:

Survey design (e.g., sample size too small)

Questionnaire design/length (too long and tedious)

Recall bias (mothers don’t remember)

Survey implementation
The rules are represented as logic programs in Prolog

the WUENIC estimate for the Country, Vaccine and Year is \( R \)
if the nationally reported data for a Country, Vaccine and Year is \( R \)
and there is no survey data \( S \) for the Country, Vaccine and Any-Year
and there is no working group decision to assign an estimate \( W \)
for the Country, Vaccine and Year

the WUENIC estimate for the Country, Vaccine and Year is \( W \)
if there is a working group decision to assign an estimate \( W \)
for a Country, Vaccine and Year

In Prolog:    wuenic(Country, Vaccine, Year, R) :-
reported(Country, Vaccine, Year, R),
not(survey(Country, Vaccine, Any-Year, S)),
not(wgd(Country, Vaccine, Year, W)).

wuenic(Country, Vaccine, Year, W) :-
wgd(Country, Vaccine, Year, W).
The rules are represented as logic programs in Prolog

the WUENIC estimate for the Country, Vaccine and Year is $R$
if the nationally reported data for a Country, Vaccine and Year is $R$
and there is survey data $S$ for the Country, Vaccine and Year
and the survey data $S$ supports the reported data $R$
and there is no working group decision to assign an estimate $W$
for the Country, Vaccine and Year

the WUENIC estimate for the Country, Vaccine and Year is $S$
if the nationally reported data for a Country, Vaccine and Year is $R$
and there is survey data $S$ for the Country, Vaccine and Year
and the survey data $S$ does not support the reported data $R$
and there is no working group decision to assign an estimate $W$
for the Country, Vaccine and Year

the survey data $S$ supports the reported data $R$
if the absolute difference between $S$ and $R$ is $D$
and $D \leq 10\%$
The general structure of the WUENIC implementation

*Level one.* The reported and survey data are evaluated separately, and if necessary are ignored or adjusted.

*Level two.* If data are available from only a single source (national reports or surveys), then the estimates are based on that source alone. Otherwise, the estimates are made at “anchor years”, which are years in which there are both reported data and survey data.

*Level three.* Estimates are made at non-anchor years, before, between and after anchor years, influenced by the estimates at the anchor years.

*Level four.* The resulting estimates for the different vaccines are then cross checked for consistency between related vaccines, and adjustments are made if necessary.

Estimates for new years are not based on estimates for previous years.
Forward reasoning fills the triangle bottom-up. Backward reasoning fills the triangle top-down.

Level 0: Unprocessed reported and survey data.
Level 1: “Clean” the data.
Level 2: Estimate at “anchor years”, with both reported and survey data.
Level 3: Estimate before, between and after anchor years.
Level 4: Adjust the estimates for consistency among related vaccines.

Prolog executes the rules top-down.
THE PYRAMID PRINCIPLE
BARBARA MINTO
LOGICAL WRITING,
THINKING AND PROBLEM SOLVING

INTERNATIONAL BESTSELLER
The structure of the Prolog program

```
wuenic(C, V, Y, Prpt) :-
    not wgd(C, V, Y, Pwrd),
    reported(C, V, Y, Prpt),
    survey(C, V, Y, Psurv),
    surveySupportsReported(Psurv, Prpt).
```

```
surveySupportsReported(Psurv, Prpt) :-
    abs(Psurv - Prpt) < 10.
```

```
wgd(C, V, Y, Pwrd)
```

```
survey(C, V, Y, Psurv),
surveySupportsReported(Psurv, Prpt).
```

```
reported(C, V, Y, Prpt)
```

```
reported(egy, dtp3, 2004, 97)
succeeds
```

```
survey(egy, dtp3, 2004, 94)
```

```
abs(97 - 94) < 10
```

```
wgd(egy, dtp3, 2004, Pwgd)
fails
```

```
abs(97 - 94) < 10
```

```
reported(egy, dtp3, 2004, 94)
```

```
survey(egy, dtp3, 2004, 94)
```

```
surveySupportsReported(Psurv, Prpt) :-
    abs(Psurv - Prpt) < 10.
```

```
wuenic(egy, dtp3, 2004, P)
```

```
abs(97 - 94) < 10
```

```
survey(egy, dtp3, 2004, 94)
```

```
abs(97 - 94) < 10
```

```
wgd(egy, dtp3, 2004, Pwgd)
fails
```

```
survey(egy, dtp3, 2004, 94)
```

```
abs(97 - 94) < 10
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```
survey(egy, dtp3, 2004, 94)
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surveySupportsReported(Psurv, Prpt) :-
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survey(egy, dtp3, 2004, 94)
```

```
abs(97 - 94) < 10
```
Problems with the Prolog implementation

Prolog top-down execution repeatedly re-solves lower-level subgoals. 20 minutes per country is too long.

Solution

XSB Prolog top-down execution puts subgoals in a table and solves them only once. 20 seconds per country.

(Tableling was invented in H. Tamaki and T. Sato, OLD resolution with tabulation. Proc. 3rd International Conference on Logic Programming, 1986.)
Conclusions

Well-written legal texts have the form of logic programs.

Well-written legal texts often express rules and exceptions, as in PROLEG.

Poorly written legal texts can be improved by rewriting them into logic programming form.

Logic programs can be executed top-down (backwards) or bottom-up (forwards).

Top-down execution with tabling combines the best features of top-down and bottom-up execution.