

# A CNL for Contract-Oriented diagrams

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**CHALMERS**



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# REMU

## Reliable Multilingual Digital Communication: Methods and Applications

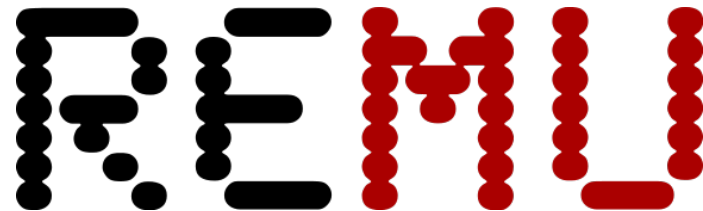
<http://remu.grammaticalframework.org/>



REMU

# REMU

1. Hybrid machine translation
  - Grammars + statistics
2. Formal methods for grammars
  - Ambiguity detection
3. Contract reasoning



# Contracts

# What is a contract?

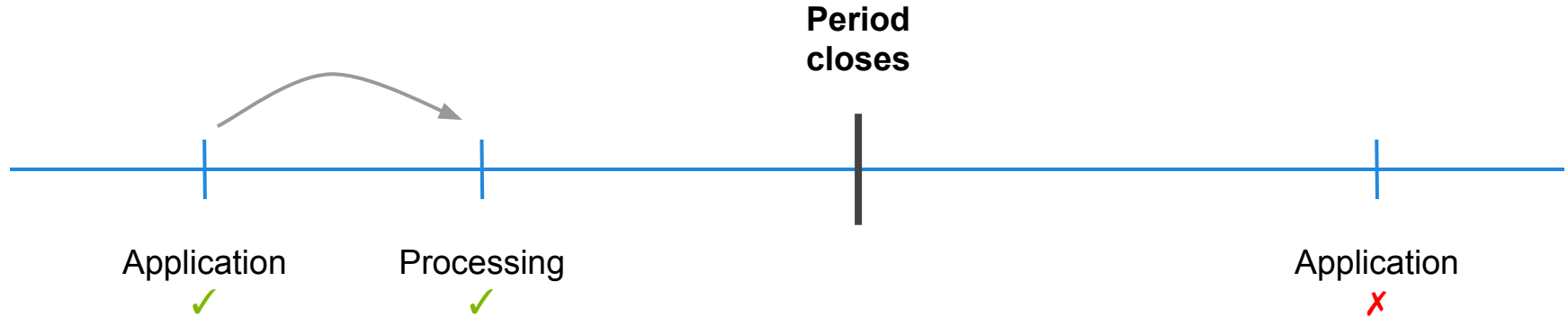
- **Document containing norms** prescribing procedures, behaviours, rights
- **Examples**
  - requirement specification
  - privacy policy
  - terms of service
  - service-level agreement

# Motivating example

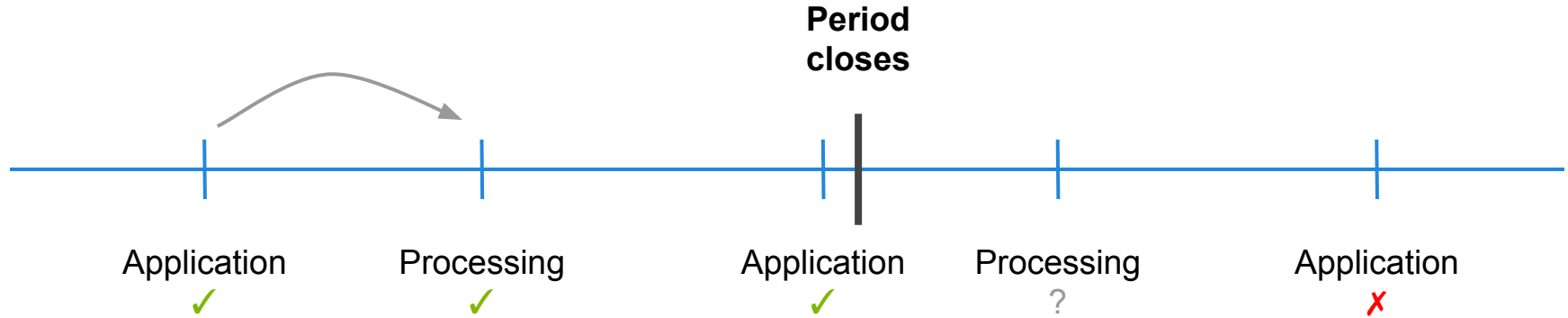
## **Application procedure**

1. Applications may be submitted between 1st–31st May.
2. The secretary must process each application within 5 days.
3. The secretary should not process any applications after the period has closed.

# Motivating example



# Motivating example





# Potential conflicts

- Is something wrong with this contract?
  - Should it be changed?
- 
- That's for a human to decide
  - Computer can find potential conflicts

# Desired tasks: static

- Detect conflicts
  - While writing (author)
  - Before accepting (party)
- Query
- Check properties
- Simulate

# Desired tasks: runtime

- Detect violations
- Enact reparations
- Logs, without interference

*Only computer-mediated transactions*

# Originals & models

## Natural Language

Original  
contract

קטץ מנוו קטרי  
Katz Menu Cattery

Sales Contract

On the Date of \_\_\_\_\_, Katz Menu (hereinafter referred to as the Seller or Breeder) agrees to sell to \_\_\_\_\_ (hereinafter referred to as the Buyer) with the understanding that the Buyer agrees to be used for breeding purposes. The Seller hereby warrants or represents (hereinafter referred to as the Seller's representation) that the above information is true and correct and that the above information is true and correct and that the above information is true and correct.

Buyer Address: \_\_\_\_\_  
City: \_\_\_\_\_ State: \_\_\_\_\_ Zip: \_\_\_\_\_

Price of \$ \_\_\_\_\_ for the cat described below;  
The Seller and Buyer have agreed upon the price of \$ \_\_\_\_\_ for the cat described below;

Color: \_\_\_\_\_ Sex: \_\_\_\_\_ Bred on this Date: \_\_\_\_\_  
Breed: Traditional Siamese or Oriental Shorthair  
Registering Organization: CFA (American Cat Association) or PCA (Traditional Cat Association) or other: \_\_\_\_\_

Sold as Breeder. For the Buyer's use:  
The Seller is transferring the Cat/Kit to the Buyer in good faith as a healthy and well-cared-for animal. The Buyer is encouraged to have the Cat/Kit checked on by a Veterinarian of the Buyer's own preference within a period of 72 hours. Provided that 72 hours passed the Kit is deemed to be the Buyer's to keep; the Buyer must have written documentation from the Seller's veterinarian before the Cat/Kit will be returned to the Seller/Breeder for a full refund. After this period, the Seller makes no guarantee as to the health or suitability of the Cat/Kit with the following exception: If, any time prior to the CFA or PCA Official Cat/Breeder, the Cat should develop an undiagnosed hereditary defect, please have written documentation from a veterinarian providing the Cat's ability to be normally used as a pet; the Seller/Breeder will provide replacement cat.

Signature (Buyer): \_\_\_\_\_ Signature (Seller): \_\_\_\_\_  
Contract Date: \_\_\_\_\_

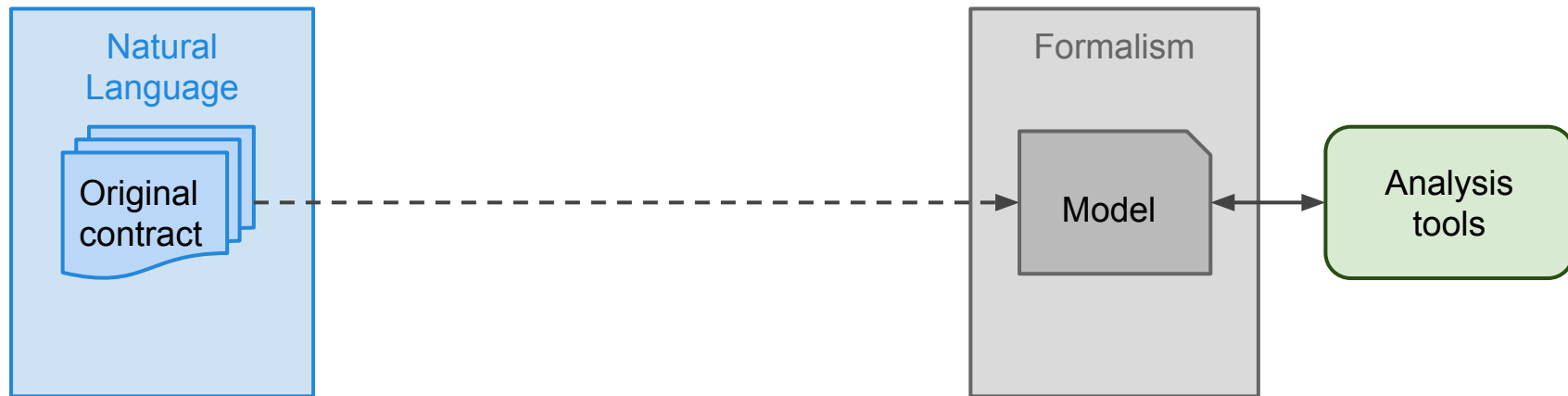
## Formalism

Model

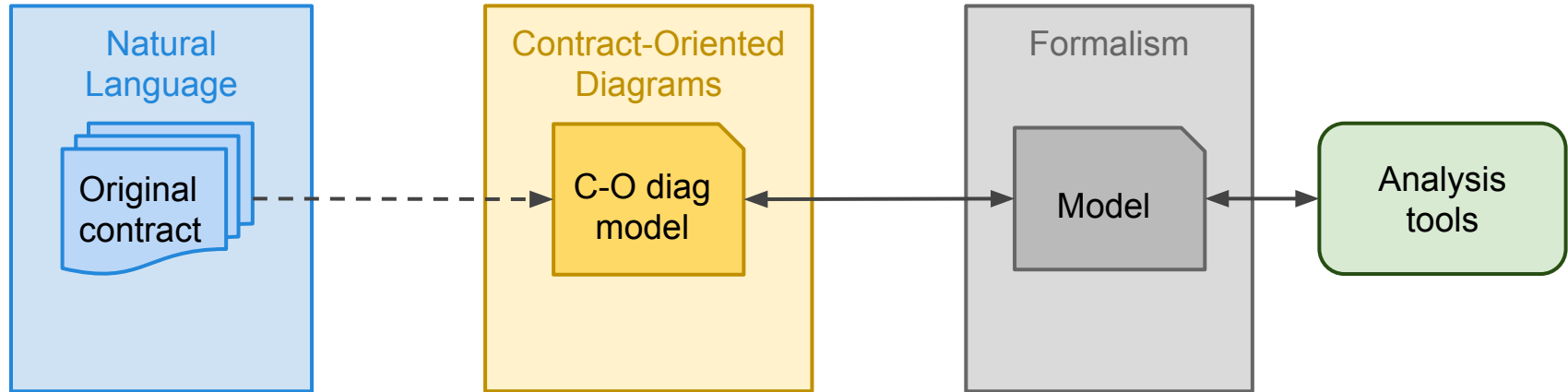
$$P(\text{su}) \wedge [\text{cl}]^F_{O(x)}(\text{pr.co}) \oplus O_{\perp}(\text{xy} \wedge (\text{w} \vee \text{z}))$$

```
<contract>
  <clauses>
    <clause>[a3] (P(a1)) </clause>
    <clause>(P(a2.a3)) </clause>
  </clauses>
  <concurrentActions>
    <action>a3#a4</action>
  </concurrentActions>
</contract>
```

# The divide



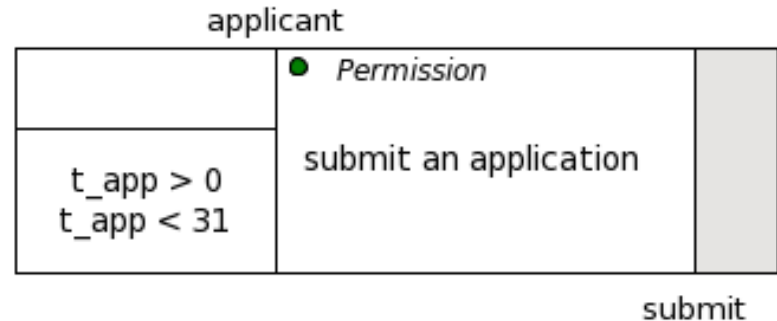
# Introducing C-O diagrams



# Contract-Oriented diagrams

# Contract-Oriented diagrams

- A visual representation of a contract
- Modular
- Boxes as clauses
- Modalities
  - Obligation O
  - Permission P
  - Prohibition F

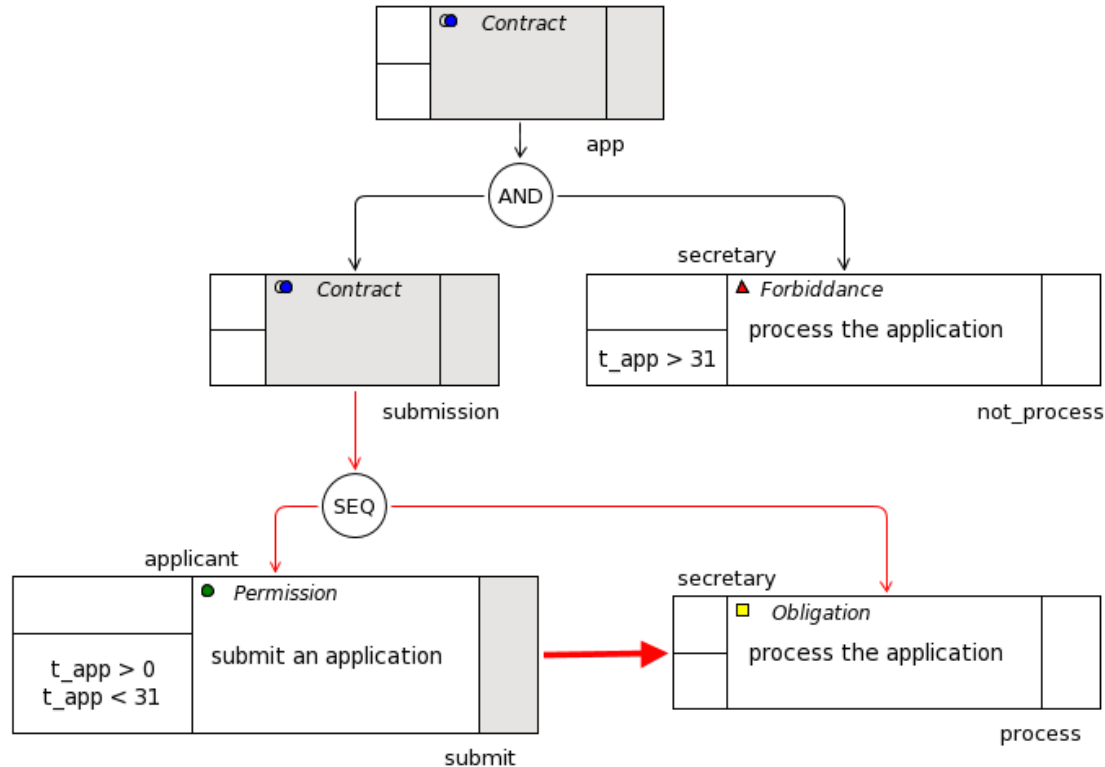




# Contract-Oriented diagrams

- Guards & timing constraints
- Complex actions, contracts
  - conjunction / choice / sequence
- Reparations
- Cross-references

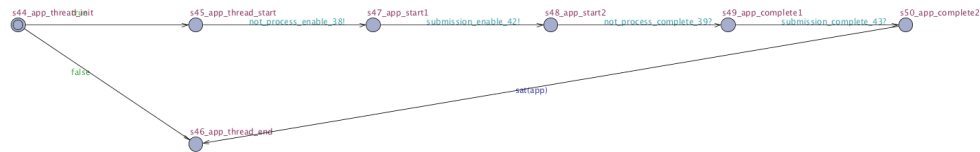
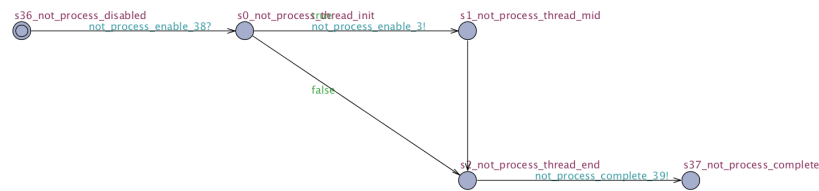
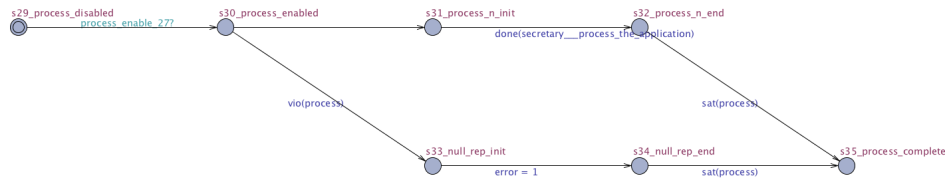
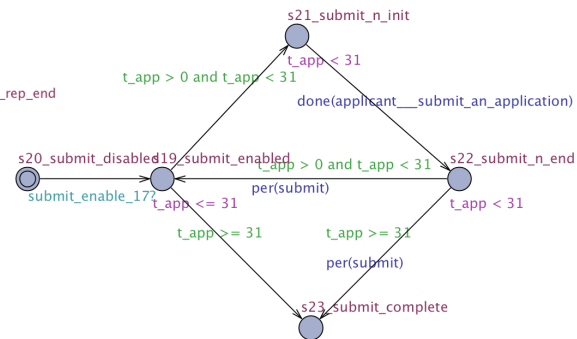
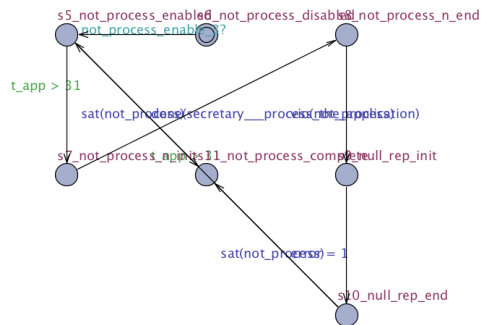
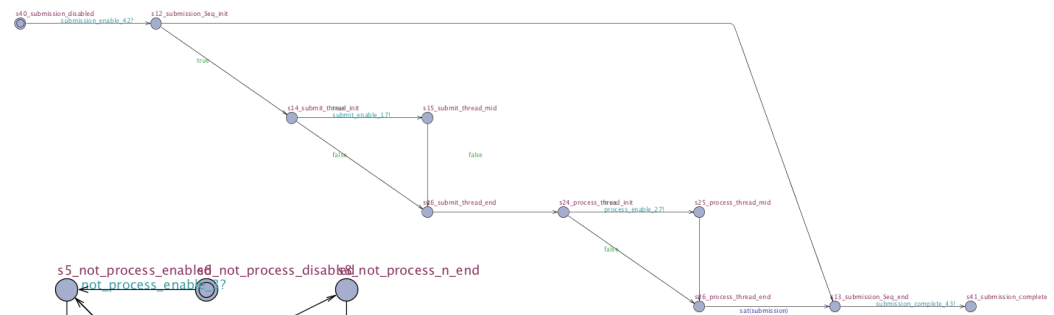
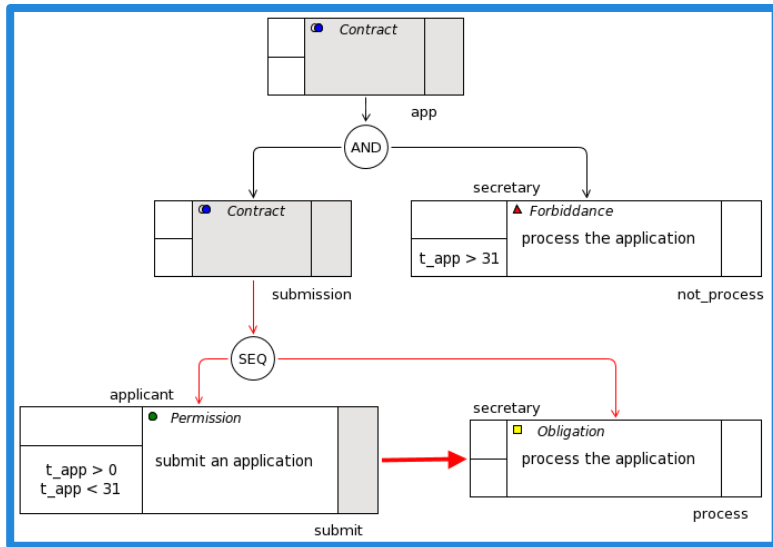
# First example



# Conversion to NTA

Translation into **networks of timed automata**

- Real clocks
- Guards on transitions
- Automata running in parallel
- Synchronisation channels



# Model checking

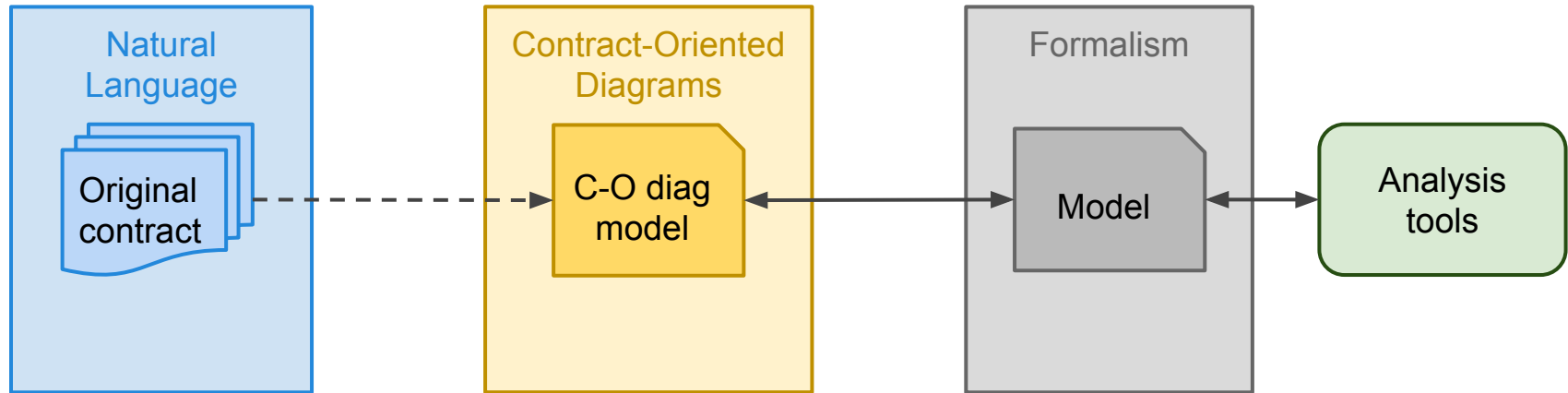
What can we do with automata?

- Simulation
- Model checking
  - Test properties in temporal logic  
“it is never the case that x and y”
- Querying by model checking

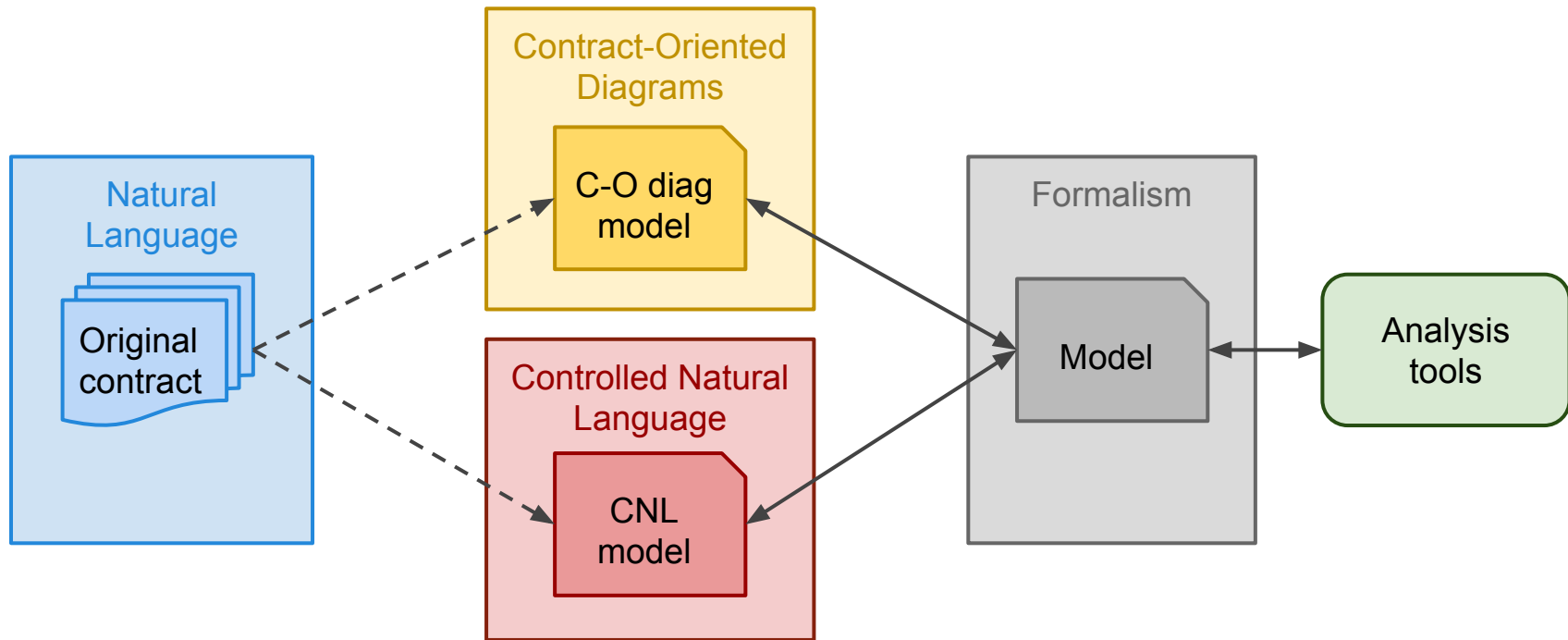
# The need for CNL

- Some tasks benefit from visualisation
- Natural language cannot be replaced
  - Original documents are in NL
  - We want to produce NL
  - Collaboration with other stakeholders
- Two views for same model
  - Diagrams
  - CNL

# One view



# Two views





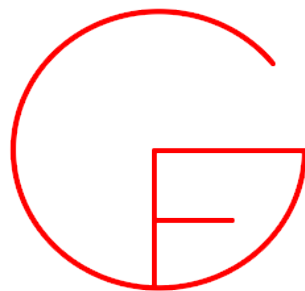
CNL

# Controlled Natural Language

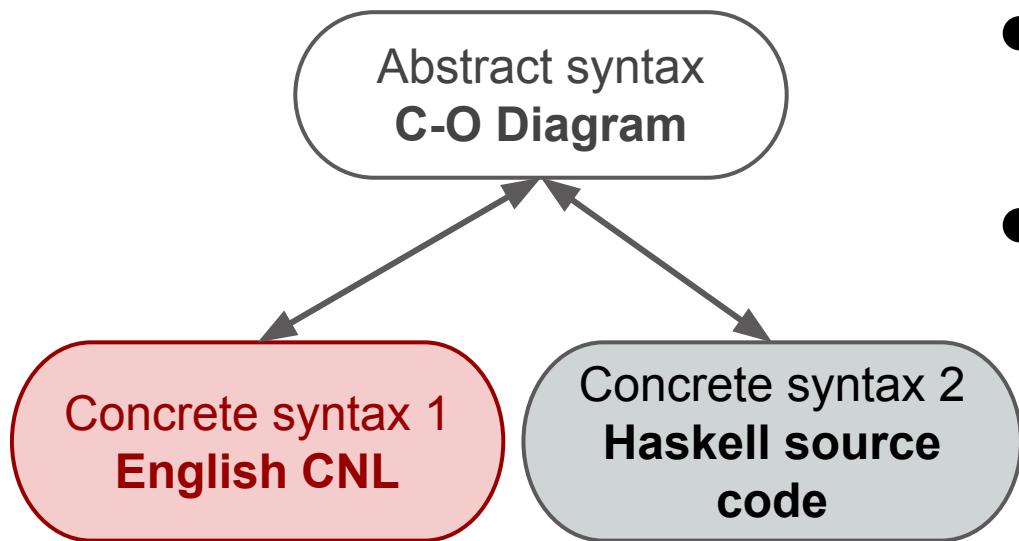
- Existing target of C-O diagrams
- Linearise to / parse from English CNL
- The usual motivations
  - Unambiguous parsing
  - Easily human-readable
  - Human-writable with little training

# Grammatical Framework (GF)

- Framework for multilingual grammars
- Language-independent semantic interlingua
- Generation and parsing from single grammar

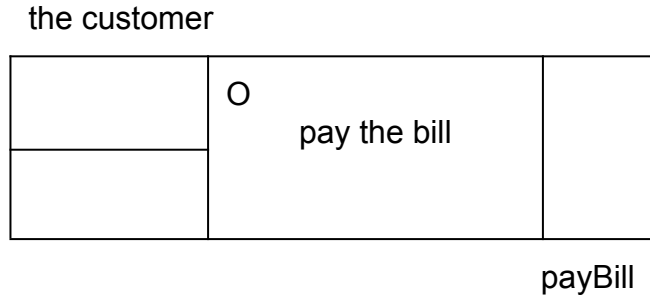


# Grammars



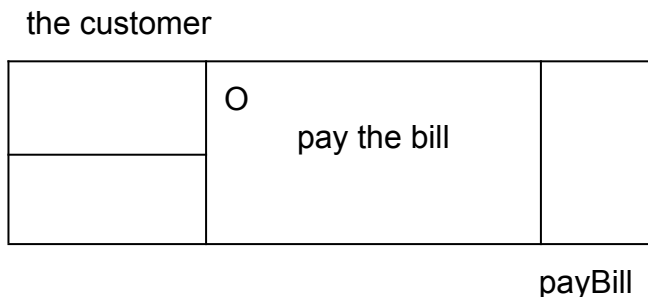
- A.S. matches formal C-O definition
- Haskell C.S. is near trivial, but:
  - Lists
  - Maybe types
  - Type Constructors

# CNL Grammar



- A box is a sentence
- Agents are NPs
- Actions are VPs
  - V
  - V2 + NP
  - Optional PP
- DictEng from RGL

# Example 1a: modal variants (O)



the customer **is obliged to** pay  
the bill

the customer **is required to** pay  
the bill

the customer **must** pay the bill

# Example 1a: modal variants (P)

the customer

	P pay the bill	

payBill

the customer **is allowed to** pay  
the bill

the customer **is permitted to** pay  
the bill

the customer **may** pay the bill

# Example 1a: modal variants (F)

the customer

	F pay the bill	

payBill

the customer **is not allowed to**  
pay the bill

the customer **may not** pay the bill

the customer **must not** pay the  
bill



# Example 1b: agreement

the customers

	O pay the bill	

payBill

the customers **are** obliged to pay  
the bill

the customers **are** required to pay  
the bill

the customers must pay the bill

# Example 1b: resulting object

the customers

	O	
	pay the bill	

payBill

the customers are obliged to pay  
the bill

```
O
  (Agent "the customers")
  (N "payBill")
  Nothing
  Nothing
  (A_Action (Action "pay the bill"))
  Just (R Nothing)
```

# Example 2: V and PP

the customers

	O pay by card	

payBill

the customers must pay **by card**

## PP attachment

- Without object, to V  
*eat with friends*
- With object, always to NP  
*eat (pizza with friends)*

# Timing restrictions

- Determine time frame during which something is applicable
- Different implications for O/P/F
- Expressed as inequalities over clocks
  - Clocks count “real” time
  - Global “wall” clocks, box clocks

# Example 3a: one timing restriction

the customer

	P request a refund	
t_orderFood > 40		

refund

when t\_orderFood is greater than 40 the customer may request a refund

```
P
  (Agent "the customer")
  (N "refund")
  Nothing
  (Just (TRL [TR
    (Ck "t_orderFood") ε C_GT 40]))
  (A_Action (Action "pay the bill"))
```

# Example 3b: two timing restrictions

the customer

	P request a refund	
t_orderFood > 40 t_orderFood < 60		

refund

when t\_orderFood is greater than 40 **and** t\_orderFood is less than 60 the customer may request a refund

when

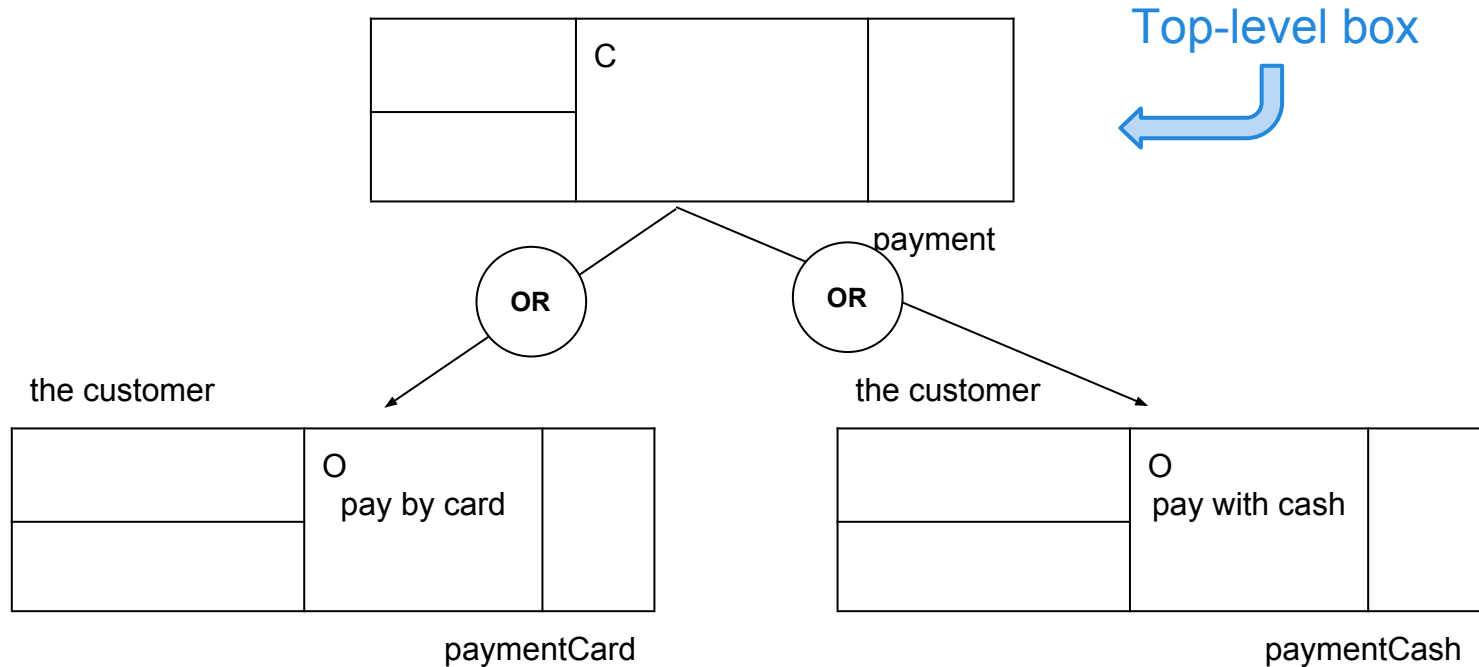
- t\_orderFood is greater than 40 , **and**
- **t\_orderFood is less than 60**

the customer may request a refund

# Complex contracts / refinement

- Boxes can be combined by
  - Conjunction AND
  - Choice OR
  - Sequence SEQ

# Example 4: refinement





# Example 4: refinement

## Inline

the customer must pay by card **or** the customer is required to pay with cash

## Bulleted

**any of**

- the customer must pay by card
- the customer is required to pay with cash

# 2-lists and refinement

## Lists and linearisations

- 1 item (no refinement): inlined
- 2 items: inlined *or* bulleted
- 3 or more: bulleted

# Labels

- Something I left out
- All clauses must include a label

**payment:** any of

- **paymentCard:** the customer must pay by card
- **paymentCash:** the customer is required to pay with cash

- Needed for cross-refs, reparations
- Easily hidden with tools

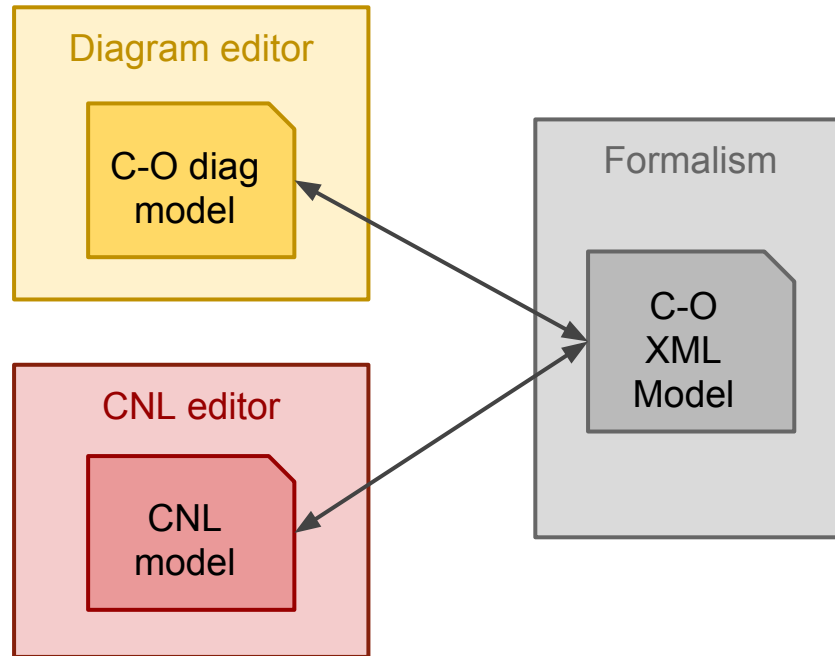
# PENS score (Kuhn, 2014)

Precision	Expressiveness	Naturalness	Simplicity
5	1	2-3	4
Implementing a formal grammar	Restricted to expressivity of formalism	Labels, bullets	Concisely described as a GF grammar

Formal representation, Written,  
specific Domain, Academic

# Tools

# Two tools



# CNL editor

- Basic completion
- Snippets
- Highlighting/folding
- Syntax checking
- Export to visual editor

# Visual diagram editor

- Point and click diagram editor
- Web-based
- Automatic validation
- Export



# Demo

...I will also be at the demo session later!

# Conclusions

# Problems: formalism

Finding suitable formalism

- Expressivity, features, generality
- Validating translation to target formalism
- Formal semantics (only translation to NTA)

# Problems: CNL (1)

- Still un-natural in places
- Making arbitrary algebraic expressions natural is... not natural
- More work on editing tools
  - Constructive error messages

# Problems: CNL (2)

- Parsing agent/action as grammatical chunks
  - Agreement
  - Multi-lingual considerations
  - Analysis of entities
- Out of lexicon words
  - Unable to handle

# Future: query language

## Properties and counter-examples

- We want queries and answers in NL
  - a. NL query  $\rightarrow$  property in temp. logic
  - b. Manipulation of properties to find answer
  - c. “answer”  $\rightarrow$  NL response



Thanks

# Q & A

