

Smart Derivatives Contracts

Christopher D. Clack

Professor of Blockchain and Smart Contracts
Department of Computer Science
University College London

Joint Field Chief Editor
Frontiers in Blockchain

clack@cs.ucl.ac.uk

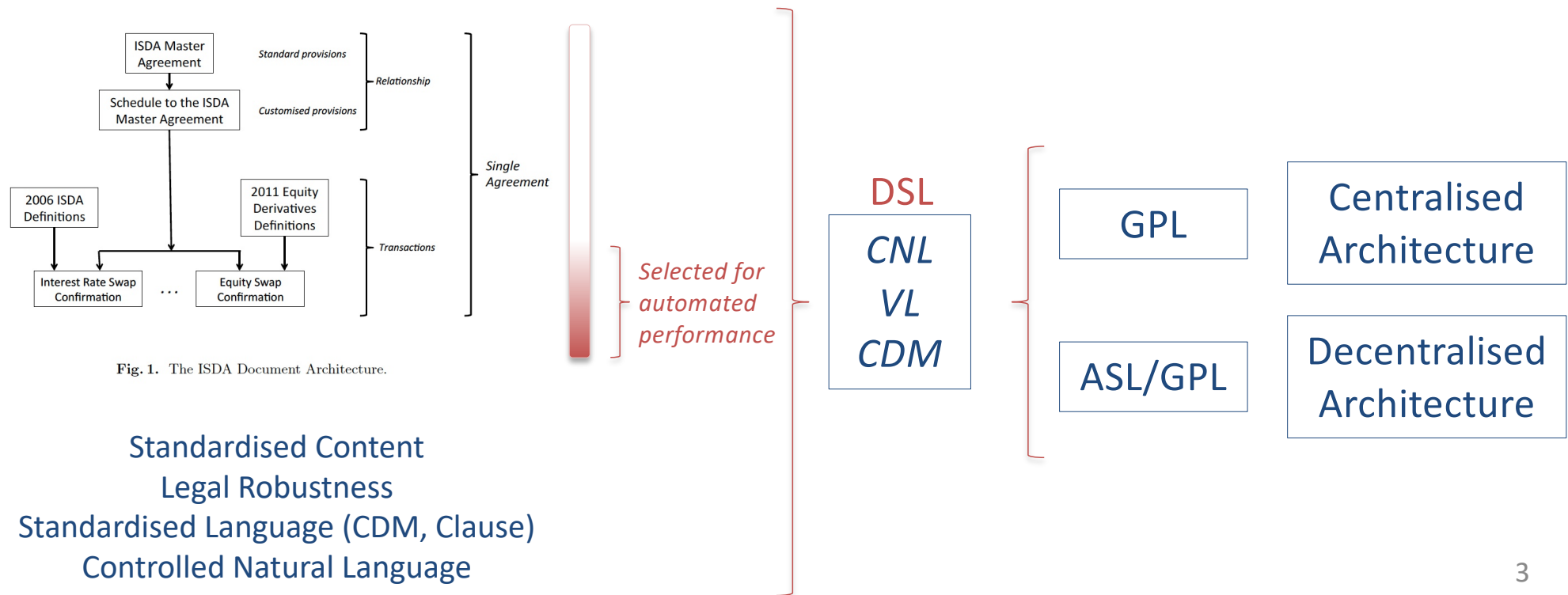
*CodeX Computable Contracts Workshop
9 April 2024*

Copyright (c) 2024 Christopher D. Clack

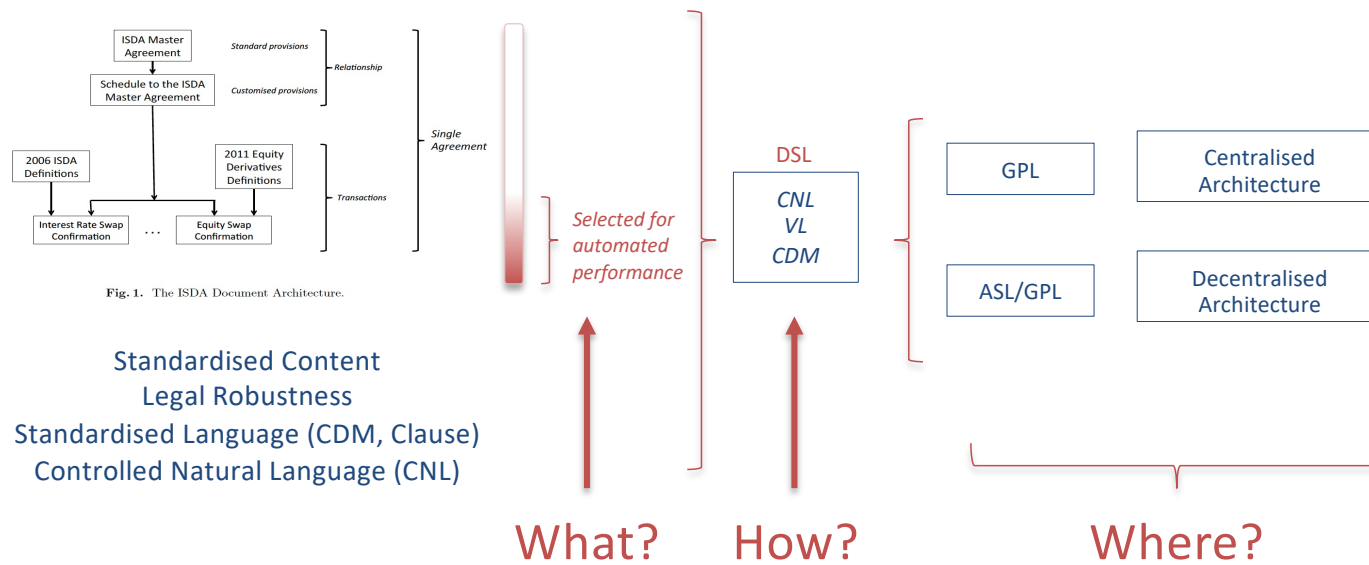
Agenda

- Context: Smart Derivatives Contracts
- Examples of student projects

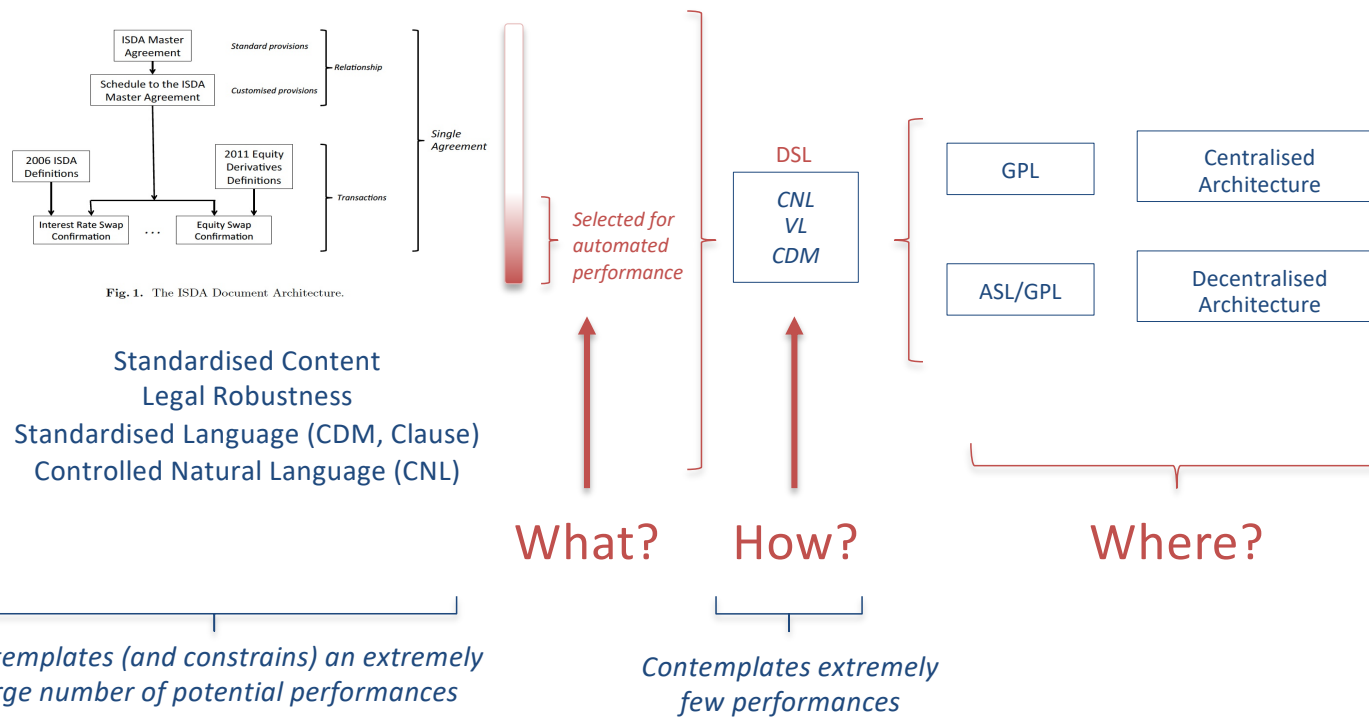
Smart Derivatives Contracts



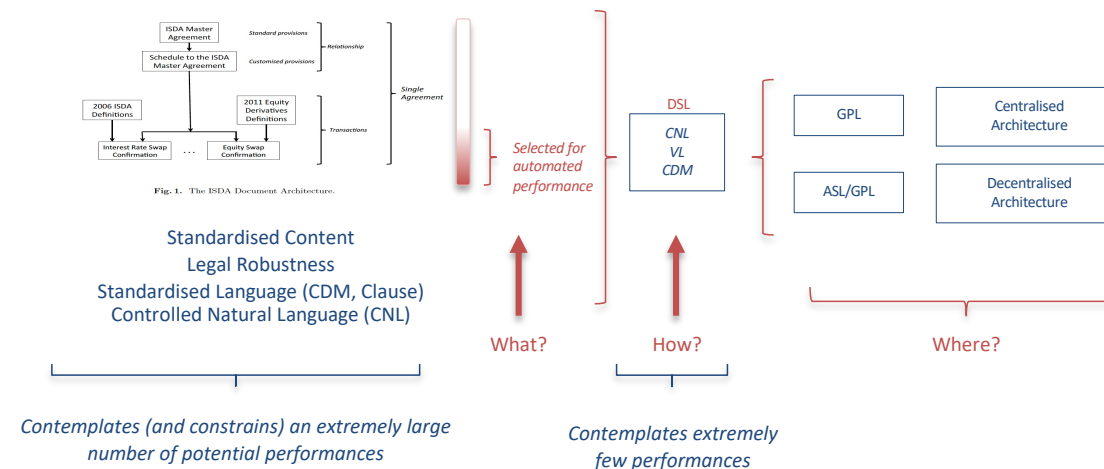
Smart Derivatives Contracts



Smart Derivatives Contracts



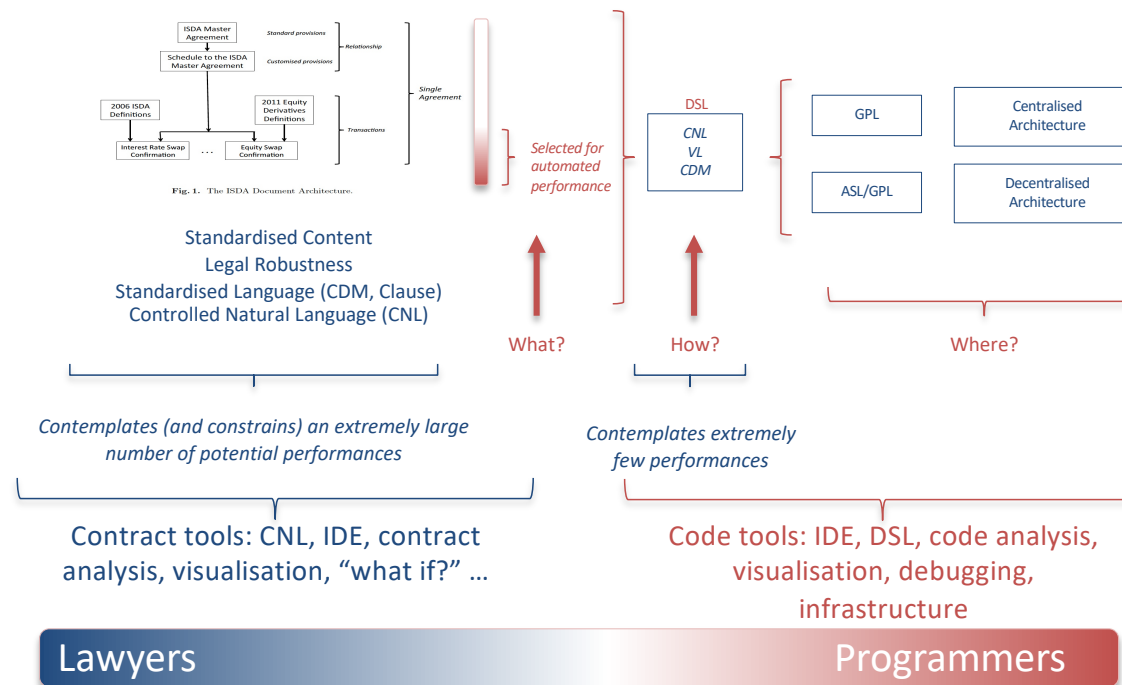
Smart Derivatives Contracts



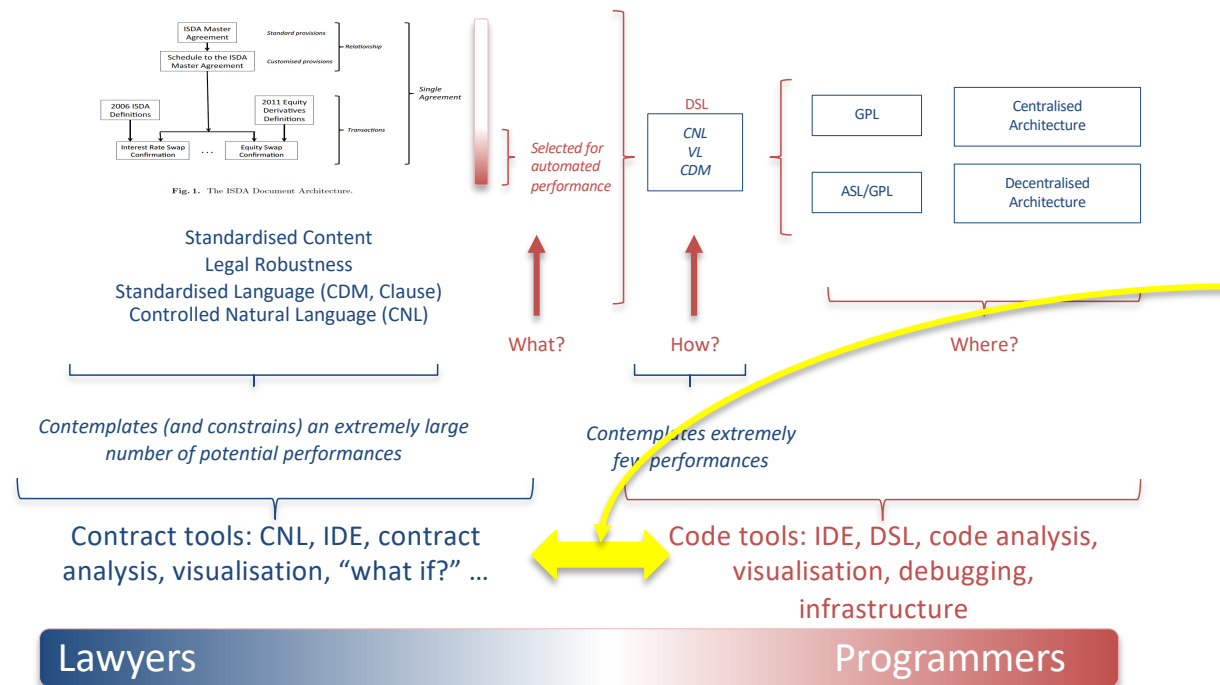
Lawyers

Programmers

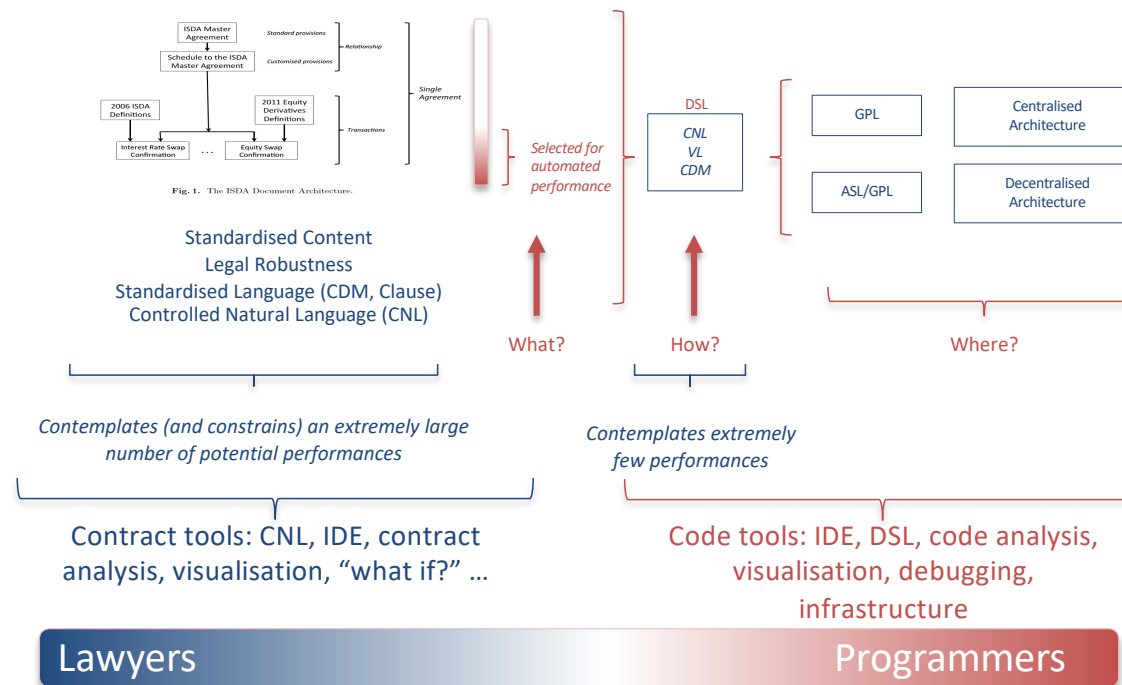
Smart Derivatives Contracts



Smart Derivatives Contracts



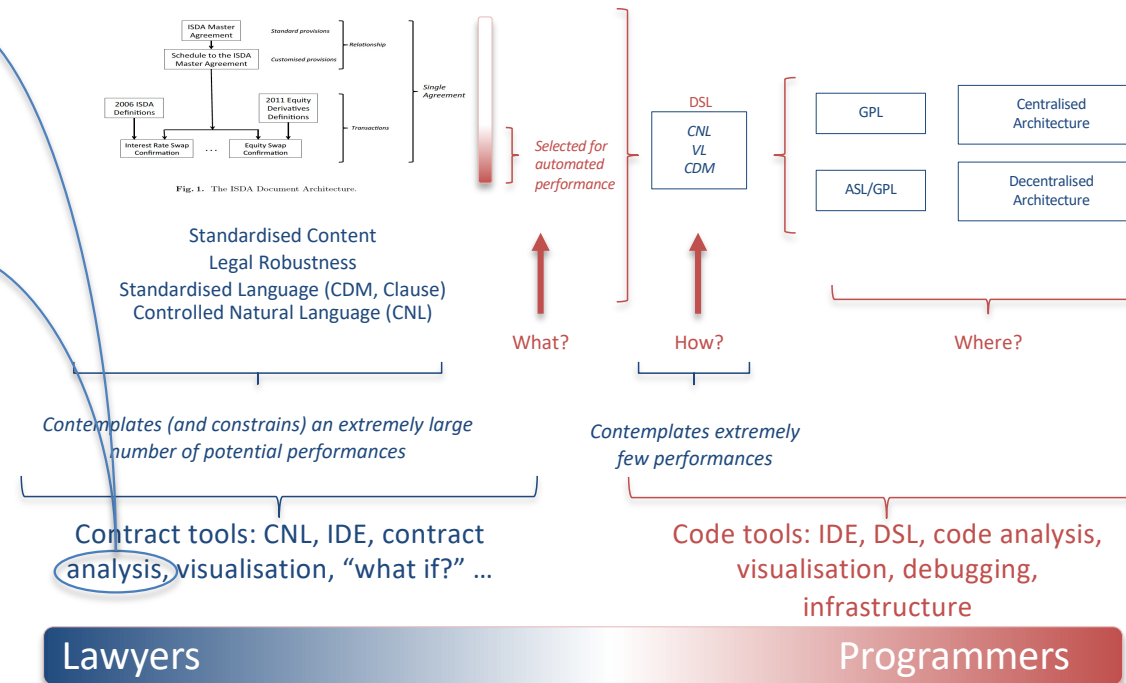
Student projects *(selected)*



Student projects *(selected)*

Semantic Analysis
(G.Vanca, 2018)

Temporal Semantics
(V.Mathur, 2019)



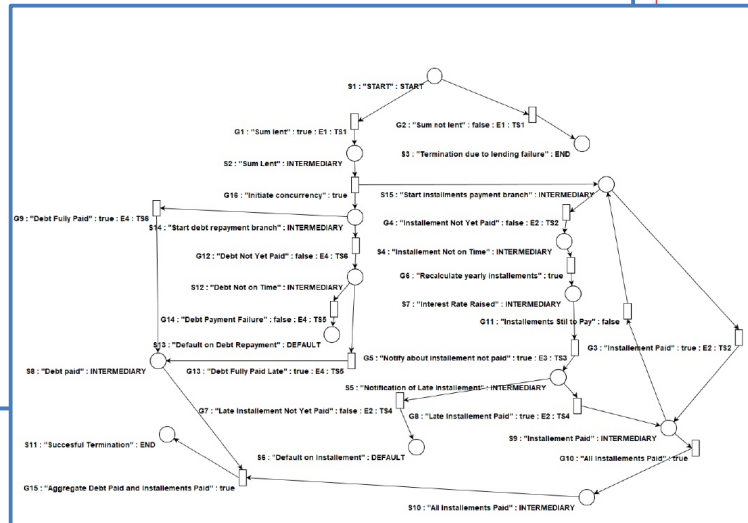
Semantic Analysis
(G.Vanca, 2018)

Temporal Semantics
(V.Mathur, 2019)



THE SEMANTICS OF SMART CONTRACTS USED IN BANKING AND FINANCIAL SERVICES

GABRIEL VANCA



Representing the Temporal Semantics of Financial Derivatives Contracts

Varun Mathur

MENG COMPUTER SCIENCE
Submitted: April 29, 2019

Arbitrary Precision Absolute Time References

Continuous Time Periods

Intervals

Semantics of Interval Relations

Temporal Operations

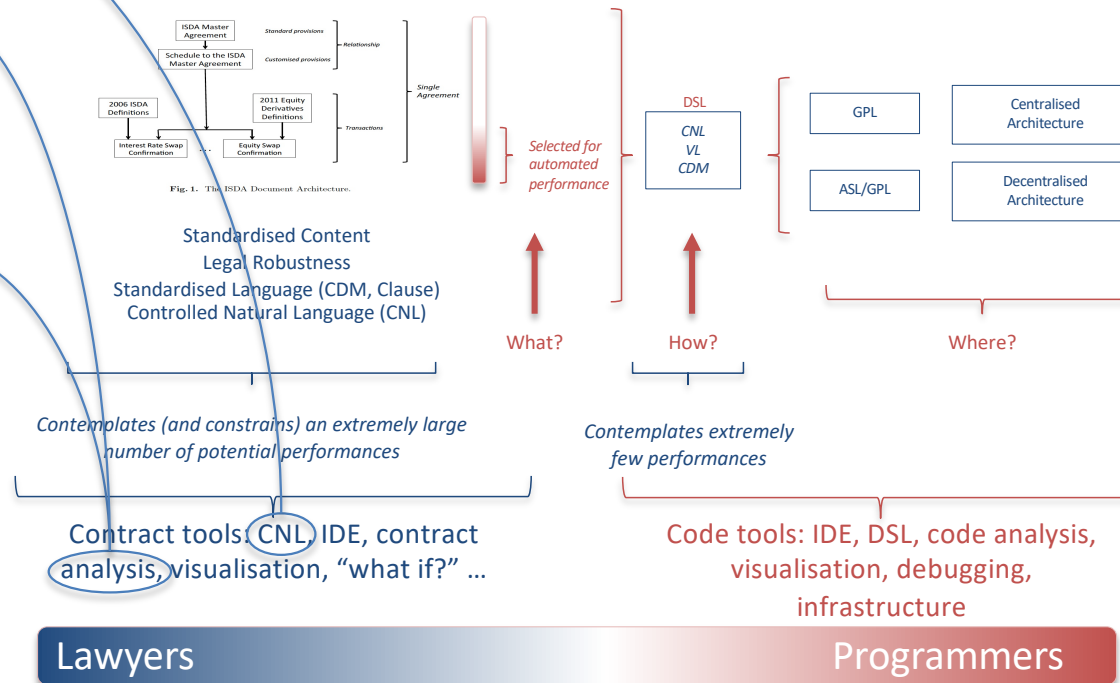
Extending the RU Calculus

Student projects *(selected)*

"CoLa" PoC
facilitator (S.Fattal,
2021)

Semantic Analysis
(G.Vanca, 2018)

Temporal Semantics
(V.Mathur, 2019)



Student

"CoLa" PoC
facilitator (S.Fattal,
2021)

Semantic Analysis
(G.Vanca, 2018)

Temporal Semantics
(V.Mathur, 2019)

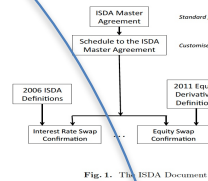


Fig. 1. The ISDA Document

Standardised
Legal Robust
Standardised Language
Controlled Natural L

Contemplates (and constrains,
number of potential pe

Contract tools: CNL, IDE, contract
analysis, visualisation, "what if?" ...

Code tools: IDE, DSL, code analysis,
visualisation, debugging,
infrastructure

Lawyers

Programmers

Finally, we can use CoLa to represent Section 2(c) of the ISDA Master Agreement:

```

IF [1] it is the case that AMOUNT 'A' is more than AMOUNT 'B'
THEN
  [2] ExcessAmount EQUALS AMOUNT 'A' MINUS AMOUNT 'B'
  AND
  [3] ExcessParty IS PartyA
C-AND
IF [4] it is not the case that AMOUNT 'A' is more than AMOUNT 'B'
THEN
  [5] ExcessAmount EQUALS AMOUNT 'B' MINUS AMOUNT 'A'
  AND
  [6] ExcessParty IS PartyB
C-AND
IF [7] it is the case that PartyA shall pay AMOUNT 'A' on ADATE
AND
[8] it is the case that PartyB shall pay AMOUNT 'B' on THEDATE
THEN
  [10] it is not the case that PartyA shall pay AMOUNT 'A' on THEDATE
  AND
  [11] it is not the case that PartyB shall pay AMOUNT 'B' on THEDATE
  AND
  [12] it is the case that ExcessParty shall pay AMOUNT "ExcessAmount"
  on THEDATE
  
```

Student projects *(selected)*

"CoLa" PoC
facilitator (S.Fattal,
2021)

Semantic Analysis
(G.Vanca, 2018)

Vagueness Analysis +
CNL (K.Sparks, 2023)

Temporal Semantics
(V.Mathur, 2019)

Petri Net visualisation
of CoLa and Lexon
(D.Kloecker, 2023)

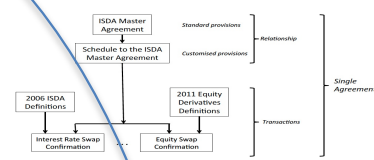


Fig. 1. The ISDA Document Architecture.

Standardised Content
Legal Robustness
Standardised Language (CDM, Clause)
Controlled Natural Language (CNL)

Contemplates (and constrains) an extremely large
number of potential performances

Contract tools: CNL, IDE, contract
analysis, visualisation, "what if?" ...

Lawyers

What?

Selected for
automated
performance

How?

DSL
CNL
VL
CDM

Code tools: IDE, DSL, code analysis,
visualisation, debugging,
infrastructure

Programmers



Where?

Contemplates extremely
few performances

Stude

Figure 1: Indicators → Taxonomy (mapping diagram)

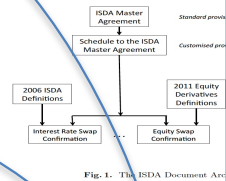
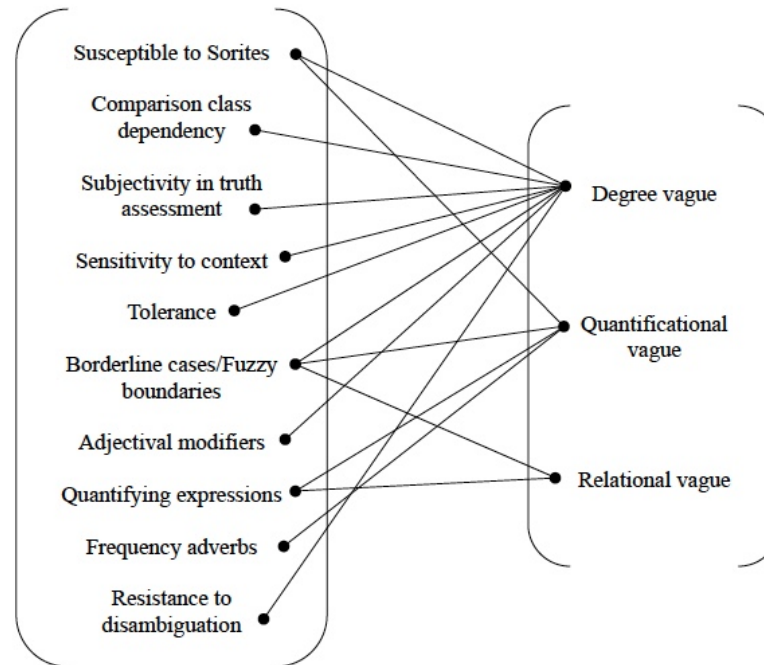


Fig. 1. The ISDA Document Architecture

Standardised Contract
Legal Robust
Standardised Language
Controlled Natural Language

Contemplates (and constrains) a
number of potential per

Contract tools: CNL, IDE, contract
analysis, visualisation, "what if?" ...

Code tools: IDE, DSL, code analysis,
visualisation, debugging,
infrastructure

Lawyers

Programmers

"CoLa" PoC
facilitator (S.Fattal,
2021)

Semantic Analysis
(G.Vanca, 2018)

Vagueness Analysis +
CNL (K.Sparks, 2023)

Temporal Semantics
(V.Mathur, 2019)

Petri Net visualisation
of CoLa and Lexon
(D.Kloecker, 2023)

Student projects *(selected)*

"CoLa" PoC
facilitator (S.Fattal,
2021)

Semantic Analysis
(G.Vanca, 2018)

Vagueness Analysis +
CNL (K.Sparks, 2023)

Temporal Semantics
(V.Mathur, 2019)

Petri Net visualisation
of CoLa and Lexon
(D.Kloecker, 2023)

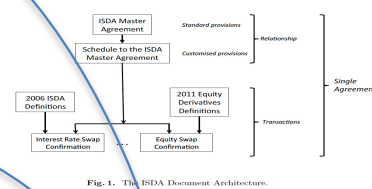


Fig. 1. The ISDA Document Architecture.

Standardised Content
Legal Robustness
Standardised Language (CDM, Clause)
Controlled Natural Language (CNL)

Contemplates (and constrains) an extremely large
number of potential performances

Contract tools: CNL, IDE, contract
analysis, visualisation, "what if?" ...

Lawyers

What?

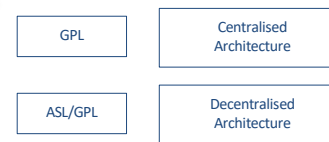
Selected for
automated
performance

How?

DSL
CNL
VL
CDM

Code tools: IDE, DSL, code analysis,
visualisation, debugging,
infrastructure

Programmers



Where?

Contemplates extremely
few performances

A Digital Contract Model Representing Smart Computable Contracts as Petri Nets using Controlled Natural Language

Dominic Kloecker

Supervisor: Professor Christopher Clack
Faculty of Engineering
Department of Computer Science
University College London

This report is submitted as part requirement for the
MSc Computer Science degree at UCL.

It is substantially the result of my own work except where explicitly
indicated in the text. The report may be freely copied
and distributed provided the source is explicitly acknowledged.

Monday 11th September, 2023



Figure A.4: Performance Simulation snapshots of modified ISDA Master Agreement showing voidance of obligations. Scenario [(C4, True), (C2, True)]

Petri Net visualisation
of CoLa and Lexon
(D.Kloecker, 2023)

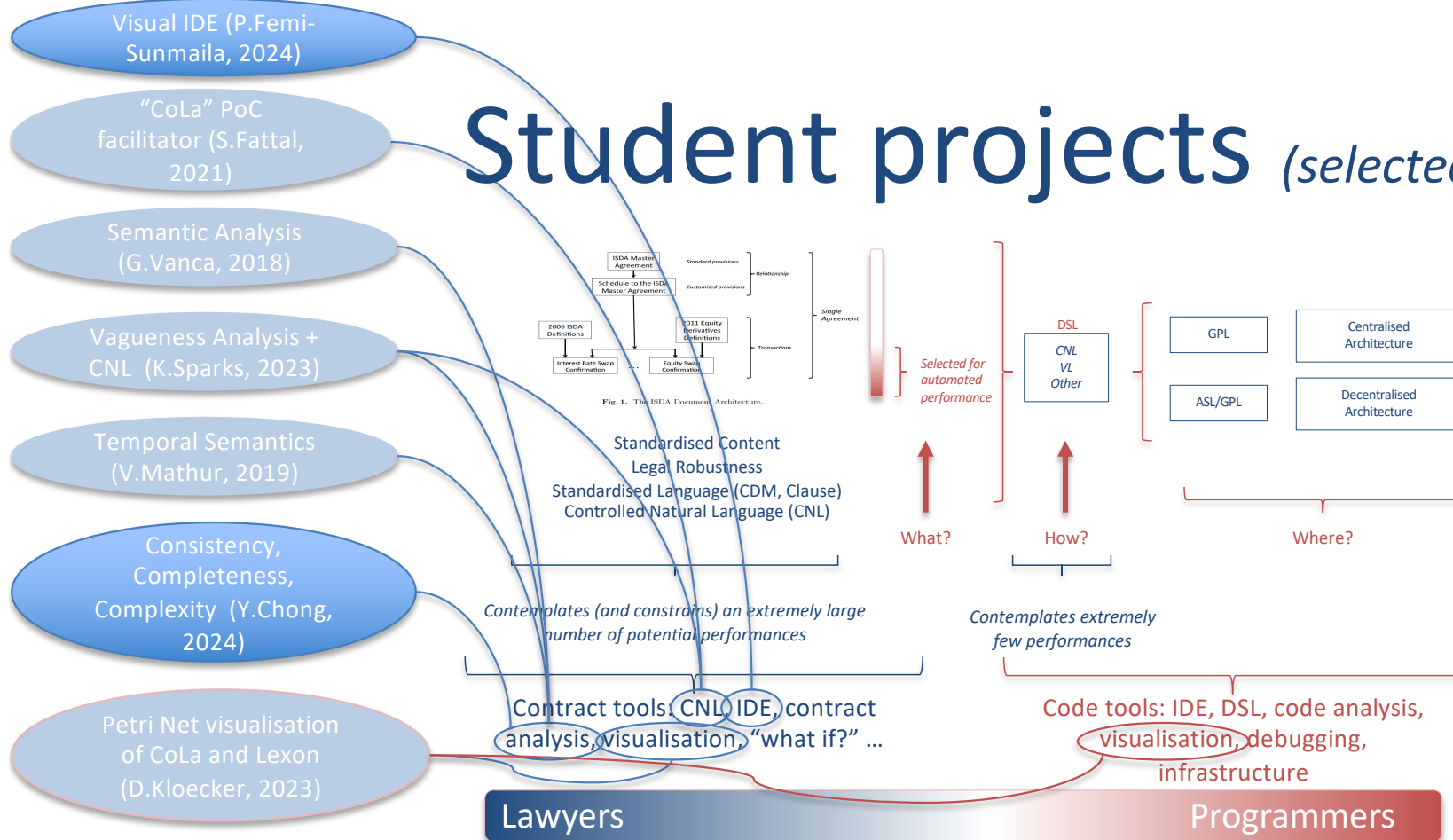
Contract tools: CNL, IDE, contract
analysis, visualisation, "what if?" ...

Code tools: IDE, DSL, code analysis,
visualisation, debugging,
infrastructure

Lawyers

Programmers

Student projects *(selected)*



Student

Visual IDE (P.Femi-Sunmaila, 2024)

"CoLa" PoC facilitator (S.Fattal, 2021)

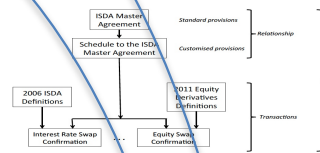
Semantic Analysis (G.Vanca, 2018)

Vagueness Analysis + CNL (K.Sparks, 2023)

Temporal Semantics (V.Mathur, 2019)

Consistency, Completeness, Complexity (Y.Chong, 2024)

Petri Net visualisation of CoLa and Lexon (D.Kloecker, 2023)



Standardised Content
Legal Robustness
Standardised Language (CDM, Clause
Controlled Natural Language (CNL)

Contemplates (and constrains) an extremely large number of potential performances

Contract tools: CNL, IDE, contract analysis, visualisation, "what if"

tk

Create New Contract Save Contract Open Contract

Contract

Subject-Pair Definition

[0] Twitter IS COMPANY

Subject-Pair Definition

[1] Facebook IS COMPANY

Subject-Modal Statement

[2] it is the case that Twitter shall pay GBP 1000000 on the 1 March 2024

If Conditional Statement

Subject-Modal Statement

[3] it is the case that Facebook shall deliver NAMEDOBJECT "Employee" on THEDATE

IF

Subject-Verb-Status Condition

[4] it is the case that Twitter paid GBP 1000000 on THEDATE

Infrastructure

Lawyers

Programmers

Visual IDE (P.Femi-Sunmaila, 2024)

“CoLa” PoC facilitator (S.Fattal, 2021)

Semantic Analysis (G.Vanca, 2018)

Vagueness Analysis + CNL (K.Sparks, 2023)

Temporal Semantics (V.Mathur, 2019)

Consistency, Completeness, Complexity (Y.Chong, 2024)

Petri Net visualisation of CoLa and Lexon (D.Kloecker, 2023)

Consistency Analysis

• Inconsistent Contract Logic

Input Contract

```
[1] Alice must pay POUNDS 100 to Bob on 3 April 2024
C-AND
[2] Bob must deliver OTHEROBJECT bicycle to Alice before 10 April 2024
C-AND
[3] Alice is forbidden to pay POUNDS 100 to Bob on 3 April 2024
```

```
% -----
% Version: Vampire 4.8 (commit )
% Termination reason: Refutation

% Memory used [KB]: 4861
% Time elapsed: 0.010 s
% -----
% -----
Inconsistency detected.
```

Theorem Prover Output

Lawyers

Infrastructure

Programmers

Student projects *(selected)*

IDE (P.Femi-Sunmaila, 2024)

"CoLa" PoC facilitator (S.Fattal, 2021)

Semantic Analysis (G.Vanca, 2018)

Vagueness Analysis + CNL (K.Sparks, 2023)

Temporal Semantics (V.Mathur, 2019)

Consistency, Completeness, Complexity (Y.Chong, 2024)

Petri Net visualisation of CoLa and Lexon (D.Kloecker, 2023)

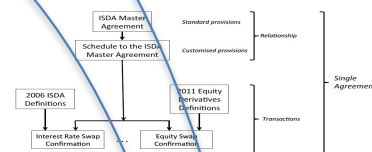


Fig. 1. The ISDA Document Architecture.

Standardised Content
Legal Robustness
Standardised Language (CDM, Clause)
Controlled Natural Language (CNL)

Contemplates (and constrains) an extremely large number of potential performances

Contract tools: CNL, IDE, contract analysis, visualisation, "what if?" ...

Lawyers

What?

How?

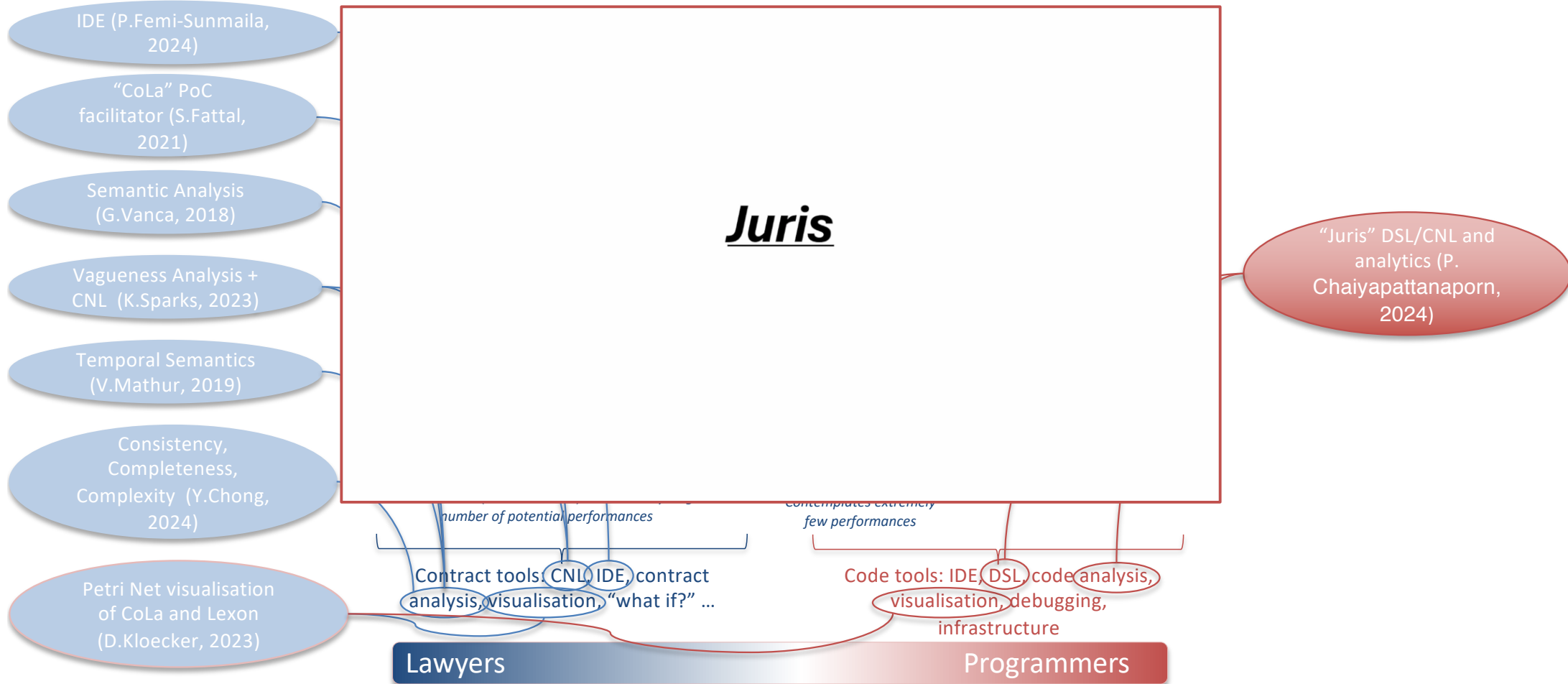
Where?

Contemplates extremely few performances

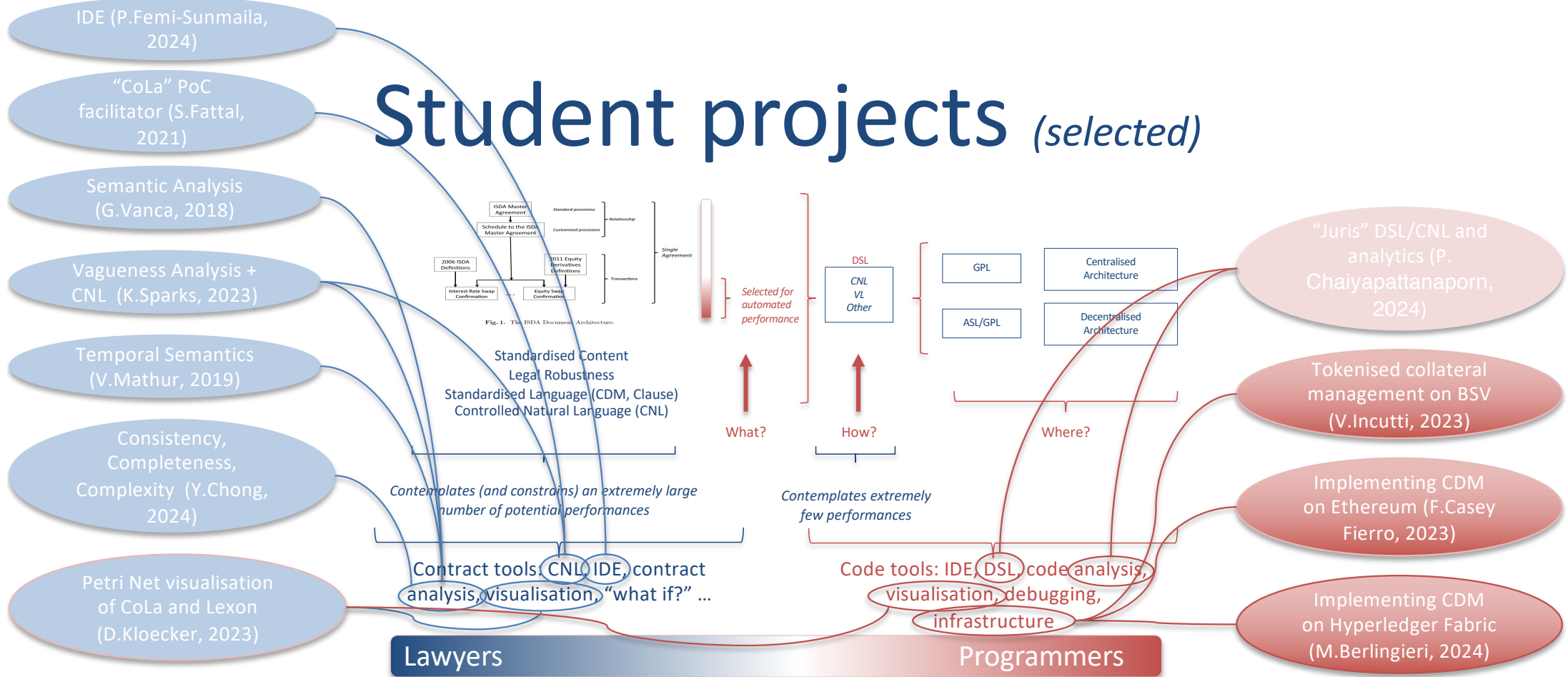
Code tools: IDE, DSL, code analysis, visualisation, debugging, infrastructure

Programmers

"Juris" DSL/CNL and analytics (P. Chaipattanaporn, 2024)



Student projects *(selected)*



UNIVERSITY COLLEGE LONDON

DEPARTMENT OF COMPUTER SCIENCE

A THESIS SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR
THE DEGREE OF MASTER OF SCIENCE IN FINANCIAL TECHNOLOGY,
UNIVERSITY COLLEGE LONDON

STREAMLINING DERIVATIVE TRADING: ENHANCED LIQUIDITY AND RISK MITIGATION WITH BLOCKCHAIN-BASED TOKENISED COLLATERAL MANAGEMENT

Author
Vincenzo INCUTTI

Industrial Supervisors
Richard BARKER (CEO),
Gerard BANASZKIEWICZ (COO),
Steve HAIGH (CTO),
John ANDERSON (CPO),
Nazish ZAIDI (LEAD BUSINESS ANALYST),
Stephen ASHWORTH (HEAD OF PLATFORM),
Brendan BRADELY (CHAIRMAN),
TOKENOVATE

Academic Supervisor
Prof. Christopher D. CLACK
DEPARTMENT OF COMPUTER
SCIENCE
UNIVERSITY COLLEGE LONDON

September 8, 2023



Petri Net visualisation
of CoLa and Lexon
(D.Kloecker, 2023)

analysis

Lawyers

Programmers

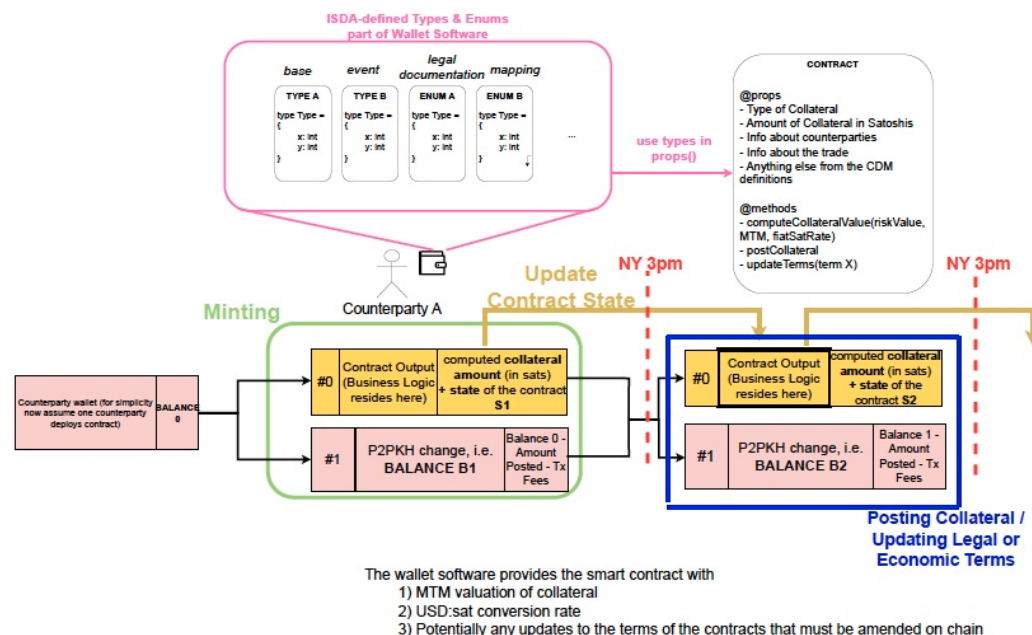


Figure 3.1: The diagram illustrates the key components of the system. The Wallet software incorporates ISDA Common Domain Model type definitions to populate smart contracts with essential properties. UTXOs are categorized as Smart Contracts (yellow) and Balances (pink). Collateral relationships begin with Minting and can be modified through Collateral Posting or Economic Terms updates. Collateral re-evaluation occurs regularly (e.g., at 3pm New York time) to accommodate potential price fluctuations.

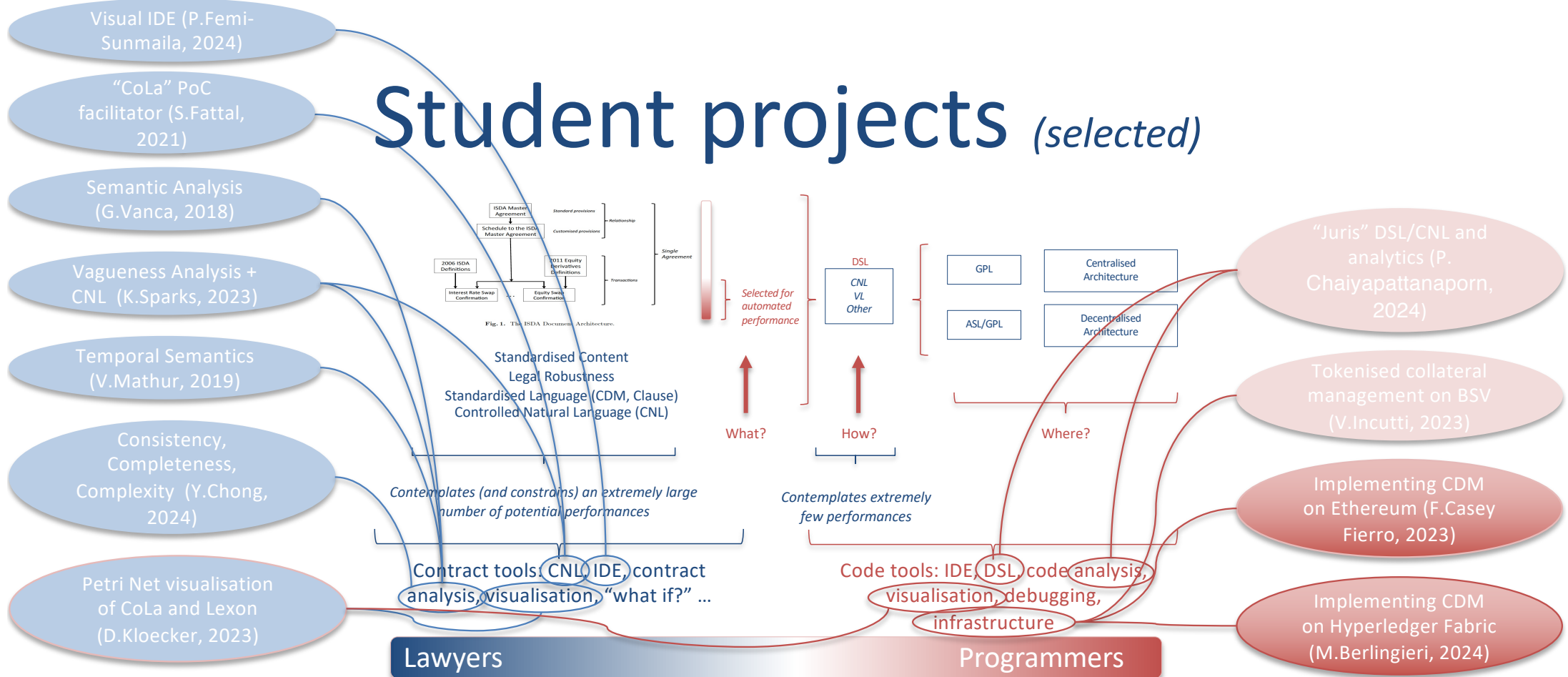
"Juris" DSL/CNL and analytics (P. Chaiyapattanaporn, 2024)

Tokenised collateral management on BSV (V.Incutti, 2023)

Implementing CDM on Ethereum (F.Casey Fierro, 2023)

Implementing CDM on Hyperledger Fabric (M.Berlingieri, 2024)

Student projects *(selected)*



UNIVERSITY COLLEGE LONDON

DEPARTMENT OF COMPUTER SCIENCE

A THESIS SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR
THE DEGREE OF MASTER OF SCIENCE IN COMPUTATIONAL
FINANCE/FINANCIAL RISK MANAGEMENT, UNIVERSITY COLLEGE LONDON

SMART CONFIRMATION CONTRACTS: AN ARCHITECTURE FOR ISDA SMART CONTRACTS

Author

Finn CASEY FIERRO

Academic Supervisor

Professor Christopher CLACK
DEPARTMENT OF COMPUTER
SCIENCE
UNIVERSITY COLLEGE LONDON

Industrial Supervisor

Mr Ciarán MCGONAGLE
LEGAL DEPARTMENT
INTERNATIONAL SWAPS AND
DERIVATIVES ASSOCIATION

September 11, 2023



This dissertation is submitted as part requirement for the MSc Computational Finance degree at UCL. It is substantially the result of my own work except where explicitly indicated in the text. The report may be freely copied and distributed provided the source is explicitly acknowledged.

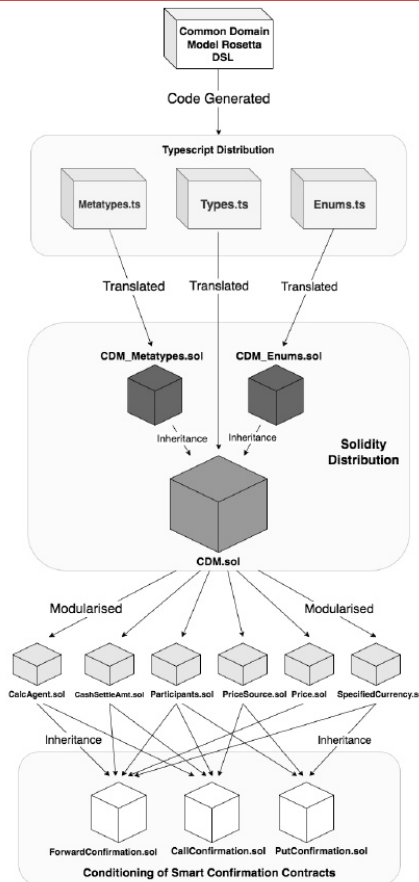
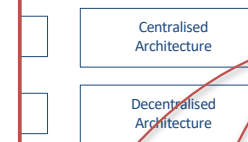


Figure 3.5: The process of going from the CDM that is written in Rosetta, to a code-generated CDM in Typescript, to a CDM written in Solidity, to CDM-type Smart Contract modules.

(selected)



DSL code analysis,
debugging,
structure
grammers

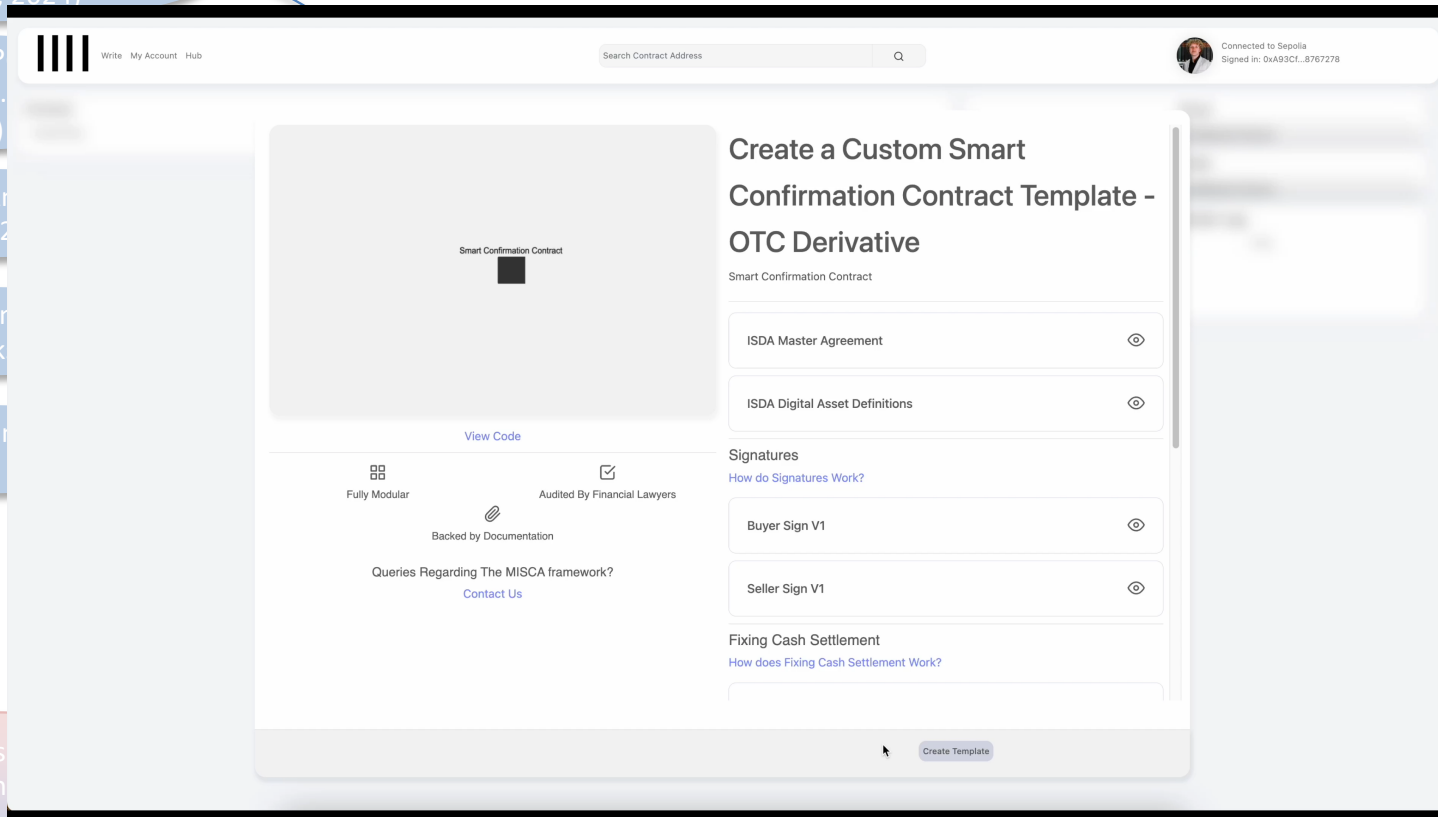
"Juris" DSL/CNL and analytics (P. Chaipattanaporn, 2024)

Tokenised collateral management on BSV (V.Incutti, 2023)

Implementing CDM on Ethereum (F.Casey Fierro, 2023)

Implementing CDM on Hyperledger Fabric (M.Berlingieri, 2024)

MISCA framework



The screenshot shows a web interface for the MISCA framework. At the top, there's a navigation bar with a logo, links for 'Write', 'My Account', and 'Hub', a search bar for 'Contract Address', and a user profile section indicating 'Connected to Sepolia' and 'Signed in: 0xA93Cf...8767278'. The main content area is titled 'Create a Custom Smart Confirmation Contract Template - OTC Derivative'. It features a large placeholder for a 'Smart Confirmation Contract' with a 'View Code' link. Below this, there are sections for 'ISDA Master Agreement' and 'ISDA Digital Asset Definitions', each with an eye icon. The 'Signatures' section includes 'Buyer Sign V1' and 'Seller Sign V1', also with eye icons. At the bottom, there's a 'Fixing Cash Settlement' section with a link 'How does Fixing Cash Settlement Work?'. A 'Create Template' button is at the bottom right. On the left side of the interface, there are icons for 'Fully Modular' and 'Audited By Financial Lawyers', along with a 'Backed by Documentation' icon and a link 'Queries Regarding The MISCA framework? Contact Us'.

Lawyers

Programmers

Visual IDE (P.Femi-Sunmaila, 2024)

“CoLa” P
facilitator (S.
2021)

Semantic Ar
(G.Vanca, 2

Vagueness Ar
CNL (K.Spark

Temporal Se
(V.Mathur,

Petri Net vis
of CoLa an
(D.Kloecker, 2023)

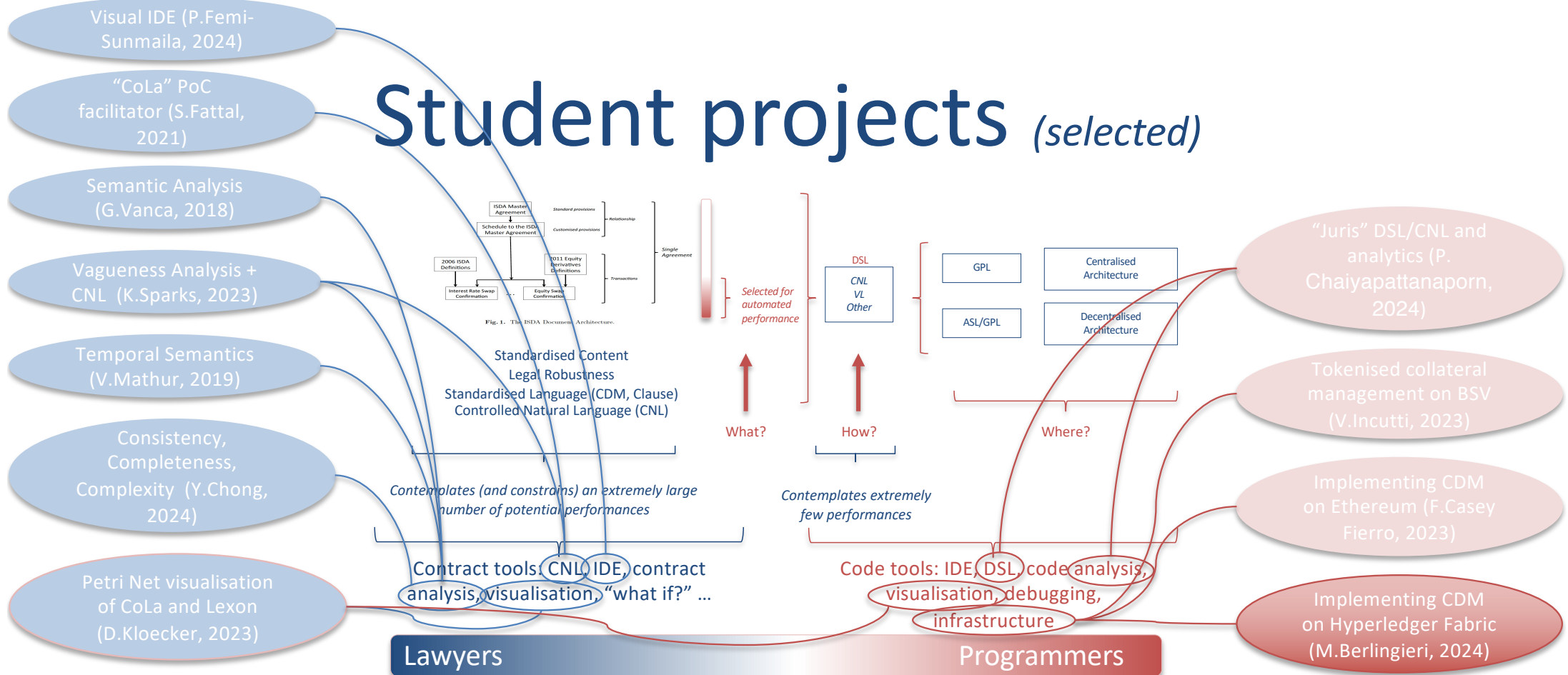
“Juris” DSL/CNL and
analytics (P.
Chaipayattanaporn,
2024)

Tokenised collateral
management on BSV
(V.Incutti, 2023)

Implementing CDM
on Ethereum (F.Casey
Fierro, 2023)

Implementing CDM
on Hyperledger Fabric
(M.Berlingieri, 2024)

Student projects *(selected)*



Student projects *(selected)*

Visual IDE (P.Femi-Sunmaila, 2024)

“CoLa” PoC facilitator (S.Fattal, 2021)

Semantic Analysis (G.Vanca, 2018)

Vagueness Analysis + CNL (K.Sparks, 2023)

Temporal Semantics (V.Mathur, 2019)

Consistency, Completeness, Complexity (Y.Chong, 2024)

Petri Net visualisation of CoLa and Lexon (D.Kloecker, 2023)

Comparing CDM implementations on Hyperledger Fabric and Ethereum

Michael Berlingieri

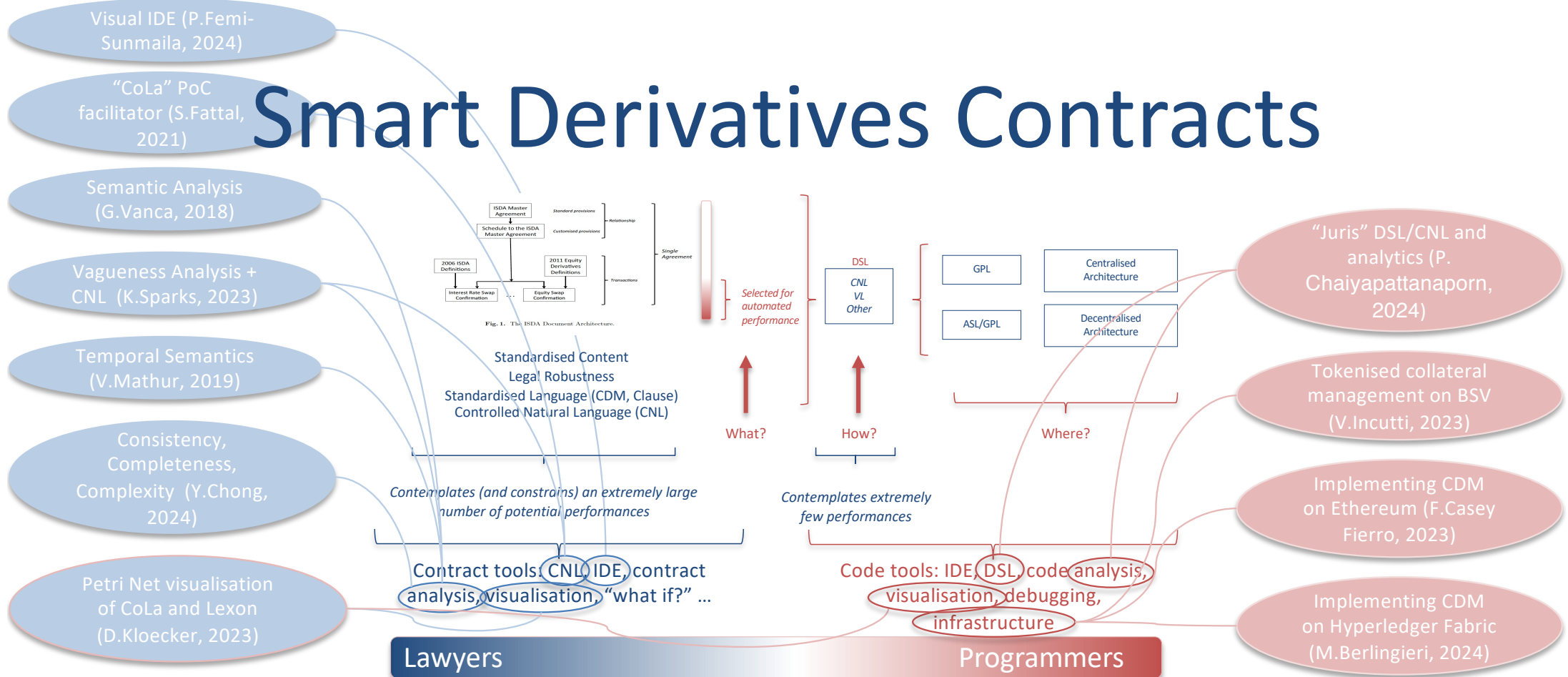
“Juris” DSL/CNL and analytics (P. Chaipayattanaporn, 2024)

Tokenised collateral management on BSV (V.Incutti, 2023)

Implementing CDM on Ethereum (F.Casey Fierro, 2023)

Implementing CDM on Hyperledger Fabric (M.Berlingieri, 2024)

Smart Derivatives Contracts



Questions?

Smart Derivatives Contracts

Christopher D. Clack

Professor of Blockchain and Smart Contracts
Department of Computer Science
University College London

Joint Field Chief Editor
Frontiers in Blockchain

clack@cs.ucl.ac.uk

*CodeX Computable Contracts Workshop
9 April 2024*