Cognitive social evaluations for multi-context BDI agents

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IIIA - Artificial Intelligence Research Institute
CSIC - Spanish Scientific Research Council

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Outline

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Approaches to control interactions among agents:

- **Security Approach**: Integrity and authenticity of messages, agent's identity validation...
- **Institutional Approach**: Institutions observe agents' behaviors, and may punish them.
- **Social Approach:** Reputation mechanisms are here.

Mechanism to control agents' behavior in MAS when:

- Agents in open environments.
- Agents may have unknown intentions.
- Agents need to interact to each other to achieve their goals.

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Reputation in Multi-Agent Systems (MAS)

- Several models have appeared in literature:
  - **Centralized approach:** eBay, SPORAS, HISTOS ...
  - **Distributed approach:** Regret, AFRAS, Schillo et al., Yu and Singh...
- Among them, **Repage:**
  - Computational system based on a cognitive theory of reputation.
    - Fundamental distinction between **Image** and **Reputation**
    - Image: Social evaluation that is **believed** by the agent.
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Current state-of-the-art work

Focus on model definitions, not in the integration with the agent's architecture.

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Integrate Repage information into a BDI agent architecture.

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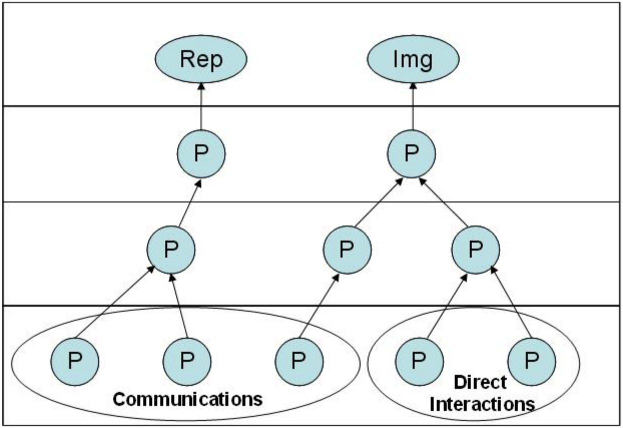
Rep
Img
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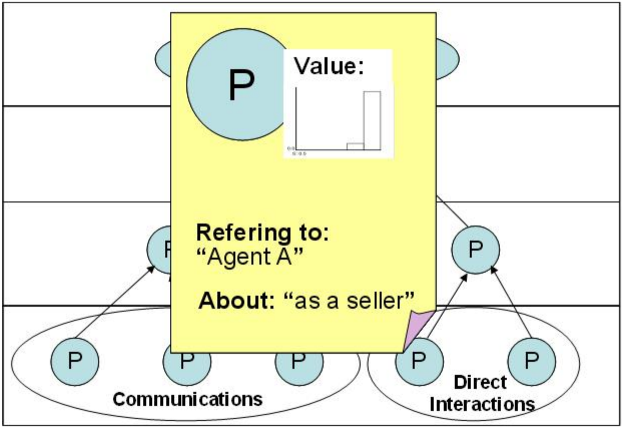
Communications
Direct
Interactions



P
Value:
Refering to:
"Agent A"
About: "as a seller"
P
P
P
P
P
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Communications
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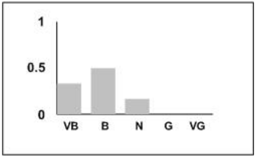
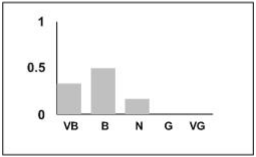
Image of A as a *seller* is



Implies that in the next direct interaction with A, agent **believes** that

- with a prob. of 0.3 it will be **very bad**
- with a prob. of 0.5 it will be **bad**
- with a prob. of 0.2 it will be **neutral**

Image of A as a *seller* is



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Multi-Context Systems(MCS)

Definition

Let I be the set of context names, a MCS is formalized as $\langle \{C_i\}_{i \in I}, \triangle_{br} \rangle$

- $C_i = \langle L_i, A_i, \triangle_i \rangle$, where L_i is a formal language with its syntax and semantics, A_i is a set of axioms and $\triangle_i$ the a set of inference rules.
- $\triangle_{br}$ is a set of bridge rules.

Definition

Bridge rules are inference rules to exchange information between contexts:

$$\frac{C_{i_1} : \varphi_1, \ldots, C_{i_n} : \varphi_n}{C_{i_x} : \varphi_x}$$

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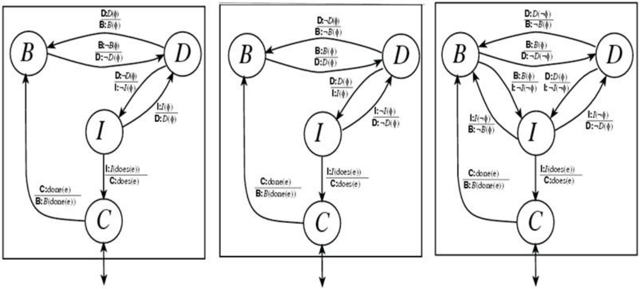
A Multi-Context BDI Agent Specification



[1]

Relation between attitudes: strong realism, realism and weak realism.

[1]Source: Parsons *et al.* Agents that reason and negotiate by arguing. *Journal of Logic and Computation*, 8(3):261-292,1998. *Page 272*

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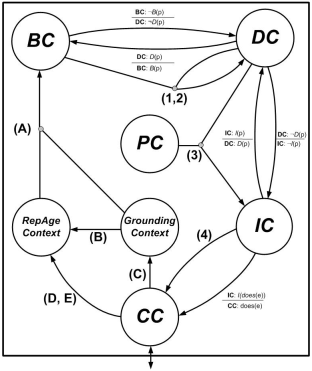

2

General Features

- Lukasiewicz Logic (many-valued logic): So, predicates become fuzzy, and attitudes are graded.
- Dynamic Logic: $[\alpha]\varphi$, after executing action α, the formula φ holds.

[2] Based on: Casali *et al.* Graded models for BDI agents. *Proceedings of CLIMA V*. Pages 18-33. 2004

Belief Context

Belief Context

- **Crisp**: If $\varphi \in L_D$ then $\varphi \in BC$
- **B-Modal**: Modal operator B over **crisp** formulas, together with a truth constant $\overline{r}$ where $r \in [0,1]$. Then:
  - If $\varphi \in L_D$ then $B\varphi \in BC$
  - If $r \in [0,1]$ then $\overline{r} \in BC$
  - If $\alpha, \beta \in BC$ then $\alpha \rightarrow_L \beta$ and $\alpha \wedge_L \beta \in BC$. Here, the connectives $\rightarrow_L$ and $\wedge_L$ (conjunction and implication of Lukasiewicz multi-valued logic).

Example

$(B[buy(alice)](haveCar \wedge hasPaid(7500)), 1)$
$(B[buy(alice)]dT(0,1), .5)$
$(B[buy(alice)]dT(3,\infty), .2)$
$(B[buy(alice)]vgCar, .3)$
$(B[buy(alice)]regularCar, .4)$
$\vdots$

Desire and Intention Context

Desire Context

- **Generic Desires**: $(D^+\varphi, \delta)$, $(D^-\varphi, \delta)$: Level of satisfaction/disgust if φ holds is δ.
- **Realistic Desires**: $(D^+[\alpha]\varphi, \delta)$: Expected level of satisfaction of φ if α is executed is δ.

Example

$(D^+(haveCar \wedge vgCar \wedge dT(0,1)), 0.9)$
$(D^+(haveCar \wedge goodCar \wedge dT(1,3)), 0.7)$
$(D^-dTime(3,\infty), 0.8)$
$(D^-(vbadCar \vee badCar \vee regularCar), 0.7)$

Intention Context

- $(I[\alpha]\varphi, \gamma)$: Trade-off between expected satisfaction level of φ after executing α, and its cost.

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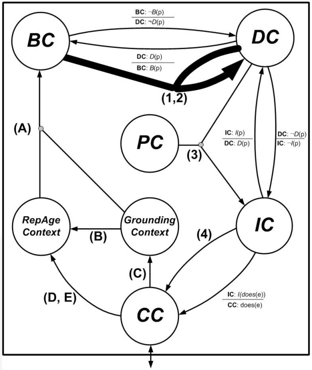
- **Generic Desire** $(D^{+}\varphi, d_{\varphi})$
- **Belief** about getting φ trough the **action** α: $(B([\alpha]\varphi), p_{\varphi})$
- **RESULT**: Realistic desire $(D^{+}[\alpha]\varphi, g(d_{\varphi}, p_{\varphi}))$

Example

$$\frac{DC : (D^{-}dT(3,\infty), 0.8) \quad BC : (B[buy(alice)]dT(3,\infty), 0.2)}{DC : (D^{-}[buy(alice)]dT(3,\infty), 0.16)}$$



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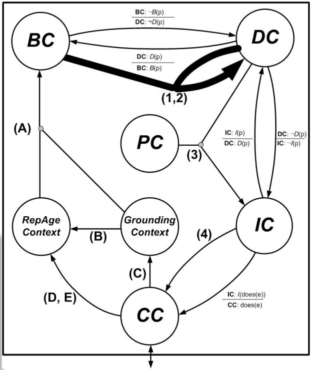

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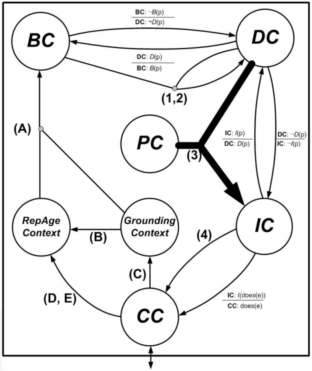
- **A positive realistic desire** $(D^{+}[\alpha]\varphi, \delta)$
- **All negative realistic desires** over the same action α.
  $(D^{-}[\alpha]\psi_1, \delta_{\psi_1}), \ldots, (D^{-}[\alpha]\psi_n, \delta_{\psi_n})$
- **Cost** of the action α:$action(\alpha, c)$
- **RESULT:** Intention of getting φ through α: $(I[\alpha]\varphi, f(\delta - \sum_{i=1}^{n} \delta_{\psi_i}, c))$



Example

$$\frac{\begin{array}{c}(D^{+}[buy(alice)](vgCar \wedge dT(0,1)), 0.3)\\ (D^{-}[buy(alice)]dT(3,\infty), 0.16)\\ (D^{-}[buy(alice)]vbadCar, 0.05)\\ action(buy(alice)), 0.9)\end{array}}{(I[buy(alice)](vgCar \wedge dT(0,1)), 0.494)}$$

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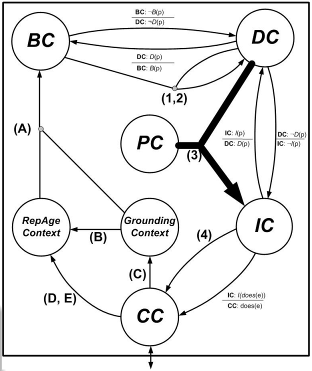

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Example

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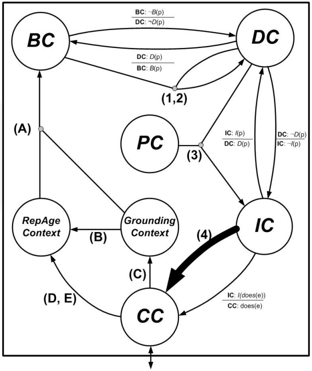

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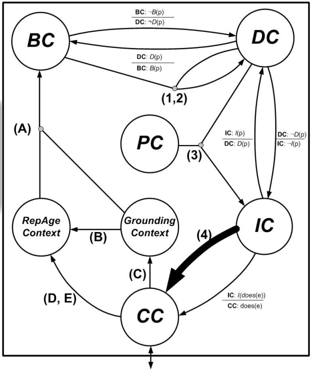
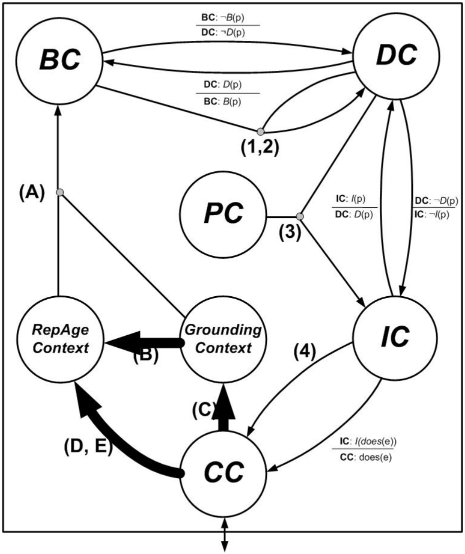
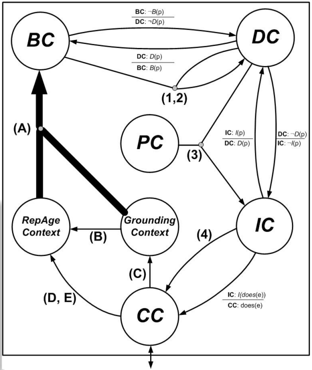




BC: ¬B(p)
DC: ¬D(p)
BC
DC
DC: D(p)
BC: B(p)
(1,2)
(A)
PC
(3)
IC: I(p)
DC: D(p)
DC: ¬D(p)
IC: ¬I(p)
RepAge Context
(B)
Grounding Context
(4)
IC
(C)
(D, E)
CC
IC: I(does(e))
CC: does(e)

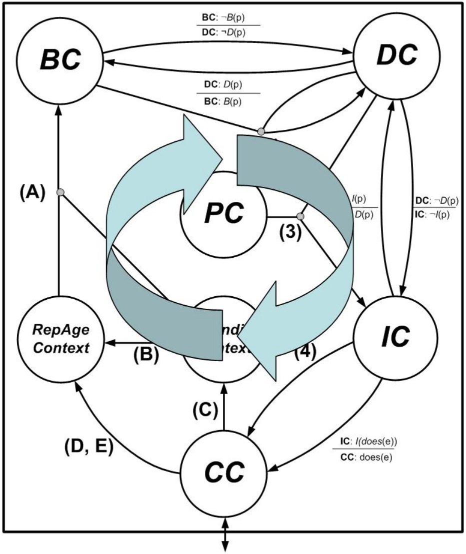
- **Image Predicate** $Img(Ag, r, [v_1, v_2, \ldots])$
- **Grounding discretization functions**: $\varphi_1(r), \varphi_2(r), \ldots$
- **Action associated to** r: $\phi(r)$



Example

$$\frac{Img(alice, seller(dTime), [0.2, 0.3, 0.5])}{\begin{array}{c}(B[buy(alice)]dT(3,\infty), 0.2)\\(B[buy(alice)]dT(1,3), 0.3)\\(B[buy(alice)]dT(0,1), 0.5)\end{array}}$$

Ending...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I(p)
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IC: I(does(e))
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(A)
(B)
(C)
(D, E)
(3)
(4)

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Conclusions and Future Work

- Incorporate Reputation (**done**)
- Implementation / Simulations
- Incorporate proactivity to solve cognitive dissonances.
- Argumentation.
- Ontology alignment.
- ...

The end

Thanks for you attention!