Extend Commitment Protocols with Temporal Regulations: Why and How

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What I will talk about

We want to find a *coordination* mechanism for

- *autonomous agents*

in the context of

- *open*
- *heterogeneous*

systems

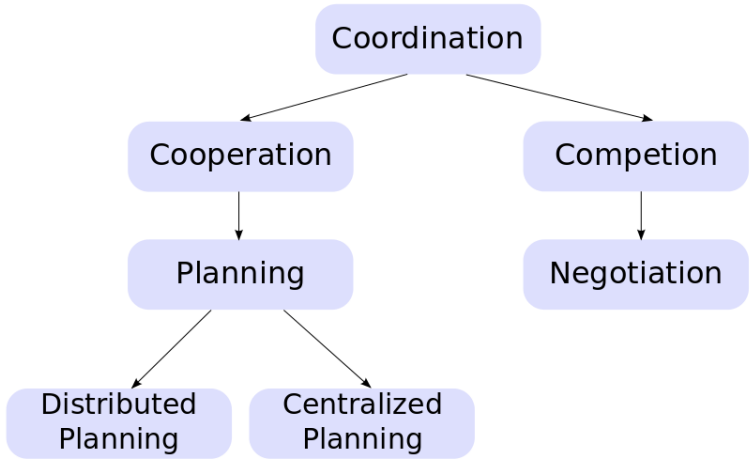

Figure: Coordination schema by M. Huns & L. Stephens [Weiss, 1999]

Interaction protocols' point of view

do not make assumptions on the agents' behaviour

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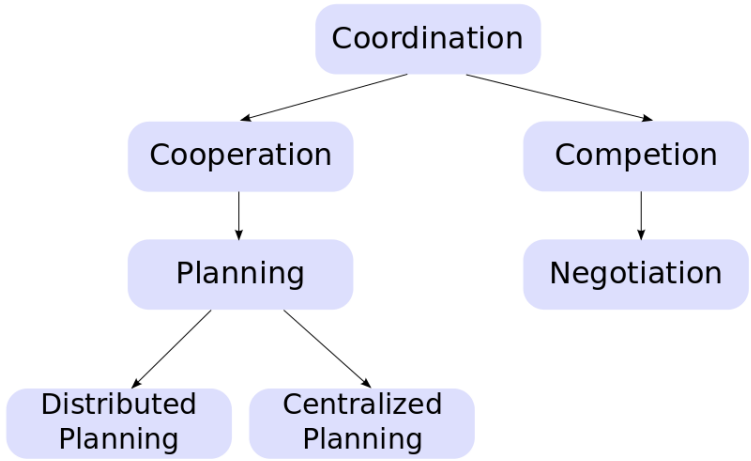

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The context

To solve the coordination task we have to be aware that

- *protocols:* they need to be verifiable
- *autonomy:* no introspection
  - No mentalistic approaches for coordination
  - Only observable behaviour can be judged
- *autonomy:* we cannot tell agents what to do
  - No procedural approaches
  - No methods invocation: they are not objects
  - It is not planning
- *heterogeneity:* no assumptions on their implementation
  - They belongs to different owners
  - We know the roles, not the players

Commitment Protocols?

Commitment protocols [Singh, 2000, Yolum and Singh, 2001a]:

$$C(\textit{debtor}, \textit{creditor}, \textit{antecedent}, \textit{consequent})$$

- Social state: contains commitments and other literals that are relevant to their interaction;
- Social actions: defined in terms of operations onto the social state;
- Regulative nature: debtors should act in accordance with the commitments they have taken.

They meet the requirements

- do not impose actions to the agents *(respecting autonomy)*
- social and observational semantics of the communication
  - no introspection *(respecting autonomy and heterogeneity)*
  - they are verifiable *(according to protocol requirement)*
- coordination is realized by means of *social expectations (respecting autonomy and heterogeneity)*

Commitment Protocols?

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What is missing?

Commitment protocols

- realize coordination through what condition is to be achieved [Winikoff et al., 2005]
- disregard coordination through how conditions should be achieved: temporal ordering [Baldoni et al., 2010]

Temporal regulations

To rule the evolution of the social state distinguishing

- legal evolutions
- undesired evolutions

Temporal regulations define patterns of interaction that

- represent conventions, norms, preferences, habits, rules and suchlike
- allow for prevision: agents can have expectations on each others' behaviour

How to specify patterns of interaction?

In a way that:

- does not compromise the flexibility of agents behaviour
- does not compromise the agents' autonomy
- fosters openness (agents can easily enter/leave a system)
- introduces modularity:
  - easier re-use of protocols in different contexts
  - easier customization of protocols
  - easier composition of protocols

Constitutive and Regulative Specifications

To meet these requirements

enhanced commitment-based protocol formal framework [Baldoni et al., 2011]:

- explicit distinction between a constitutive and a regulative specification [Searle, 1969] of the protocol
- constitutive specification: how actions affect the social state
- regulative specification: rules the evolution of the social state

Constitutive specification

$$
\begin{aligned}
&A \rightarrow (\mathit{Action}\ \textbf{means}\ \mathit{Operation}\ \textbf{if}\ \mathit{Cond})^{+}\\
&\mathit{Action} \rightarrow \mathit{protocolAction}\\
&\mathit{Operation} \rightarrow \mathit{Op}(\mathit{commitment}) \mid \mathit{fact} \mid\\
&\quad \mathit{Operation} \wedge \mathit{Operation}\\
&\mathit{Op} \rightarrow \textsc{create} \mid \textsc{delete} \mid \textsc{release} \mid \textsc{delegate} \mid\\
&\quad \textsc{assign} \mid \ldots\\
&\mathit{Cond} \rightarrow \mathit{literal} \mid \mathit{Cond} \wedge \mathit{Cond} \mid \mathit{Cond} \vee \mathit{Cond} \mid\\
&\quad \mathit{Cond}\ \textsc{xor}\ \mathit{Cond}
\end{aligned}
$$

Constitutive specification

- the *means* construct amounts to a *counts-as* relation [Searle, 1995]
- similar to [Chopra, 2009, Singh, 1999, Yolum and Singh, 2001b]

Regulative specification

2CL: Constraints among Commitment Language

allows *declarative*, *constraint-based* representation of patterns of interaction

- we defined a set of operators and their negations [Baldoni et al., 2010]
- grounded on LTL
- allows for the specification of constraints among literals and commitments
- constraints have a *regulative nature*:
  - intuitively: restrict the set of legal execution paths
  - *do not* specify *which* actions should bring conditions about
  - any evolution, of the social state, that respects the constraints respects the protocol

Relation	*Type*	*Positive*	*LTL meaning*	*Negative*	*LTL meaning*
Correlation	base	$A \bullet\!\!- B$	$\Diamond A \supset \Diamond B$	$A \bullet\!\!\not- B$	$\Diamond A \supset \neg\Diamond B$
	persistence	$A \bullet\!\!= B$	$\Box(A \supset (A \wedge B))$	$A \bullet\!\!\not= B$	$\Box(A \supset \neg(A \wedge B))$
Co-existence	base	$A \bullet\!\!-\!\!\bullet B$	$A \bullet\!\!- B \wedge B \bullet\!\!- A$	$A \bullet\!\!\not-\!\!\bullet B$	$A \bullet\!\!\not- B \wedge B \bullet\!\!\not- A$
	persistence	$A \bullet\!\!=\!\!\bullet B$	$A \bullet\!\!= B \wedge B \bullet\!\!= A$	$A \bullet\!\!\not=\!\!\bullet B$	$A \bullet\!\!\not= B \wedge B \bullet\!\!\not= A$
Response	base	$A \bullet\!\!-\!\!\triangleright B$	$\Box(A \supset \Diamond B)$	$A \bullet\!\!\not-\!\!\triangleright B$	$\Box(A \supset \neg\Diamond B)$
	persistence	$A \bullet\!\!=\!\!\triangleright B$	$\Box(A \supset (\Diamond B \wedge (A \mathcal{U} B)))$	$A \bullet\!\!\not=\!\!\triangleright B$	$\Box(A \supset \neg(A \wedge B))$
Before	base	$A -\!\!\triangleright\!\!\bullet B$	$\neg B \mathcal{U} A$	$A \not-\!\!\triangleright\!\!\bullet B$	$\Box(\Diamond B \supset \neg A)$
	persistence	$A =\!\!\triangleright\!\!\bullet B$	$\neg B \mathcal{U} (A \mathcal{U} B)$	$A \not=\!\!\triangleright\!\!\bullet B$	$\Box(\Diamond B \supset \neg A)$
Cause	base	$A \bullet\!\!-\!\!\triangleright\!\!\bullet B$	$A \bullet\!\!-\!\!\triangleright B \wedge A -\!\!\triangleright\!\!\bullet B$	$A \bullet\!\!\not-\!\!\triangleright\!\!\bullet B$	$A \bullet\!\!\not-\!\!\triangleright B \wedge A \not-\!\!\triangleright\!\!\bullet B$
	persistence	$A \bullet\!\!=\!\!\triangleright\!\!\bullet B$	$A =\!\!\triangleright\!\!\bullet B \wedge A \bullet\!\!=\!\!\triangleright B$	$A \bullet\!\!\not=\!\!\triangleright\!\!\bullet B$	$A \not=\!\!\triangleright\!\!\bullet B \wedge A \bullet\!\!\not=\!\!\triangleright B$
Premise	base	$A \triangleright\!\!\!\triangleright\!\!- B$	$\Box(\bigcirc B \supset A)$	$A \triangleright\!\!\!\triangleright\!\!\not- B$	$\Box(\bigcirc B \supset \neg A)$
Immediate after	base	$A -\!\!\triangleright\!\!\!\triangleright B$	$\Box(A \supset \bigcirc B)$	$A \not-\!\!\triangleright\!\!\!\triangleright B$	$\Box(A \supset \bigcirc \neg B)$

Table: $2\mathrm{CL}$ constraint relations and their semantics in LTL.

A commitment machine for our protocols

Legal executions

- a legal execution of a commitment-based protocols enriched with $2\mathrm{CL}$ regulative specification:
  - is accepted by the commitment machine built upon the constitutive specification [Winikoff et al., 2005]
  - satisfies the LTL formulas corresponding to the regulative specification

We implemented an extension of Winikoff et al.'s enhanced commitment machine [Winikoff et al., 2005]

- the output is an annotated and colored graph of the possible interactions
  - paths represent the possible interactions given the constitutive specification
  - annotations highlights violations and unsatisfied constraints
- by working on facts and events, and by considering a subset of LTL: verification can be performed on states, rather than on paths

Modularity for Business Protocols

In the context of regulations that change along time

- business protocols must be *compliant to regulations*
- modularity simplifies the task of adapting them to the new regulations

- new regulations usually impose the execution of new activities to be interleaved with the previous existing one
- modularity is needed to simplify the grafting of the new regulations onto existing business protocols

By separating constitutive and regulative specification

- new activities are added to the constitutive specification of the protocols
- new temporal regulation declaratively specify *when*, *how*, *where* the added activities are to be used: *grafting points*

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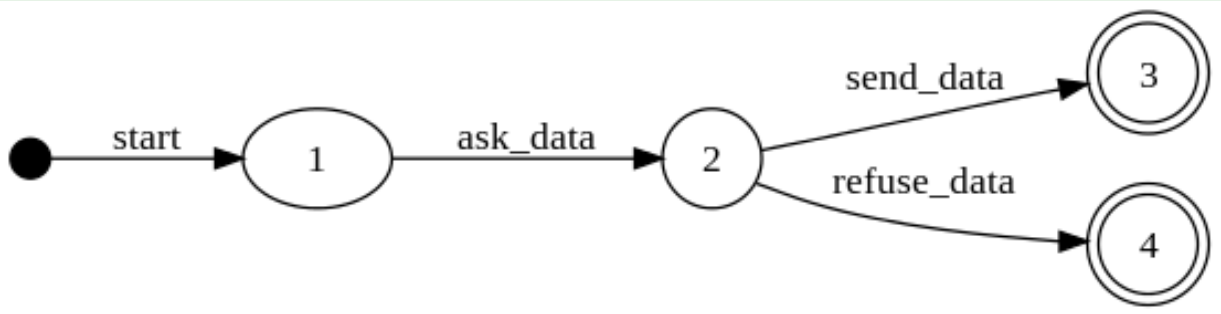
A Real-world Case Study: OECD Guidelines

Guidelines on the Protection of Privacy and Transborder Flows of Personal Data:

- protecting data owners from the violation of their fundamental rights
- encouraging the flow of data by increasing trust between countries

Pre-guidelines Data Flow Protocol

(a) *ask_data* **means** *asked_data* **if** $\neg$*asked_data*.
(b) *send_data* **means** *sent_data*
if *asked_data* $\wedge$ $\neg$*sent_data* $\wedge$ $\neg$*refuse_data*.
(c) *refuse_data* **means** *refuse_data*, $\textsc{cancel}(\mathsf{C}(dc, asker, sent\_data))$
if *asked_data* $\wedge$ $\neg$ *sent_data* $\wedge$ $\neg$ *refuse_data*.



Grafting of OECD Guidelines

New activities

(d) *periodically_verify_accuracy* **means** *accuracy_verified*
if $\neg$*asked_data* $\wedge$ $\neg$*accuracy_verified*.

(e) *check_accuracy* **means** *accuracy_verified*
if *asked_data* $\wedge$ $\neg$ *accuracy_verified*.

(f) *verify_purpose* **means** *purpose_verified*
if *asked_data* $\wedge$ $\neg$*purpose_verified*.

(g) *notify_owner* **means** *owner_notified*
if *sent_data* $\wedge$ $\neg$*owner_notified*.

New regulations

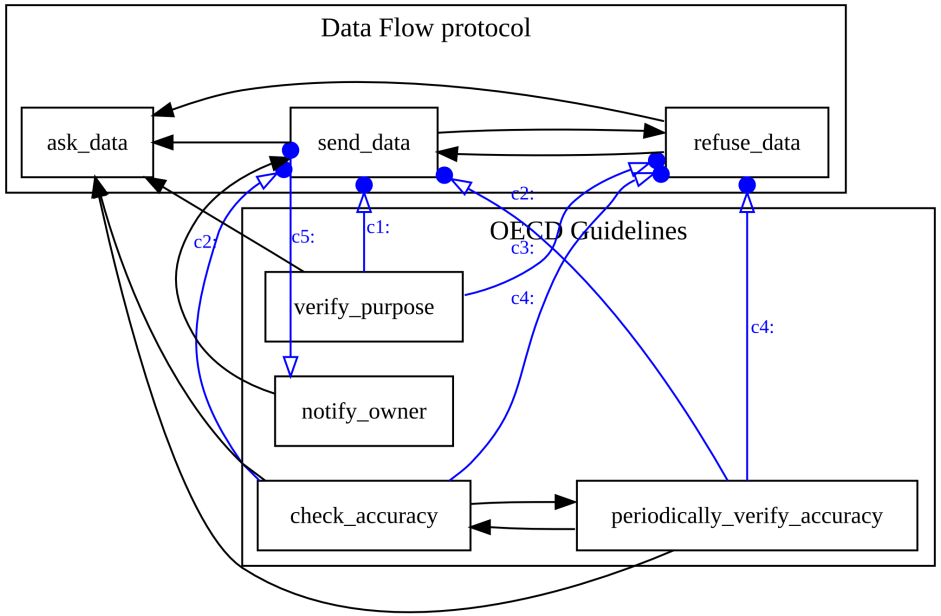
(c1) *purpose_verified* $\rightarrow\bullet$ *sent_data*

(c2) *accuracy_verified* $\rightarrow\bullet$ *sent_data*

(c3) *sent_data* $\bullet\rightarrow$ *owner_notified*

(c4) *purpose_verified* $\rightarrow\bullet$ *refuse_data*

(c5) *accuracy_verified* $\rightarrow\bullet$ *refuse_data*



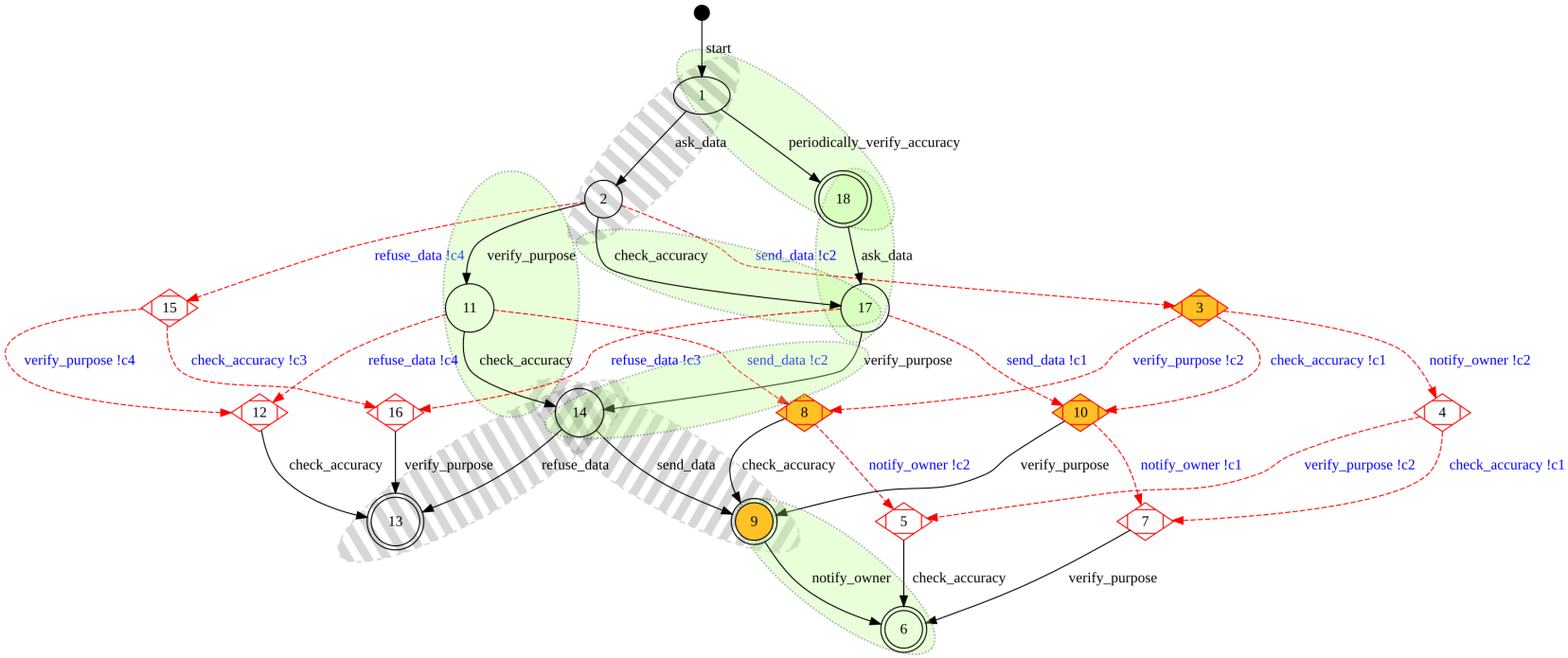


Figure: Reachability graph for the Data Flow protocol extended with OECD Guidelines.

A tool for the analysis

This tool can be used by the analysts in order to:

- identify the risk of violations the interaction can encounter
- helping the decision on when to apply regimentation or enforcement [Jones and Sergot, 1994]

A Real-world Case Study: MiFID

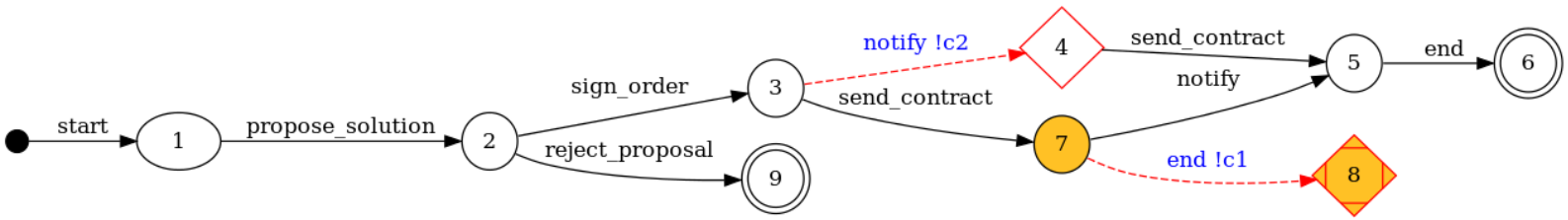
- MiFID: Markets in Financial Instruments Directive
- protection of the clients of financial service agencies
- introduces new regulations that financial services must follow

Constitutive specification

(a) *propose_solution* **means** *proposed_RiskL* **if** ....
(b) *reject_proposal* **means** *rejected_proposal*, RELEASE(C(*fp*, *inv*, *invested*)) **if** ...
(c) *sign_order* **means** CREATE(C(*inv*, *bank*, *contract_ended*)), *accepted_proposal*, *order_signed* **if** ...
(d) *countersign_contract* **means** *contract_countersigned*, CREATE(C(*bank*, *inv*, *executed_order*)), *invested* **if** ...
(e) *send_contract* **means** *contract_sent* **if** ...
(f) *notify* **means** *notified* **if** ...
(g) *end* **means** *executed_order*, *contract_ended* **if** ...

Regulative specification

(c1) *notified* $\rightarrow\!\!\triangleright\!\!\bullet$ *contract_ended*
(c2) *contract_sent* $\bullet\!\!\rightarrow\!\!\triangleright$ *notified*



MiFID regulation

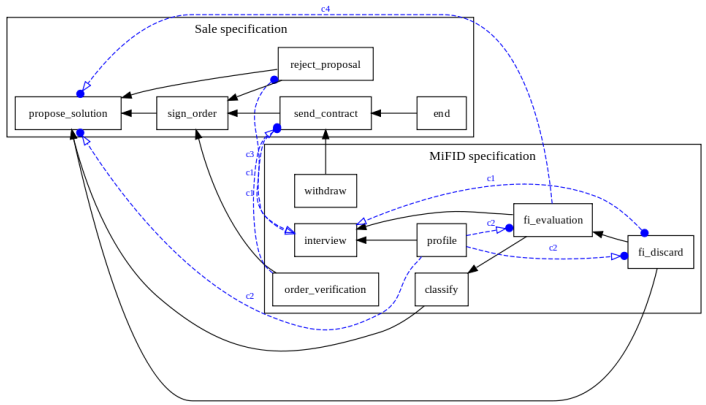
- MiFID dictates how the interaction with the client should be carried
- violation of some constraint does not affect the sale directly, but creates a risk of sanction and a risk of exposure for the intermediary

New activities

(h) *interview* **means** *investor_identified*, *document_supplied* **if** ...
(i) *profile* **means** CREATE(C(*fp*, *inv*, *evaluation*)), *investor_classified* **if** $\neg$*investor_classified* $\wedge$ *investor_identified* $\wedge$ $\neg$*contract_ended* $\wedge$ $\neg$*contract_abort* $\wedge$ $\neg$*rejected_proposal* $\wedge$ $\neg$*fi_discarded*.
(j) *classify* **means** *classified* **if** ...
(k) *fi_evaluation* **means** CREATE(C(*fp*, *inv*, *proposed_RiskL*)), *evaluation* **if** ...
(l) *fi_discard* **means** *fi_discarded*, CANCEL(C(*fp*, *inv*, *invested*)), CANCEL(C(*fp*, *inv*, *proposed_RiskL*)) **if** ...
(m) *order_verification* **means** *order_verified*, CREATE(C(*bank*, *inv*, *executed_order*)) **if** ...
(n) *withdraw* **means** *contract_abort*, RELEASE(C(*bank*, *inv*, *ex_order*)), CANCEL(C(*inv*, *bank*, *contract_ended*)) **if** ...

New regulations

(c3) C(*fp*, *inv*, *invested*) $\bullet\!\!\rightarrow\!\triangleright$ *investor_identified* $\wedge$ *document_supplied*
(c4) *investor_classified* $\rightarrow\!\triangleright\!\bullet$ C(*fp*, *inv*, *propose_riskL*)
(c5) *evaluation* $\wedge$ $\neg$*fi_discarded* $\rightarrow\!\triangleright\!\bullet$ *proposed_RiskL*
(c6) *order_verified* $\rightarrow\!\triangleright\!\bullet$ *contract_countersigned*



Current and Future work

- operational semantics for our commitment machine
- how to:
  - reify regulations into business relationships?
  - bring normative force to the specification?

First step: REGULA, committing to regulations [Marengo et al., 2011]

$$\mathrm{C}(\mathit{debtor}, \mathit{creditor}, \mathit{ant}_1 \cdot \mathit{ant}_2 \ldots, \mathit{cons}_1 \cdot \mathit{cons}_2 \ldots)$$

- temporal regulations can be expressed inside commitments
- '$\cdot$' (*before* [Singh, 2003]) is a temporal operator on events: *both events must occur and in the specified order*

About Regula

Control

It is the problem to establish whether an agent can bring about an event or complex action so as to detach or discharge a given commitment

- innate control
- social control

Safety

A commitment is safe for its debtor when the coordination necessary to fulfill the regulation is *supported* by commitments by the other agents involved, i.e. when:

- the debtor *controls* the negation of the antecedent (avoiding the commitment become active)
- or, whenever the antecedent holds, the debtor *controls* the residuation of the consequent (there is a way to satisfy the commitment)

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