

BDI Concepts and Agent Oriented Systems

Knowledge Representation and Reasoning

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- The Intentional Stance
- Beliefs, Desires and Intentions
- Rational Agency and BDI
- Rao and Georgeff's Theoretical BDI Interpreter
- Wooldridge's Agent Control Loops
- dMARS and JACK
- BDI Agent Architecture
- Example dMARS Plan
- BDI Dynamics
- References

The Intentional Stance

The philosopher Daniel Dennet proposed three ways (stances) at which we can predict things about the world:

Dennet's Stances

- **Physical** Stance
- **Design** Stance
- **Intentional** Stance

Beliefs, Desires and Intentions

Internal mental attitudes of a rational BDI agent (or mental state):

Beliefs

What an agent believes about the world, itself and other agents (informational).

Desires

What an agent want to achieve (motivational).

Intentions

How the agent tries to achieve desires (deliberational).

Rational Agency and BDI

Daniel Dennet: Folk Psychology

Michael Bratman: Rational Agency

Rao and Georgeff: Formal Logical Framework

Programming Languages: PRS, dMARS, JACK, JAM, C-PRS, IRMA

BDI Interpreter

```
initialize-state();  
repeat  
    options := option-generator(event-queue);  
    selected-options := deliberate(options);  
    update-intentions(selected-options);  
    execute();  
    get-new-external-events();  
    drop-successful-attitudes();  
    drop-impossible-attitudes();  
end repeat
```

Basic Agent Control Loop 1

Adapted from Wooldridge...

procedure AGENT CONTROL LOOP 1

while True **do**

 observe-the-world();

 update-internal-world-model();

 deliberate-about-what-intention-to-achieve-next()

 use-means-end-reasoning-to-get-a-plan-for-next-intention()

 execute-the-plan

end while

end procedure

Basic Agent Control Loop 2

Adapted from Wooldridge...

procedure AGENT CONTROL LOOP 2(B_0)

$B \leftarrow B_0$

while True **do**

$\rho \leftarrow \text{get_next_percept}();$

$B \leftarrow \text{brf}(B, \rho);$

$D \leftarrow \text{deliberate}(B);$

$\pi \leftarrow \text{plan}(B, I);$

$\text{execute}(\pi);$

end while

end procedure

Basic Agent Control Loop 3

Adapted from Wooldridge...

procedure AGENT CONTROL LOOP 3(B_0, I_0)

$B \leftarrow B_0$

$I \leftarrow I_0$

while True **do**

$\rho \leftarrow \text{get_next_percept}();$

$B \leftarrow \text{brf}(B, \rho);$

$D \leftarrow \text{options}(BI);$

$I \leftarrow \text{filter}(B, D, I);$

$\pi \leftarrow \text{plan}(B, I);$

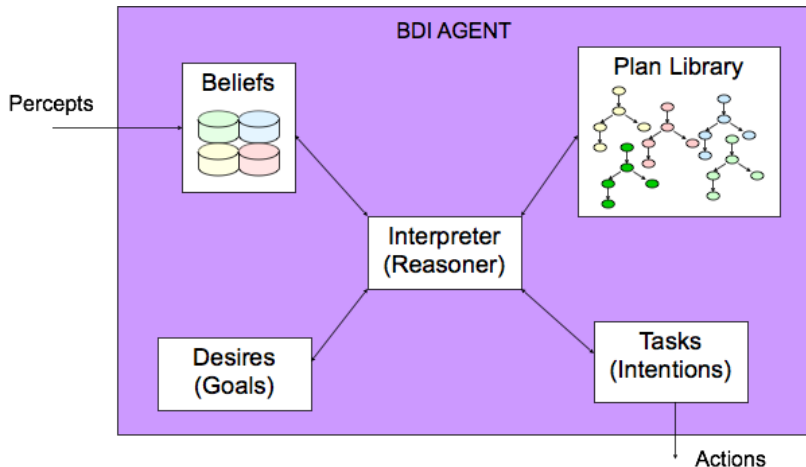
$\text{execute}(\pi);$

end while

end procedure

- Implementations of the BDI model
- Idea of plans as recipes (pre-planning)
- Least commitment
- Bounded rationality
- Dynamic environment
- Goals, beliefs, plans
- Intentions and run-time (not design time) constructs

A BDI Agent Architecture



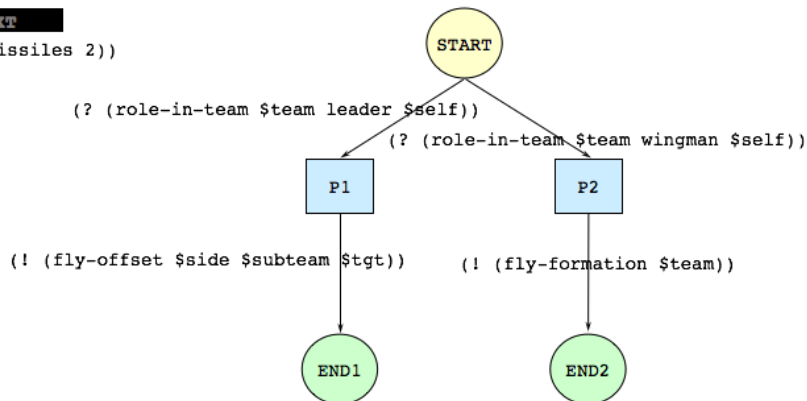
Example dMARS Plan

INVOCATION

```
(new-goal (! (intercept $team $tgt)))
```

CONTEXT

```
(= (num-missiles 2))
```



- 1 An event occurs.
 - A goal is posted (internal).
 - A change in the environment and hence a change in belief (external).
- 2 Agent reasoner searches through the plan library to find the set of plans which can handle this event (defined by the invocation condition).
- 3 This may result in 10 plans out of 500 which can handle the event. Out of these 10 plans, the agent reasoner then chooses only those which are appropriate for this **context** – that is, the current situation.

- 5 This may result in 6 plans out of the 10 which are **applicable** in this context.
- 6 The agent then chooses one of the plans, puts it on the **intention stack**, and starts executing the plan steps in the plan.
- 7 This executing plan is called an **intention** to achieve the original **goal**.
- 8 If the plan fails, the agent will try on of the other applicable plans until one of them succeeds in achieving the goal or all of them fail, in which case the goal will fail.

- It is possible to determine which plan is chosen in the applicable plan set by using **meta-level reasoning**.
- Plans can wait until particular beliefs are satisfied.
- Plan steps can involve trying to achieve **sub-goals**.
- When trying to achieve a sub-goal, the existing plan is suspended and the new plan is put on top of the **intention stack**.

References

- *Reasoning About Rational Agents*, Michael Wooldridge
- *The Intentional Stance*, Daniel Dennet
- *BDI Agents: From Theory to Practice*, Anand Rao and Michael Georgeff
- *Modeling Rational Agents within a BDI-Architecture*, Anand Rao and Michael Georgeff