IMPLEMENTATION OF THE PLANNING MODULE

Emiliano Lorini and Jorge Luis Fernandez Davila

CNRS, IRIT, Université Paul Sabatier, Toulouse

ANR CoPains meeting, 18th June 2020

LOGIC OF DOXASTIC ATTITUDES (LDA)*

- 2-agent logic explicit and implicit belief
  - Agent A: artificial agent
  - Agent H: human agent
- Operators with $i \in \{A, H\}$:
  - $\triangle_i \alpha$: agent i explicitly believes that α
    $\Rightarrow$ Information in i's belief base
  - $\Box_A \alpha$: A implicitly believes that α
    $\Rightarrow$ Information deducible from A's belief base
  - $\Diamond_A \alpha$: α is compatible with A's explicit beliefs
  - $+_i \alpha$: agent i learns that α

$$
\begin{array}{llll}
\mathcal{L}_0 & \alpha & ::= & p \mid \neg\alpha \mid \alpha_1 \wedge \alpha_2 \mid \triangle_i \alpha \\
\mathcal{L} & \varphi & ::= & \alpha \mid \neg\varphi \mid \varphi_1 \wedge \varphi_2 \mid \Box_A \alpha \mid \Diamond_A \alpha \mid [+_i \alpha]\varphi
\end{array}
$$

where α ranges over $\mathcal{L}_0$ and $i \in \{A, H\}$

Belief base

$\triangle_{Bob} temp_{>10} \rightarrow \triangle_{Bob} \neg cold$
$\triangle_{Bob} \neg cold \rightarrow int_{Bob,out}$

Deduction process (reasoning)

$[+_{HAL} \triangle_{Bob} temp_{>10}] \Box_{HAL} int_{Bob,out}$

* Rethinking Epistemic Logic with Belief Bases. E. Lorini, 2019

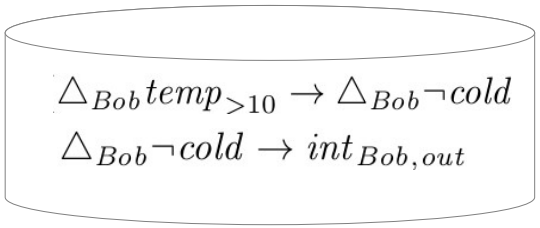
LOGIC OF DOXASTIC ATTITUDES (LDA)*

- 2-agent logic explicit and implicit belief
  - Agent A: artificial agent
  - Agent H: human agent
- Operators with $i \in \{A, H\}$:
  - $\triangle_i \alpha$: agent i explicitly believes that α
    $\Rightarrow$ Information in i's belief base
  - $\Box_A \alpha$: A implicitly believes that α
    $\Rightarrow$ Information deducible from A's belief base
  - $\Diamond_A \alpha$: α is compatible with A's explicit beliefs
  - $+_i \alpha$: agent i learns that α

$$\begin{array}{llll} \mathcal{L}_0 & \alpha & ::= & p \mid \neg\alpha \mid \alpha_1 \wedge \alpha_2 \mid \triangle_i \alpha \\ \mathcal{L} & \varphi & ::= & \alpha \mid \neg\varphi \mid \varphi_1 \wedge \varphi_2 \mid \Box_A \alpha \mid \Diamond_A \alpha \mid [+_i \alpha]\varphi \end{array}$$

where α ranges over $\mathcal{L}_0$ and $i \in \{A, H\}$

Belief base



Deduction process (reasoning)

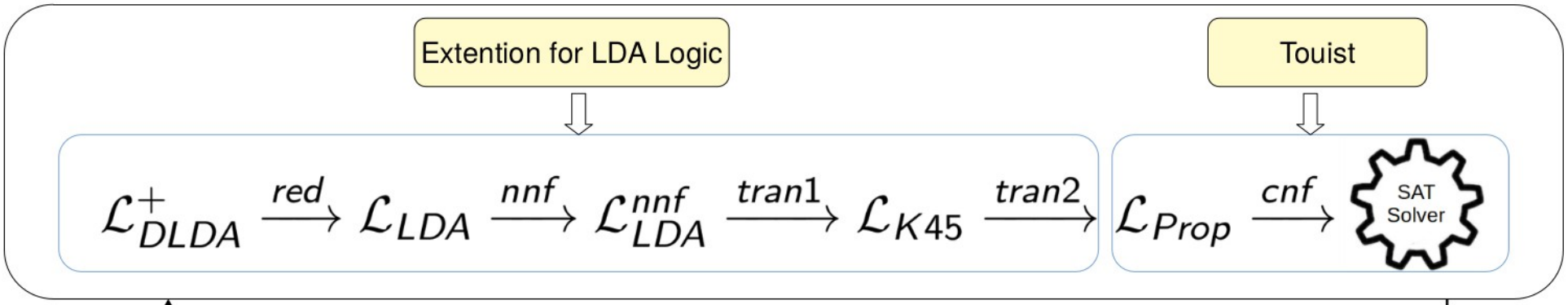
$$[+_{HAL} \triangle_{Bob} temp_{>10}] \Box_{HAL} int_{Bob,out}$$

Speech act "informing" (from the speaker's perspective):

$$inform(i, j, \alpha) \stackrel{\text{def}}{=} +_i \triangle_j \triangle_i \alpha$$

* Rethinking Epistemic Logic with Belief Bases. E. Lorini, 2019

IMPLEMENTATION OF LDA



INPUT

$$\triangle_A \triangle_H (p \rightarrow q) \rightarrow [+_A p] \Box_A q$$

OUTPUT

Model 1 : p = 0, q = 1
Model 2 : p = 1, q = 1

SAT ✔

or

No Model

UnSAT ✖

Note :

A = Artificial Agent
H = Human

IMPLEMENTATION OF LDA

Extention for LDA Logic

Touist

$\mathcal{L}^{+}_{DLDA} \xrightarrow{red} \mathcal{L}_{LDA} \xrightarrow{nnf} \mathcal{L}^{nnf}_{LDA} \xrightarrow{tran1} \mathcal{L}_{K45} \xrightarrow{tran2} \mathcal{L}_{Prop} \xrightarrow{cnf}$ SAT Solver

INPUT

OUTPUT

$\triangle_A \triangle_H (p \rightarrow q) \rightarrow [+_A p] \Box_A q$

Model 1 : p = 0, q = 1
Model 2 : p = 1, q = 1

SAT ✔

or

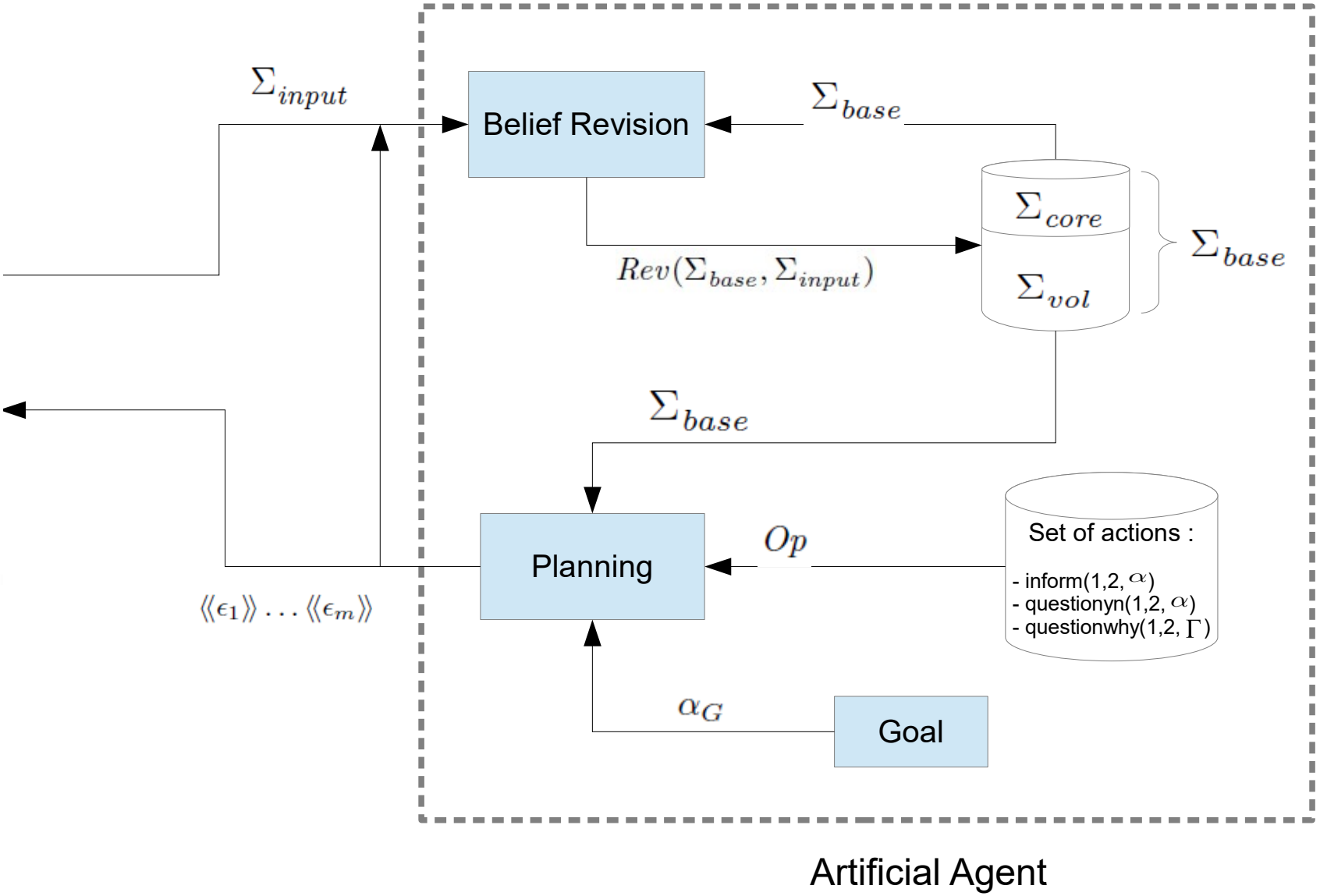
No Model

UnSAT ✘

Note :

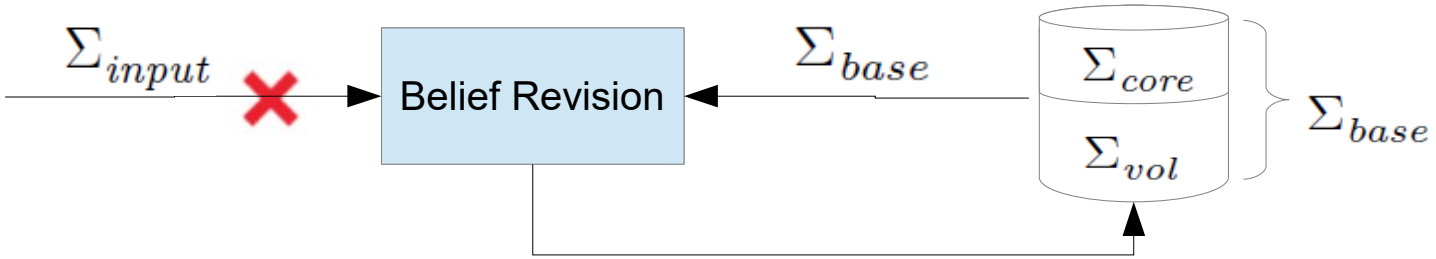
A = Artificial Agent
H = Human

ARCHITECTURE OF THE SYSTEM



BELIEF REVISION

Case 1 : Σ_{input} contradicts Σ_{core}

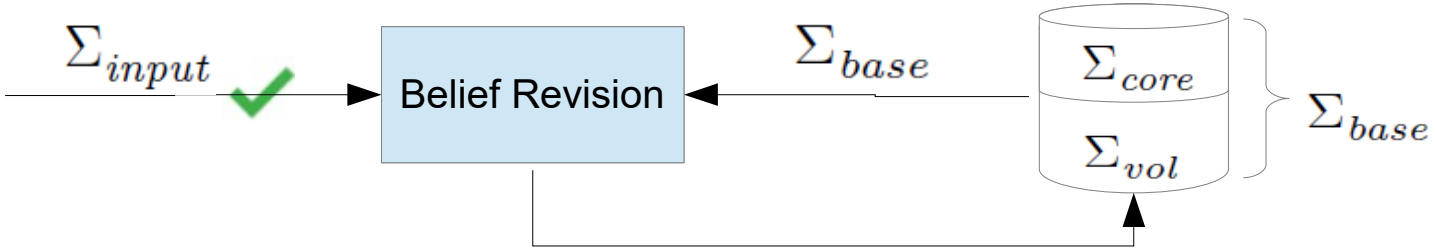


$S = \Sigma_{core} \wedge \Sigma_{input}$

Is S SAT? = no

$Rev(\Sigma_{base}, \Sigma_{input}) = \Sigma_{base}$

Case 2 : Σ_{input} does not contradict Σ_{core}



$S = \Sigma_{core} \wedge \Sigma_{input}$

Is S SAT? = yes

$C[] = \Sigma_{vol}$

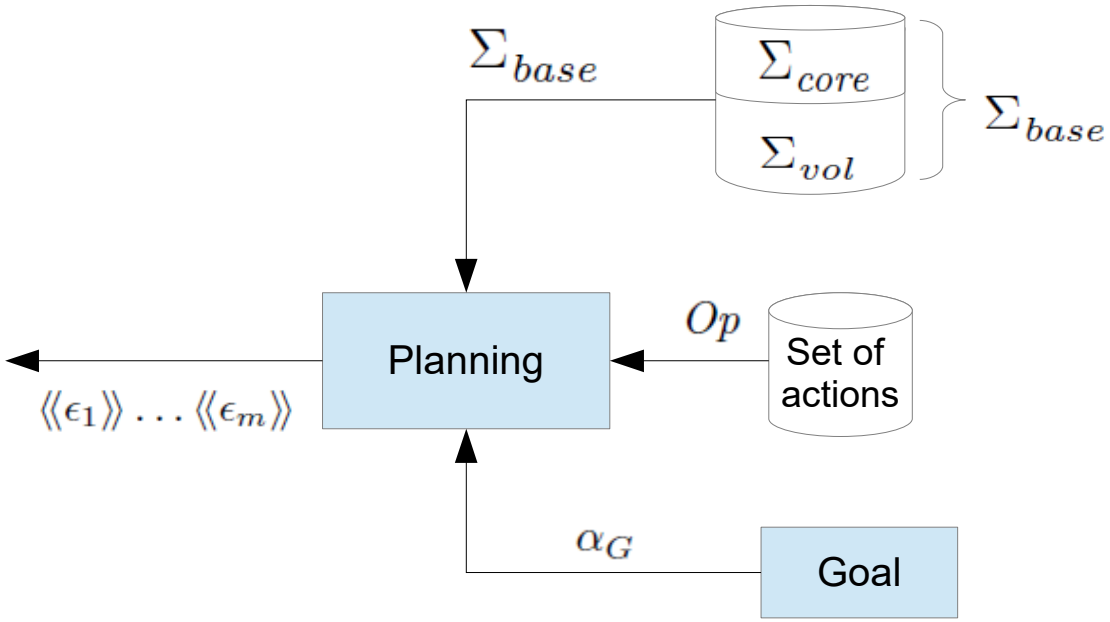
$C'[] = \text{Combinations}(C[], n - i)$

$X = \Sigma_{core} \wedge C'[j] \wedge \Sigma_{input}$

$MCS[] \leftarrow X$

$Rev(\Sigma_{base}, \Sigma_{input}) = \bigcap_{X \in MCS[]} X$

PLANNING PROCESS



Algorithm

$m = 1$

WHILE $m \leq |ACT|$:

$OS = \bigcup_{S \in 2^{ACT}_m} Perm(S)$

FOR $O \in OS$:

$P = \neg(I \rightarrow [O]\, G)$

$P' = \text{reductionsApplying}(P)$

IF $\text{TouIST}(P') == unsat$:

P is valid

exit

$m{+}{+}$

IF $m > |ACT|$:

No plan available