What is Logical English (LE)?

Historical development of LE

Examples of LE

Lessons Learned and Prospects for the Future
Legal applications of LE

- expert systems
- computable and smart contracts
- rules as code
- plain English laws
Basic Logical English (LE)

- syntactic sugar for logic programs (pure Prolog):
  conclusion if conditions form
  infix predicates
  implicit quantification of variables
  higher-order (or meta? or modal?) predicates.

- unambiguous:
  no pronouns (he, she, it, they)
  one word = one meaning
  no inflection
  time, but no tense
  no lexicon.

- readable without training in mathematics, computing or logic.
Relationships with other work

- Controlled natural languages, implemented in Prolog: Attempto Controlled English (ACE), PENG, etc.

- English-like domain-specific languages for legal applications, based on logic programming: Blaux, Oracle Intelligent Advisor

- Syntactic sugar for the logic programming language ASP: PENG$^{ASP}$

- RegelSpraak?
Outline of the talk

- The University of Michigan lease termination clause
- The British Nationality Act
- Rock Paper Scissors Smart Contract*
- ISDA (International Swaps and Derivatives) Early Termination
- Australian Small Business Rollover*
- The default clause of the Flood-Goodenough loan agreement*

*with online implementation in SWISH

style is as important as form

LP logical form

higher-order form

Prolog-like form
At the beginning, Leibniz develops a general theory of conditions. Later on, he modifies this theory for moral or legal conditions.

According to Leibniz, a condition is a structure consisting of two parts (propositiones partialibus): the “if” part (conditio) and the “then” part (conditionatum).
The University of Michigan lease termination clause - Allen and Saxon 1984

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.
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.
The clause has the ambiguous form:

A if A1 and A2 or A3 or A4 or A5 or A6 or A7 unless B1 or B2 or B3 or B4 or B5 in which cases B.

Allen & Saxon (1984) conclude that the intended interpretation is:

\[
((A \text{ IF } ((A1 \text{ AND } (A2 \text{ OR } A3)) \text{ OR } A4 \text{ OR } A5 \text{ OR } A6 \text{ OR } A7)) \text{ IF NOT } (B1 \text{ OR } B2 \text{ OR } B3 \text{ OR } B4 \text{ OR } B5)) \text{ AND } (\text{IF } (B1 \text{ OR } B2 \text{ OR } B3 \text{ OR } B4 \text{ OR } B5) \text{ THEN } B) \text{ AND } (\text{IF NOT } (B1 \text{ OR } B2 \text{ OR } B3 \text{ OR } B4 \text{ OR } B5) \text{ THEN NOT } B)
\]
The intended meaning has logic programming form:

\[
((A \text{ IF } ((A_1 \text{ AND } (A_2 \text{ OR } A_3)) \text{ OR } A_4 \text{ OR } A_5 \text{ OR } A_6 \text{ OR } A_7)) \text{ IF } \neg (B_1 \text{ OR } B_2 \text{ OR } B_3 \text{ OR } B_4 \text{ OR } B_5)) \text{ AND } (\text{IF } (B_1 \text{ OR } B_2 \text{ OR } B_3 \text{ OR } B_4 \text{ OR } B_5) \text{ THEN } B) \text{ AND } (\text{IF } \neg (B_1 \text{ OR } B_2 \text{ OR } B_3 \text{ OR } B_4 \text{ OR } B_5) \text{ THEN } \neg B)
\]
A
IF A1
    AND A2
    OR A3
    OR A4
    OR A5
    OR A6
    OR A7
    AND NOT B.

B
IF B1
    OR B2
    OR B3
    OR B4
    OR B5.

unless B
Well-written legislation has logic programming form:

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

As a first approximation, 1.-(1)(a) can be represented by the rule

\[ x \text{ is a British citizen} \]
if \[ x \text{ was born in the U.K.} \]
and \[ x \text{ was born on date } y \]
and \[ y \text{ is after or on commencement} \]
and \[ z \text{ is a parent of } x \]
and \[ z \text{ is a British citizen on date } y \]
the templates are:

*a person* acquires british citizenship on *a date*,
*a person* is born in the uk on *a date*,
*a date* is after commencement,
*a person* is the mother of *a person*,
*a person* is the father of *a person*,
*a person* is a british citizen on *a date*,
*a person* is settled in the uk on *a date*.

the knowledge base citizenship includes:

*a person* acquires british citizenship on a date

if the person is born in the uk on the date
and the date is after commencement

and an other person is the mother of the person

or the other person is the father of the person

and the other person is a british citizen on the date

or the other person is settled in the uk on the date.

scenario one is:

john is born in the uk on 2016-06-02.
2016-06-02 is after commencement.
mary is the mother of john.
mary is settled in the uk on 2016-06-02.

query one is:

which person acquires british citizenship on which date.
TaxLog

An expert system shell midway between Prolog and Logical English

with support from and collaboration with

Bruce and Chris Mennell, Aora, London
Andrew Noble, LodgeIT, Perth
The Aora Nationality Determiner provides legal opinions for claims to British nationality and Irish citizenship. It uses a unique combination of fact-finding, workflow and legal reasoning technologies to provide accurate, audited, and reliable determinations.

HOW IT WORKS

Introducing AORA Nationality (with subtitles)
Example: **R&D Tax Reliefs**
http://demo.logicalcontracts.com:8082/p/research_and_development_tax_reliefs.pl

Example: **Net Asset Value**
http://demo.logicalcontracts.com:8082/p/cgt_maximum_net_asset_value.pl

Example: **Rollover**
http://demo.logicalcontracts.com:8082/p/cgt_concessions_sb_restructure_rollover.pl

Example: **Affiliates**
http://demo.logicalcontracts.com:8082/p/cgt_affiliates.pl

Example: **Reserve Tax reliefs**
http://demo.logicalcontracts.com:8082/p/stamp_duty_reserve_tax_reliefs.pl

Example: **Statutory residence**
http://demo.logicalcontracts.com:8082/p/statutory_residence_test_guidance.pl
https://www.gov.uk/hmrc-internal-manuals/residence-domicile-and-remittance-basis/rdrm11040
Small business restructure rollover

The small business restructure rollover allows small businesses to transfer active assets from one entity (the transferor) to one or more other entities (transferees), on or after 1 July 2016, without incurring an income tax liability.

This rollover applies to the transfer of active assets that are capital gains tax (CGT) assets, trading stock, revenue assets or depreciating assets.

You can access this concession if your aggregated turnover is less than $10 million.
The small business restructure rollover applies to an event if the event occurs at a time and the time is after 2016-07-01 and the event is a transfer of an asset by a transferor to a transferee and the asset is an eligible asset and the event is part of genuine restructuring as informed by a source and the event meets the ultimate ownership test at the time.

And for all cases in which a party is a party of the event and an amount is the aggregated turnover of the party it is the case that: the party is an eligible party and the amount < 10000000.

An event meets the ultimate ownership test at a time if the event is a transfer of an asset by a transferor to a transferee and a previous time is immediately before the time and for all cases in which an entity is an ultimate owner of the asset at the time and the entity has a share in the asset at the time it is the case that: the entity is an ultimate owner of the asset at the previous time and the entity has a share in the asset at the previous time.
Logical English meets legal English for swaps and derivatives

Robert Kowalski\textsuperscript{1} \textsuperscript{ID} \hspace{1em} Akber Datoo\textsuperscript{2}

\textsuperscript{2} D2 Legal Technology, London

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6(a) Right to Terminate Following Event of Default. If at any time an Event of Default with respect to a party (the “Defaulting Party”) has occurred and is then continuing, the other party (the “Non-defaulting Party”) may, by not more than 20 days notice to the Defaulting Party specifying the relevant Event of Default, designate a day not earlier than the day such notice is effective as an Early Termination Date in respect of all outstanding Transactions.

If, however, “Automatic Early Termination” is specified in the Schedule as applying to a party, then an Early Termination Date in respect of all outstanding Transactions will occur immediately upon the occurrence with respect to such party of an Event of Default specified in Section 5(a)(vii)(1), (3), (5), (6) or, to the extent analogous thereto, (8), and as of the time immediately preceding the institution of the relevant proceeding or the presentation of the relevant petition upon the occurrence with respect to such party of an Event of Default specified in Section 5(a)(vii)(4) or, to the extent analogous thereto, (8).
It is permitted that a party designates by a notice at a time T2 to an other party that an Early Termination Date in respect of a Transaction occurs at a time T3 if the Transaction is outstanding at T3 and an Event of Default occurs with respect to the other party at a time T1 and the Event of Default is continuing at T2 and the notice specifies the Event of Default and T2 ≤ T3 and T3-T2 ≤ 20 days

and it is not the case that the Schedule specifies that Automatic Early Termination applies to the other party for the Event of Default.

Adds an exception to the rule
Higher-order or
Metalevel or
Modal predicates

An event happens at a time T2
if it is permitted that a party designates by an action at a time T1 that the event happens at T2
and the party designates by the action at T1 that the event happens at T2.

T2 could be after T1
the templates are:

* it is permitted that *an eventuality*,
  *a party* designates by *an action* at *a time* to
  *an event* happens at *a time*,
  *a party* performs *an action* at *a time*.
  *a time* is on or before *a time*.

the knowledge base metaevent includes:

An event happens at a time T2
  if it is permitted that a party designates by an
  and the party designates by the action at T1 that

scenario test is:

  it is permitted that bob designates by email at a
  if T1 is on or before T2.

  bob designates by email at Monday that this meeti
  Monday is on or before Friday.

query one is:

  which event happens at which time.
Contract as Automaton: The Computational Representation of Financial Agreements

Mark D. Flood
Office of Financial Research
mark.flood@ofr.treasury.gov

Oliver R. Goodenough
Office of Financial Research and Vermont Law School
oliver.goodenough@ofr.treasury.gov
ogoodenough@vermontlaw.edu
Table 2: A Streamlined Loan Agreement

Agreement

This loan agreement dated June 1, 2014, by and between Lender Bank Co. ("Lender") and Borrower Corp. (Borrower), will set out the terms under which Lender will extend credit in the principal amount of $1,000 to Borrower with an un-compounded interest rate of 5% per annum, included in the specified payment structure.

1. The Loan:
At the request of Borrower, to be given on June 1, 2014, Lender will advance $1000 to Borrower no later than June 2, 2014. If Borrower does not make such a request, this agreement will terminate.

2. Repayment:
Subject to the other terms of this agreement, Borrower will repay the loan in the following payments:

(a) Payment 1, due June 1, 2015, in the amount of $550, representing a payment of $500 as half of the principal and interest in the amount of $50.

(b) Payment 2, due June 1, 2016, in the amount of $525, representing a payment of $500 as the remaining half of the principal and interest in the amount of $25.

3. Representations and Warranties:
The Borrower represents and warrants, at the execution of this agreement, at the request for the advance of funds and at all times any repayment amount shall be outstanding, the Borrower’s assets shall exceed its liabilities as determined under an application of the FASB rules of accounting.

4. Covenants:
The Borrower covenants that at the execution of this agreement, at the request for the advance of funds and at all times any repayment amount shall be outstanding it will make timely payment of all state and federal taxes as and when due.

5. Events of Default:
The Borrower will be in default under this agreement upon the occurrence of any of the following events or conditions, provided they shall remain uncured within a period of two days after notice is given to Borrower by Lender of their occurrence (such an uncured event an "Event of Default");

(a) Borrower shall fail to make timely payment of any amount due to Lender hereunder;

(b) Any of the representation or warranties of Borrower under this agreement shall prove untrue;

(c) Borrower shall fail to perform any of its covenants under this agreement;

(d) Borrower shall file for bankruptcy or insolvency under any applicable federal or state law.

A default will be cured by the Borrower (i) remedying the potential event of default and (ii) giving effective notice of such remedy to the Lender. In the event of multiple events of default, the first

to occur shall take precedence for the purposes of specifying outcomes under this agreement.

6. Acceleration on Default:
Upon the occurrence of an Event of Default all outstanding payments under this agreement will become immediately due and payable, including both principal and interest amounts, without further notice, presentment, or demand to the Borrower.

7. Choice of Law:
This agreement will be subject to the laws of the State of New York applicable to contracts entered into and performed wholly within that state.

8. Amendments and Waivers:
Any purported amendment to, or waiver of rights under, this agreement will only be effective if set forth in writing and executed by both parties.

9. Courts and Litigation:
Any legal action brought to enforce, interpret or otherwise deal with this agreement must be brought in the state courts of the State of New York located in New York County, and each of the parties agrees to the jurisdiction of such courts over both the parties themselves and over the subject matter of such a proceeding, and waives any claim that such a court may be an inconvenient forum.

10. Time of Essence: No Pre-Payment:
Timely performance is required for any action to be taken under this agreement, and, except as may otherwise be specifically provided herein, failure to take such action on the day specified will constitute a binding failure to take such action. Payments shall only be made on or after the dates specified in Section 2 or on or after such other date as may be required under Section 6; pre-payments made on earlier dates shall not be accepted.

11. Notices:
Notices provided for in this agreement will be given by an email to the email addresses set out below and will be effective upon receipt.

[Email: Lender email here]
[Borrower email here]

Accepted and agreed:

LENDER BANK CO. BORROWER CORP.

By: ________________________ By: ________________________
Title: ________________________ Title: ________________________

[NOTE: Statute of Limitations on debt obligations in NY is 6 years]
Draft of July 23, 2014
The loan agreement as a Discrete Finite Automaton

Key Messages

- Financial contracts are structured internally as state-transition systems.
- Discrete finite automata (DFA) are an adequate formalism to represent this structure as finite sets of states, events, and transitions.
The loan agreement in LPS simulating DFA

% The simplest case with no complications:

observe request(borrower, 1000) at '2014-06-01'.
observe advance(lender, 1000) at '2014-06-01'.
observe pay(borrower, lender, 550) at '2015-06-01'.
observe pay(borrower, lender, 525) at '2016-06-01'.

?- state_diagram(Graph).
The English formulation of the loan agreement is incoherent.

An event of default occurs **retroactively** when one of the events (a)-(d) occurs if the borrower does not cure the event within two days after the lender notifies the occurrence.

All outstanding payments need to be made **immediately (and retroactively)** as soon as the Event of Default occurs.
A more direct representation of the loan agreement in LE, with only events and without states/fluents

the borrower has obligation1.

obligation1 is that the borrower pays 550 to the lender on 2015-06-01.

the borrower has obligation2.

obligation2 is that the borrower pays 525 to the lender on 2016-06-01.

the borrower defaults on a date D3

if the borrower has an obligation

and the borrower fails on a date D0 to fulfil the obligation

and the lender notifies the borrower on a day D1 that the borrower fails on D0 to fulfil the obligation

and D3 is 2 days after D1

and it is not the case that

the borrower cures on a day D2 the failure of the obligation

and D2 is on or before D3.
the borrower defaults on a date D3
if the borrower has an obligation
and the borrower fails on a date D0 to fulfil the obligation
and the lender notifies the borrower on a day D1 that the borrower
and D3 is 2 days after D1
and it is not the case that
the borrower cures on a day D2 the failure of the obligation
and D2 is on or before D3.

the borrower fails on a date to fulfil an obligation
if the obligation is that the borrower pays an amount to the lender
and it is not the case that
the borrower pays the amount to the lender on the date.

the borrower cures on a first date the failure of an obligation
if the obligation is that the borrower pays an amount to the lender
and the borrower pays the amount to the lender on the first date.

A date D1 is on or before a date D2
if D2 is a X days after D1
and X >= 0.

scenario one is:
the lender notifies the borrower on 2016-06-02 that the borrower
% the borrower pays 525 to the lender on 2016-06-02.

query one is:
which person defaults on which day.
Lessons learned

- It is hard to design a CNL that is a simple and powerful computer language, is natural to read in English, has very wide coverage.

- Important to have easy-to-use editing, debugging and exploration tools.

- Essential to have a free, easy-to-use online implementation (e.g. on SWISH).
Prospects for the Future

● All computer languages should be readable without training.
● But learning to write will be harder than learning to read.
● Learning to write well will be much harder.
● We need a corpus of well-written examples.
● Legal applications are a good place to start.

Online implementation soon to be available from:
http://logicalcontracts.com