

# Smart Contract Templates: the Semantics of Smart Legal Agreements

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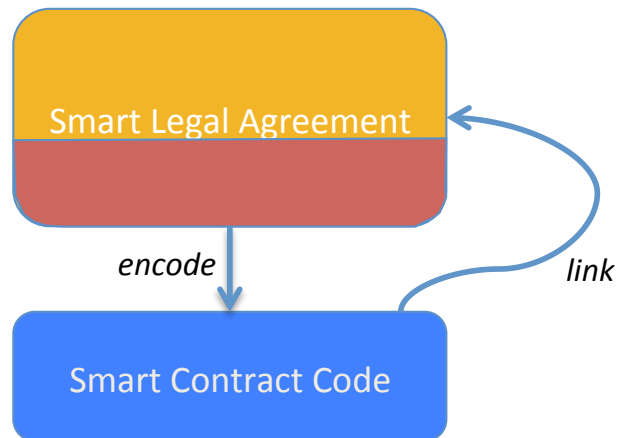
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## The Ricardian Link

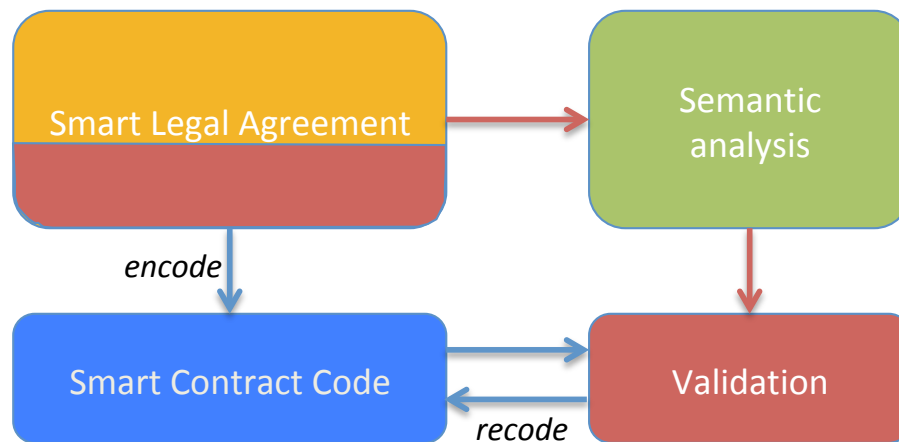
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- A Ricardian Contract incorporates into the smart contract code a link to the smart legal agreement (to be used in the case of dispute)
- This is not sufficient.
- We also need to be certain that the smart contract code is behaving in accordance with the agreement
- The smart contract code requires:
  - **testing** (it operates without error) and
  - **validation** (it correctly performs the contract)

# Semantic analysis

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- Semantic analysis is used:
  - To generate validation scenarios systematically
    - Reducing validation time & cost
    - Improving quality of validation
  - To clarify the runtime information needed by the code
  - To simplify the code
    - Code obscurity often derives from semantic obscurity
    - Code obscurity often hides bugs

# Semantic Variations

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- **Temporal semantics**
  - The time aspects of the agreements – past, present, future, fixed, floating, conditional
- **Deontic semantics**
  - The rights and obligations of the parties
- **Operational semantics**
  - The required actions – some of which may not be encodable, or we may not wish to encode

# Separability and Interaction

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- Are the temporal, deontic and operational semantics separable?
  - Temporal often linked to operational: “**upon** reasonable *demand*”
  - Operational, temporal and deontic are often linked:

Key:  
**Temporal**  
Deontic  
*Operational*

“...*a single or partial exercise* of any right, power or privilege will not be presumed to preclude any **subsequent or further exercise**, of that right...”

NB – if such exercising of a right were automated in the smart contract code, two validation scenarios might be (i) that the code should only exercise such a right appropriately (e.g. once per occasion), and (ii) there should not exist any code that would prevent the exercise of the same right on a different occasion. This requires the code to be able to identify separate “occasions”.

*ISDA 2002 Master Agreement, Sections 4(a)(iii) and 9(f), reproduced with the permission of International Swaps and Derivatives Association, Inc.*

## Separability and Interaction

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- Many clauses have a complex mix of deontic, operational and temporal aspects

“Liability. If:- (1) X is required by any applicable law, as modified by the practice of any relevant governmental revenue authority, to *make any deduction or withholding* in respect of which X **would not be required to pay an additional amount to Y** under Section 2(d)(i)(4); (2) X *does not so deduct or withhold*; and (3) a liability resulting from such Tax is assessed directly against X. then, except to the extent Y has satisfied or **then satisfies the liability** resulting from such Tax, Y **will promptly pay to X** the amount of such liability (including any related liability for interest, but including any related liability for penalties only if Y **has failed to comply with or perform any agreement** contained in Section 4(a)(i), 4(a)(iii) or 4(d)).”

*ISDA 2002 Master Agreement, Section 2(d)(ii), reproduced with the permission of International Swaps and Derivatives Association, Inc.*

# Can Smart Contract Code have Non-Operational Semantics?

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- **There are some operational aspects that cannot be encoded**
  - e.g. because they are conditioned on information that is not available to smart contract code when running on a distributed ledger – such as a change to the law (e.g. law relating to withholding tax)
  - This means smart contract code must always support human intervention
- **In a contract all actions derive from an obligation or right of some form (a deontic aspect)**
  - Furthermore, some actions may be discretionary
  - Smart contract code may be able to detect breach of a contract term that requires human action
  - This means smart contract code may need to support pause and call-out for human action
- **Many actions have embedded temporal aspects (trivially) and may have embedded deontic aspects**
  - E.g. if the code checks all expected payments and detects failure, it is obliged to send notice of failure to the other party, and check again in one Local Business Day (ISDA 2002 Master Agreement Section 5(a)(i))



# Can smart contract code have non-operational semantics?

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- **Smart contract code may need to encode the dynamic replacement of obligations**
  - For example, if netting were supported on the distributed ledger:

“Netting of Payments. If **on any date** amounts would otherwise be payable:- (i) in the same currency; and (ii) in respect of the same Transaction, by each party to the other, then, **on such date**, each party’s obligation to make payment of any such amount will be automatically satisfied and discharged and, if the aggregate amount that would otherwise have been payable by one party exceeds the aggregate amount that would otherwise have been payable by the other party, replaced by an obligation upon the party by which the larger aggregate amount would have been payable to pay to the other party the excess of the large aggregate amount over the smaller aggregate amount. ...”

*ISDA 2002 Master Agreement, Section 2(c), reproduced with the permission of International Swaps and Derivatives Association, Inc.*

# Semantic Issues

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- **Issues with the semantics of words**

- Culture clash between law and computer science: e.g. “execute”, “performance”, “termination”

- Language imprecision:

- “some” (“at least one”? or “at least one but not all”)
    - “reasonable” (to whom? In what context?)
    - “soon”, “promptly”, “timely” (Months? Weeks? Days? Hours? Minutes? Seconds?)
    - “or” (including or excluding both being true?)
    - “if deemed” (by whom? when?)

- The semantics of complex modal verbs can be difficult to express in formal logic

- E.g. “If:- (A) **a party does not pay** any amount **that, but for Section 2(a)(iii), would have been payable**, it will, to the extent permitted by applicable law and subject to Section 6(c) and clauses (B) and (C) below, pay interest...”

# Semantic Issues

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- **Issues arising from temporal semantics**

- Terms relating to unknown times of possible future events (e.g. “do X upon demand”)
- Terms relating to conditional past or conditional future or both, and complex drafting (e.g. use of modal verbs again):

“Interest on Deferred Payments. If:- (A) a party *does not pay* any amount that, but for Section 2(a)(iii), would have been payable, it **will**, to the extent permitted by applicable law and subject to Section 6(c) and clauses (B) and (C) below, *pay interest* (**before as well as after judgement**) on that amount to the other party **on demand** (after such amount becomes payable) in the same currency as that amount, **for the period from (and including) the date the amount would, but for Section 2(a)(iii), have been payable to (but excluding) the date the amount actually becomes payable, ...**”

*ISDA 2002 Master Agreement, Sections 9(h)(i)(3), reproduced with the permission of International Swaps and Derivatives Association, Inc.*

# Semantics and Pragmatics

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- **Linguistics: semantics and pragmatics**
  - Syntax: the written words
  - Semantics; what those words mean
  - Pragmatics: what the writer means, and what the reader thinks the writer means
    - Shared context
    - Understood implications
- **The “pragmatic gap” – legal context and legal implication**
  - Semantic formalisms (logics) may diverge from the pragmatics of natural language
  - Language as a process of communication, not as a static definition
- **The role of law (e.g. implied terms)**
  - Are these “semantically encoded” implicatures or are they “pragmatics”?

# Semantics, Pragmatics and the ISDA Master Agreement

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- Focus only on what is necessary for validation of smart contract code
- Focus only on the ISDA documentation
- Provide a clear, unambiguous and formal definition of its semantics and pragmatics (shared context and understood implications)
- This may not be a trivial task. For example:
  - All pre-suppositions and implicatures (pragmatic or semantically-encoded) must be identified. This includes implied terms at law, and any undetermined implicatures must either be resolved or highlighted as being “un-resolvable by computer”
  - “un-resolvable” aspects must be encoded to halt automated performance and request human input.
  - The “normative rationale” for ISDA contracts must be established. Is a contract a set of moral promises or a set of legal promises? Do courts interpret [intent](#) or [words](#)? (c.f. Ethereum and The DAO)

## Discussion Points and Next Steps

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- Is the issue of semantics of practical importance?
- Has this issue already been addressed elsewhere?
- What are the practical constraints for further developing these ideas?
- Any preferences for research directions and next steps?
- For example, are academic publications useful to this community?