Checking Legal Contracts – On a Not So Usual Application of Mechanized Logic

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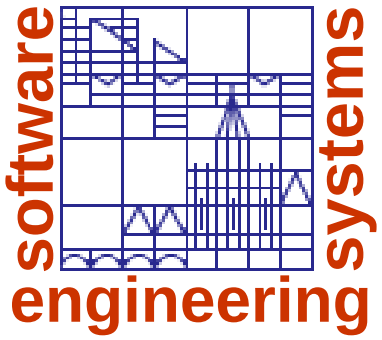
VardiFest 22



Joint Work With

- Alan Khoja (Law)
- Martin Kölbl (Computer Science)
- Rüdiger Wilhelmi (Law)

Logic and Law

- **Leibniz, Law and Logic**
  - G.W. Leibniz, 1669:

    "*In the field of legal conditions, it will be shown that certainty and proof exist in law.*"

    (quoted after M. Armgart, Leibniz as a legal scholar, *Fundamina (Pretoria)*. 2014, vol.20, n.1)
- **Later**
  - deontic logic
  - defeasible logic

Analysis and Formalization

- **Our Objective: Automated Analysis**
  - legal contracts are complex collections of claims
    - here: restriction to company sales purchase agreements (SPAs)
  - contracts change often (during contract design / negotiation phase)
  - need for automated consistency analysis
    - static / syntactic consistency (e.g., completeness of contract)
    - dynamic consistency analysis:
      - can each claim in the contract be performed individually?
      - does there exist at least one contract execution?

- **Our Approach**
  - formalization using decidable fragments of FOL
  - tool-based, automated analysis using SMT-solving

Formalization in Decidable Fragment of FOL

- **Legal Facts**

$$\phi_{owner} = \bigwedge_{(p,o)\in PR} (owner(o) = p)$$

- **Claims**

$$\phi_c \equiv (d_c = -1) \vee ((c.\texttt{DueDate} \leq d_c \leq c.\texttt{Limitation}) \Rightarrow l_c)$$

- **Contract**
  - primary / independent and consequence claims

$$\phi_{SPA} \equiv \phi_{owner} \wedge \bigwedge_{c\in\mathcal{C}} \phi_c \wedge \bigwedge_{c\in\mathcal{C}_I} (d_c \geq 0 \vee \bigvee_{\forall s\in\mathcal{C}(c)} d_s \geq 0)$$

  - preference on primary / independent claims: soft-assert

$$\phi_{soft} \equiv \bigwedge_{c\in\mathcal{C}_I} d_c \geq 0 \wedge \bigwedge_{s\in\mathcal{C}(c)} d_s = -1$$

  - contract execution (partially satisfiable MaxSMT problem)

$$\wedge \phi_{soft}$$

Blocks: Capturing Contract Texts

SPA

§1 1.1 The Seller Eva hereby sells the shares of Bakery AG with all rights and obligations pertaining thereto (including the dividend right for the current financial year), to the Purchaser Chris who accepts such sale.
1.2 The purchaser pays the purchase price 40.000 € to the seller.
1.3 If the TransferClaim is not performed, the claim.Debtor has the right to withdraw.
1.4 If the PayClaim is not performed, the claim.Debtor has the right to withdraw.
…

Webinterface:

Block1 Remove Hide Up Down
The Seller Eva hereby sells shares of Bakery AG, with all rights and obligations pertaining thereto (including the dividend right for the current financial year), to the Purchaser Chris, who accepts such sale.

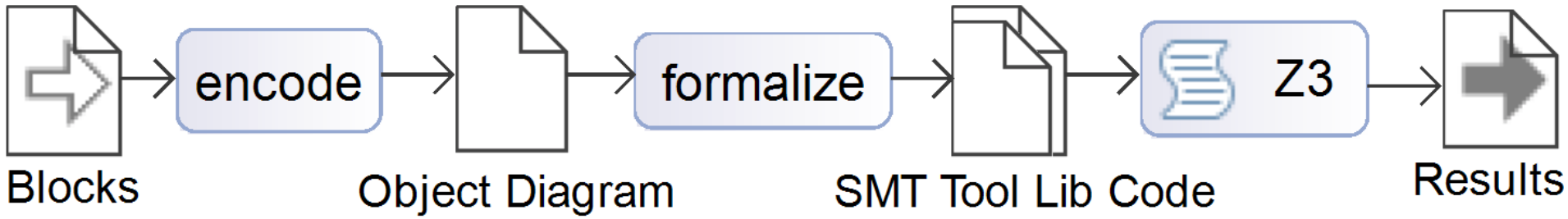
+

Block2 Remove Hide Up Down
The purchaser pays the purchase price 40000 € to the seller on date 28.

Parameterized Text Block

ID	Block1
Text	The Seller $seller.Name hereby sells the shares of $shares.Name with all rights and obligations pertaining thereto (including the dividend right for the current financial year), to the Purchaser $purchaser.Name who accepts such sale.
Objects	„seller:Person“, „shares:Share“, „transfer:Claim“
Assign-ments	„seller.Name=Eva“, „shares.Name=Bakery AG“, „transfer=$shares.transfer()“

Tool *ContractCheck*



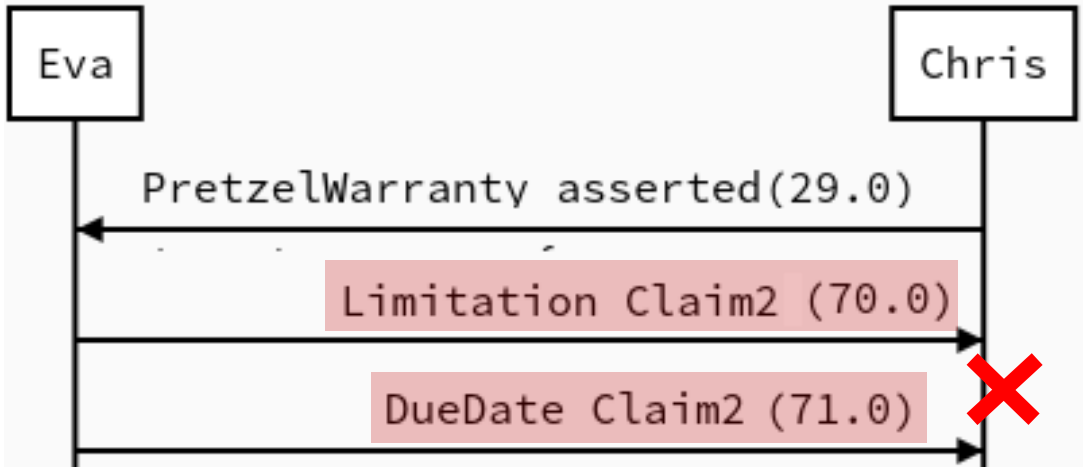
Encoding / Analysis

- **Case Study: Pretzel Bakery**
  - legal facts
    - owner function $\phi^{B}_{owner} \equiv owner(Bakery) = Bank$
  - claim encoding
    - legal claim $c \in C_I$ with date d_c with performance l_c
      - e.g. $\phi_T \equiv (d_T = -1) \vee (28 \leq d_T \leq 70 \Rightarrow owner(1) = 1)$
  - claim satisfiability analysis
    - $c \in C_I : \Phi_c \equiv \phi_{owner} \wedge \phi_c \wedge d_c \geq 0$
    - e.g. $\Phi_T \equiv owner(1) = 3 \wedge ((d_T = -1) \vee 28 \leq d_T \Rightarrow owner(1) = 1) \wedge d_T \geq 0$
  - *ContractCheck* result

Block1:	Block9:
The seller Eva sells the shares of the company Bakery AG to purchaser Chris for 40000 €.	The Bakery AG is transferred by way of security to Bank .

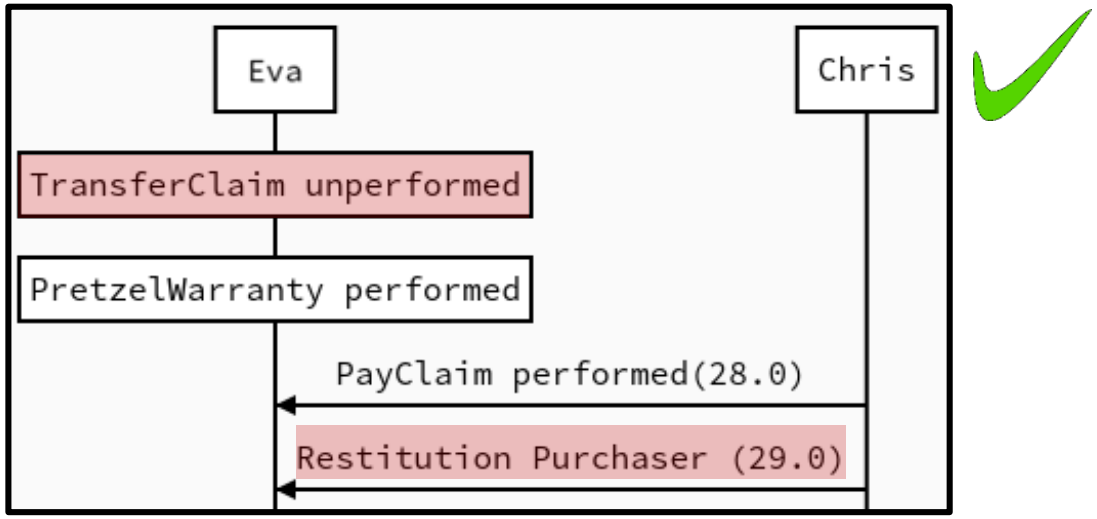
Encoding / Analysis

- **Case Study: Pretzel Bakery**
  - claim limitation before due date
  - e.g. analysis of compensation Claim2
    - $\phi_L \equiv \phi_{SPA} \wedge \texttt{Claim2.Limitation} < \texttt{Claim2.DueDate}$
      $\equiv \phi_{SPA} \wedge 70 < d_{Warranty} + 28 + 14$



Encoding / Analysis

- **Case Study: Pretzel Bakery**
  - existence of contract execution?
  - legal claim set C
    - independent claim $\mathrm{T} \in C_I$
    - consequence claim $\mathrm{WT} \in C(\mathrm{T})$
      - e.g. $\phi_{WT} \equiv (d_{WT} = -1) \vee \texttt{T.DueDate} < d_{WT}$
  - analysis
    - $\phi_{SPA} \equiv \phi_{owner} \bigwedge_{c \in C} \phi_c \bigwedge_{c \in c_I} (d_c \geq 0 \bigvee_{c' \in C(c)} d'_c \geq 0)$



Conclusion

- **What we've learned**
  - mechanized logic can be very effective in reasoning about domains other than software and systems
    - in particular SMT, since it allow us to combine domain-specific constraints
  - automation is key

- **What we're planning to do**
  - state machine models for dynamic contract execution
  - more complex contracts

- **Where more can be found:**
  - Alan Khoja, Martin Kölbl, Stefan Leue and Rüdiger Wilhelmi. Automated Consistency Analysis for Legal Contracts. Proc. SPIN 2022. Vol. 13255 of LNCS. Springer Verlag, 2022. To appear.