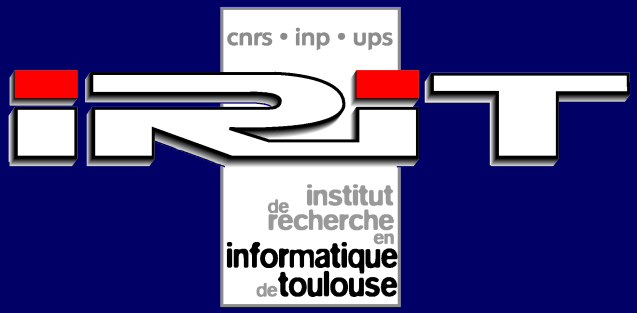
Formalising the institutional interpretation of actions in an extended BDI logic



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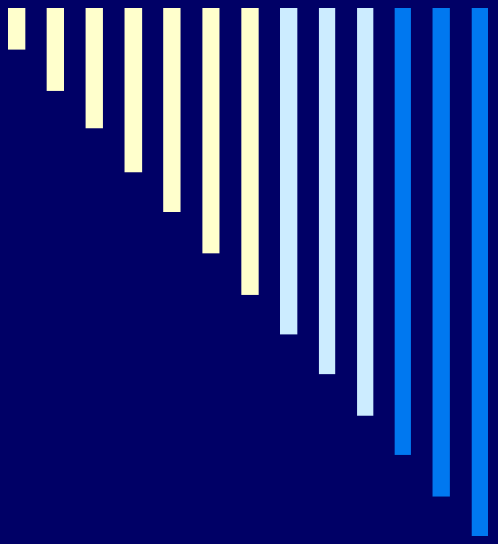
Introduction

- Existing logical frameworks for social or institutional concepts:
  - Independent from mental attitudes
  - Dedicated to the semantics of communicative acts
- Aim: combine the intentional and institutional dimensions of both communicative and material actions
- Institution = set of rules and facts accepted by a group of agents (members of the institution)
  - Either formal or informal
  - Ex: law of a country, rules of a game, business contract, social structure…

Outline

- State of the art
- Logical BDI framework
- Logical model of institutional dimension of actions
- Illustration: formalisation of example actions



1. State of the art

Existing formalisations of artificial institutions

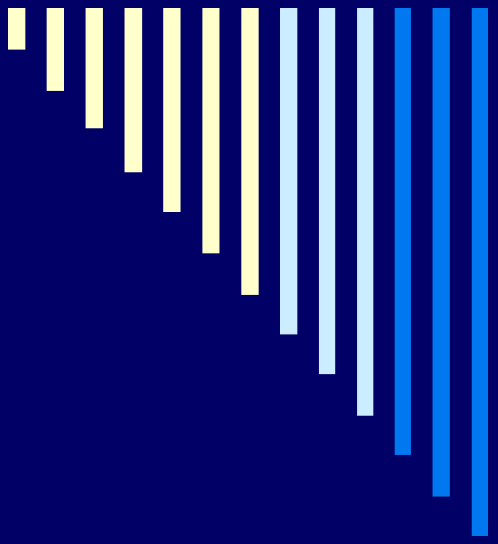
Fornara and Colombetti Social commitments

- Castelfranchi's notion of commitment = what an agent is publicly committed to
- $C_{id}(state,debtor,creditor,content|condition[,timeout])$
- Life cycle described by a finite state machine
- Social semantics of ACL

- Limitations:
  - No explicit context of validity of commitments
  - No formalisation of mental attitudes

Lorini *et al.* Group acceptance

- Hakli's notion (2006) = "decision to treat *p* as true in one's utterances and actions"
- Informal institutions = rules accepted by a group
- [C:x] φ : agents in *C* accept *φ* while functioning as group members in institutional context *x*
- Used to define some institutional concepts (institutional truth and contextual conditionals)
- Limitations:
  - Limited to informal institutions (institutional truth = facts accepted by members)
  - No dynamic operators thus no institutional dimension of actions



2. Logical framework

An extended BDI logic

Standard logical modalities

- Epistemic modalities
  - $B_i\ \varphi$: *i* believes that φ
  - $I_i\ \varphi$: *i* intends that φ
- Dynamic modalities
  - done(i,α,φ) : i has just performed α before what φ was true
  - happens(i,α,φ) : i is about to perform α and φ will be true just after
- Deontic modalities
  - $O\ \varphi$: it is obligatory that φ
  - $P\ \varphi = \neg O\ \neg\varphi$: it is permitted that φ

Institutional modalities
1. Institutional fact

- D_s φ : in institution *s*, it is official that *φ*
- Fact true in the context of an institution *s*
- Not physically observable, stored in the registry of *s*
- Examples:
  - $D_{FrenchRepublic}$ married(jean,marie)
  - $D_{FrenchRepublic}$ licensed(pierre)

Institutional modalities
2. Normative consequence

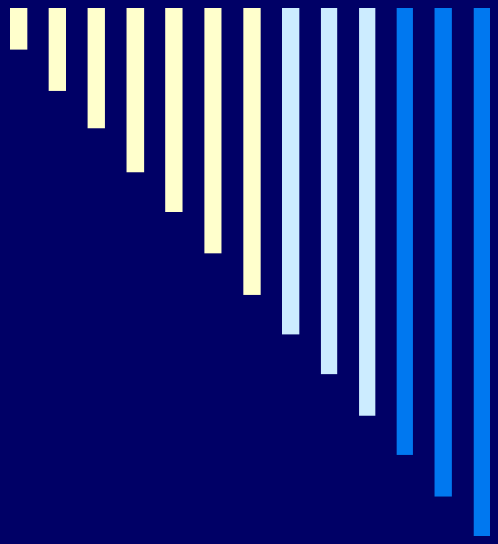
- Count as (Sergot & Jones, 1996)
- $\varphi \Rightarrow_s \psi$: according to norms holding in *s*, φ entails ψ
- Deduction of institutional facts from observable facts
  - Property : $(\varphi \Rightarrow_s \psi) \rightarrow (\varphi \rightarrow D_s \psi)$
- Examples:
  - $\forall$i hasBadge(i) $\Rightarrow_{\text{OrangeLab}}$ P happens(i,enter,T)

Institutional modalities
3. Institutional power

- power(i,s,cond,proc,n) =
  $(\text{cond} \wedge \text{done}(i,\text{proc},T)) \Rightarrow_s n$
- *i* has the power, by performing *proc* in a context where *cond* holds, to make *n* officially true in *s*
- Example:
  - $\forall i,j$ power(mayor,FrenchRepublic,agree(i,j), declareMarried(mayor,i,j),married(i,j))

Comparison with existing work

- Ratified mental attitude = MA acknowledged by (and recorded in) the institution
  - Similar to Gaudou *et al.*'s grounding, or to Lorini *et al.*'s acceptance
- Ratified belief : $D_s\ B_i\ \varphi$
  - It is official in *s* that *i* believes φ
  - Similar to Colombetti *et al.* propositional commitments
- Ratified intention : $D_s\ \mathbf{I}_i\ \varphi$
  - It is official in *s* that *i* intends to see to it that φ
  - Similar to or to Colombetti *et al.* commitments in action



Logical model of the institutional interpretation of actions

Features of action α in institution *s*

Permission precondition φ

- Necessary and sufficient condition to have the permission in *s* to perform α
- *Ex: to pay an object in a shop gives the permission to take it*
- Permission precondition axiom:

  $\varphi \leftrightarrow D_s$ P happens(i,α,T)
- Implicit effect of α:

  done(i,α,T) $\Rightarrow_s B_i \varphi$

Associated sanction χ

- Associated with the forbidden performance of the action
- *Ex: stealing an object in a shop exposes to fines or prison*
- Unauthorised execution axiom:

$$done(i,\alpha,\neg\varphi) \Rightarrow_s \chi$$

Power precondition ψ_i and institutional effect ω_i

- Institutional effect ω_i :
  - New institutional facts created in *s* by the performance of α
  - *Ex: a mayor declaring a wedding makes the two people married*
- Power precondition ψ_i :
  - Additional condition necessary to deduce ω_i
  - *Ex: the mayor must ensure that these two people agree to get married*

Power precondition ψ_i and institutional effect ω_i

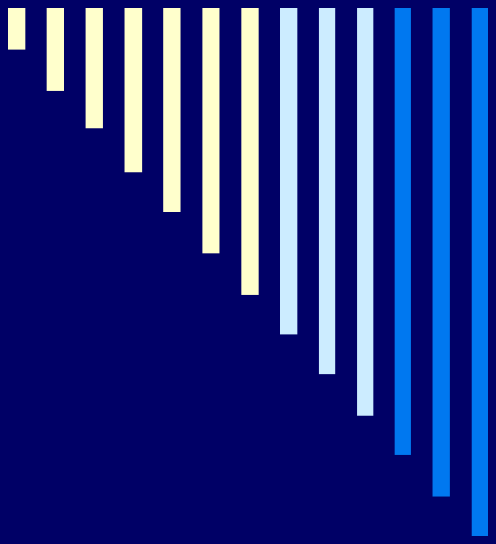
- Explicit institutional effect axiom:

  $\forall a$, power(a,s,ψ_i,α,ω_i)

- Several pairs < ψ_i,ω_i > for each action
- In particular < $\neg\varphi$,χ >

- Theorem: after(a, α, $\psi_i \rightarrow D_s\ \omega_i$)

  (i.e. $\neg$done(a, α, $\psi_i \wedge \neg D_s\ \omega_i$))



Illustration

Formalisation of a material and a communicative action

Material action: send an order 1. *Features*

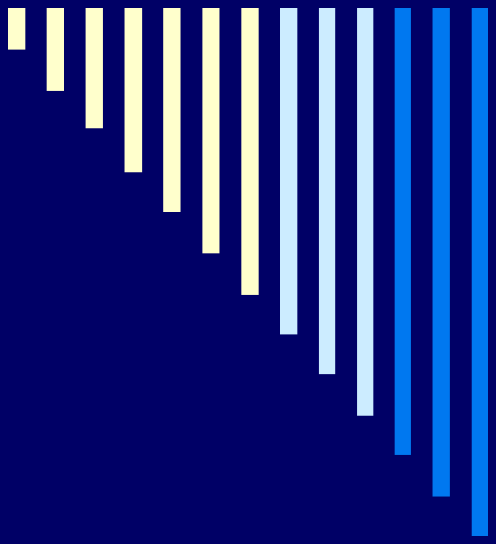
- s = B2B contract between two businesses: client c and provider p
- α = sendOrder(c,p,id) : client *c* sends purchase order *id* to provider *p*
- φ = haveCatalogue(c,p) : c has p's catalogue
- χ = O done(c,pay(c,p,100),T) : obligation to pay damages
- ψ = isCorrect(id)
- ω = O done(p,processOrder(p,c,id),T)

Material action: send an order *2. Institutional rules*

- Permission precondition axiom:
  haveCatalogue(c,p) $\leftrightarrow$ D_{B2B} P done(c,sendOrder(c,p,id),T)
- Implicit effect:
  done(c,sendOrder(c,p,id),T) $\Rightarrow_{B2B}$ B_c haveCatalogue(c,p)
- Sanction for unauthorised performance:
  done(c,sendOrder(c,p,id), ¬haveCatalogue(c,p)) $\Rightarrow_{B2B}$
  O done(c,pay(c,p,100),T)
- Explicit institutional effect:
  power(c,B2B,isCorrect(id),sendOrder(c,p,id),
  O done(p,processOrder(p,c,id),T))

Communicative action: declare

- Declare(i,j,s,cond,n) : *i* declares to *j* in the setting of institution *s* that given condition cond, the fact *n* is now established
- Intentional dimension (FIPA like)
  - FP = $\neg B_i\ D_s\ n$
  - RE = $B_j\ D_s\ n$
- Institutional dimension
  - PP = power(i,s,cond,Declare(i,j,s,cond,n),n)
  - Sanction depends on institution, content, role of *i*…
  - IE = { < cond , $n \wedge B_j\ D_s\ n$ > }



Conclusion

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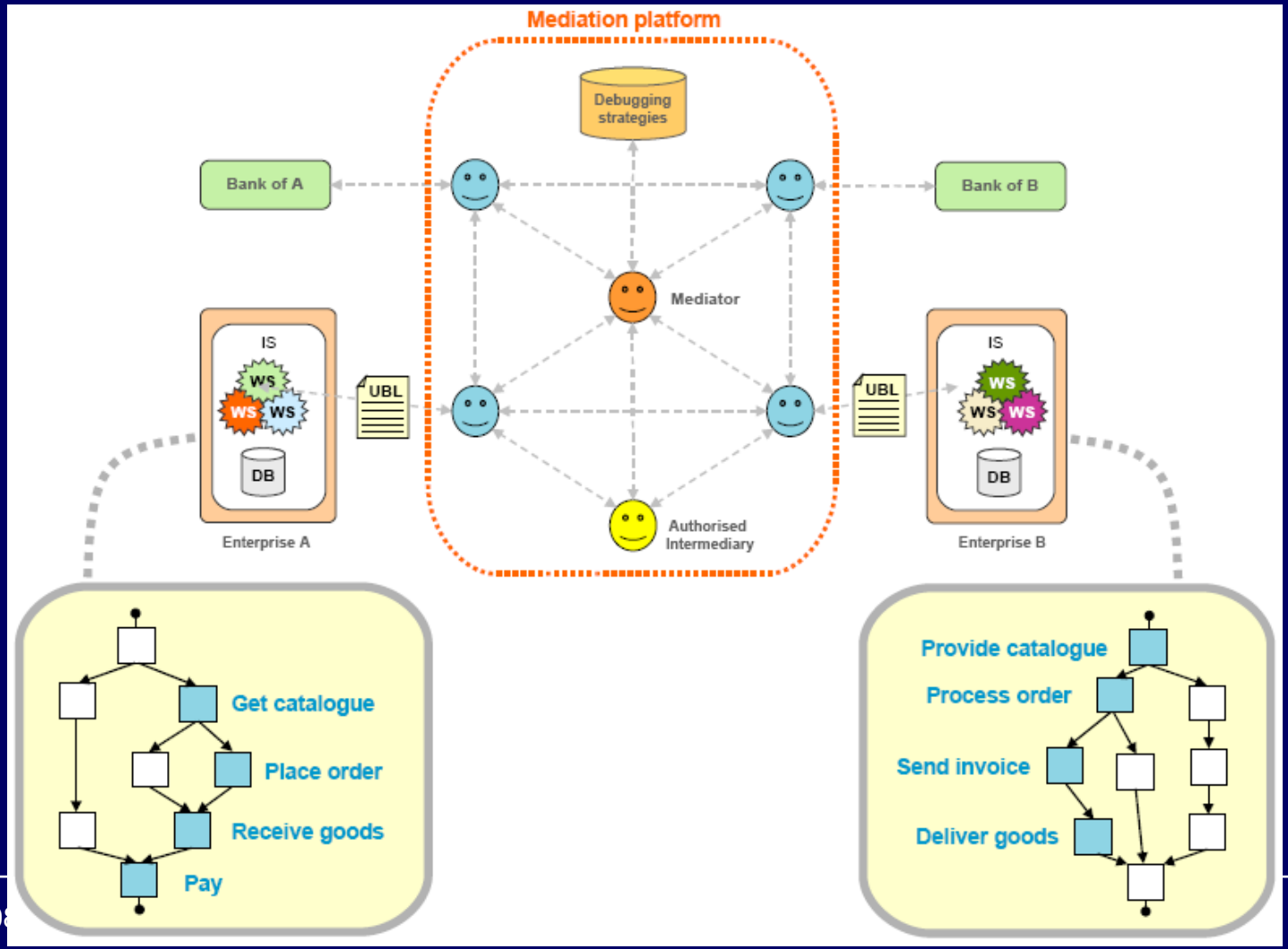
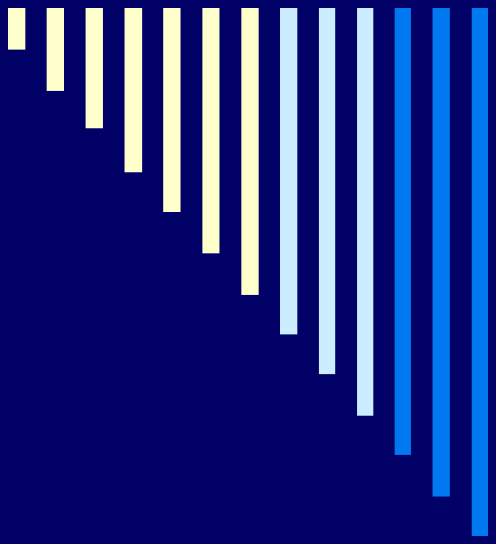
Conclusion

- Unified formalisation:
  - Intentional and institutional dimensions
  - Material and communicative actions
- Future work:
  - Institutional semantics for FIPA speech acts
- Implemented in a multi-agent application:
  - Using JSA (JADE Semantics Add-on)
  - Mediation platform for automatic B2B exchanges

Demonstration this afternoon





Thank you for listening

Questions ?

Commitments *vs* obligations

- Obligations:
  - Imposed by the institution
  - Independant of the agent's will
  - Violation exposes to specified sanctions
- Commitments:
  - Voluntary, intentional (result of a promise)
  - No sanction specified *a priori* for violation
- Possible links in specific cases
  - Obligation to respect commitments (B2B contract)
  - Commitment to respect obligations (obeying agent)