Programming with Goals (2)

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GOAL slides adapted from MAS course slides by Hindriks
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Recap

- BDI philosophy & logics
  - goals as consistent set of chosen desires
  - intention as goals that agent commits to
- Explicit representation of goals in agent systems
  - enables reasoning about goals
- Representation of goals: XML, (conjunctions of) atoms
- GOAL mental states: beliefs, goals, knowledge
- Goal types
Outline

• Dynamics of goals

• Dynamics of goals in GOAL: Action Specification & Selection
1. Dynamics of Goals
Dynamics of Goals

• When and how to adopt goals?
  • Internal motivation: beliefs, other goals, desires
  • External motivation: requests, obligations

• When and how to drop goals?
  • Commitment strategies

• When and how to suspend goals?
  • Priorities, goal conflict
Goal Life Cycle (1)

Goal Life Cycle (2)

Dropping goals: Recall...

- Intention is choice with commitment
- But... what does commitment mean exactly?
Commitment Strategies


• **Blind** commitment: keep intentions until believed they are achieved

• **Single-minded** commitment: keep intentions until believed they are achieved, or believed they are impossible to achieve

• **Open-minded** commitment: keep intentions until believed they are achieved, or they are no longer goals of the agent

Commitment strategies concern when (not) to drop intentions
Commitment Strategies for Goals (1)


Somehow...

- commitment strategies for intentions as proposed in BDI logics translated to similar commitment strategies for goals in agent programming languages
Commitment Strategies for Goals (2)

Winikoff et al. (2002):

- **Persistent**: A goal should only be deleted when it succeeds or where there is a good reason for dropping it.

- **Unachieved**: A goal to achieve $s$ should be dropped when $s$ is true.

- **Possible**: Failure condition $f$ defines when a goal should be dropped with failure; failure condition expresses impossibility to achieve.

$\approx$ single-minded commitment
Perspectives on Dropping Goals

- **Dropping over transition**
  - transition from one configuration into another: \( c \rightarrow c' \)
  - dropping of goal \( \phi \) over \( c \rightarrow c' \)
    - agent has goal \( \phi \) in \( c \) but not in \( c' \)

- **Two perspectives**
  - **deletion** perspective: deletion of goal from goal base
  - **satisfaction** perspective: formula \( G\phi \) becomes unsatisfied
Commitment Strategy of GOAL

• Goals are dropped from goal base when believed to be achieved (deletion perspective)
  ≈ blind commitment

• Mental state condition $\text{a-goal}(\phi)$ holds if $\phi$ is not believed (satisfaction perspective)

• Goals can also be dropped using the built-in drop action
  • can be used to implement single-minded commitment
Commitment Strategy of Jason


- Drop achievement goal from event base as soon as plan for it has been selected
- But, commitment strategies can be programmed using plan patterns

\[ +!g: g \leftarrow \text{true}. \]
\[ +!g: c \leftarrow p; ?g. \]
\[ -!g: \text{true} \leftarrow !g \]
Suspending Tasks (= Goals or Plans)


Reasons for suspension:

• Conflicts between tasks
• Positive interaction
• Invalid context
• No applicable plan
• Changing priorities
• Requests from other agents
Suspending & Aborting Goals


- Conditional rules for generating goals, based on mental attitudes
  - Beliefs, Obligation, Intention, Desire
  - Technically, goal set is extension in default logic
- Priorities over mental attitudes create agent types
Goal Adoption in GOAL

- Goals can be inserted into goal base in initial mental state

- Goals can be adopted at run-time using the built-in adopt action, conditional on mental state
2. 

*Dynamics of Goals in GOAL: Action Specification & Action Selection*
Actions Change Environment...

initial state

next state

move(a,d)
...and Require Updating

Mental States: Beliefs

- To ensure adequate beliefs after performing an action the belief base needs to be updated (and possibly the goal base).

```
beliefs{
  on(a, b),
  on(b, c),
  on(c, table),
  on(d, e),
  on(e, table),
  on(f, g),
  on(g, table).
}
```

- **Add effects** to belief base: insert `on(a, d)` after `move(a, d)`.

```
beliefs{
  on(a, d),
  on(b, c),
  on(c, table),
  on(d, e),
  on(e, table),
  on(f, g),
  on(g, table).
}
```

- **Delete** old beliefs: delete `on(a, b)` after `move(a, d)`.
...and Require Updating Mental States: Goals

- If a goal has been (believed to be) completely achieved, the goal is removed from the goal base.

- Default update implements a blind commitment strategy.

- Goal base updates as “side effect” of belief base updates
Action Specifications

- Actions in GOAL have **preconditions** and **postconditions** (STRIPS-style)

- Executing an action in GOAL means:
  - Preconditions are conditions that need to be true:
    - Check preconditions on the belief base.
  - Postconditions (effects) are add/delete lists:
    - Add positive literals in the postcondition
    - Delete negative literals in the postcondition

```plaintext
move(X,Y) {
    pre { clear(X), clear(Y), on(X,Z), not(on(X,Y)) }
    post { not(on(X,Z)), on(X,Y) }
}
```
Actions Specifications

move(X,Y) {
    pre { clear(X), clear(Y), on(X,Z), not(on(X,Y)) }
    post { not(on(X,Z)), on(X,Y) }
}

Example: move(a,b)
- Check:  clear(a), clear(b), on(a,Z), not(on(a,b))
- Remove: on(a,Z) ←
- Add:    on(a,b)    z = table
Actions Specifications

\[
\text{move}(X,Y) \{
\quad \text{pre} \{ \text{clear}(X), \text{clear}(Y), \text{on}(X,Z) \} \\
\quad \text{post} \{ \neg \text{on}(X,Z), \text{on}(X,Y) \}
\}
\]

Example: \text{move}(a,b)

**beliefs**{
\begin{align*}
\text{on}(a,\text{table}), \\
\text{on}(b,\text{table}).
\end{align*}
}\}

\[
\text{initial state} \quad \text{goal state}
\]

**belief**{
\begin{align*}
\text{on}(b,\text{table}). \\
\text{on}(a,b).
\end{align*}
}\}
Built-in Actions

Adopting and dropping goals:

• **adopt**(<conjunction of positive literals>)
  
  *meaning*: add a **new** goal to goal base (if not already **implied** by a goal)

• **drop**(<conjunction>)
  
  *meaning*: remove **all** goals that imply <conjunction> from the goal base

Inserting and deleting beliefs:

• **insert**(<conjunction>)

• **delete**(<conjunction>)
Drop Action

drop(on(b,a), not(on(c,table)))

- Is goal in goal base dropped?
- Check: does goal imply on(b,a), not(on(c,table))?
- A: Yes, so goal is removed by drop action.
Action Selection in Agent-Oriented Programming

• How do humans choose and/or explain actions?
• Examples:
  • I believe it rains; so, I will take an umbrella with me.
  • I go to the video store because I want to rent I-robot.
  • I don’t believe busses run today so I take the train.

• BDI not only for explaining & predicting, but also for programming!

• Use intuitive common sense concepts:
  beliefs + goals => action
Selecting Actions: Action Rules

- Action rules are used to define a strategy for action selection.
- Defining a strategy for blocks world:
  - If constructive move can be made, make it.
  - If block is misplaced, move it to table.

```plaintext
program{
    if bel(tower([Y|T])), a-goal(tower([X,Y|T])) then move(X,Y).
    if a-goal(tower([X|T])) then move(X,table).
}
```

- What happens:
  - Check condition, e.g. can \texttt{a-goal(tower([X|T]))} be derived given current mental state of agent?
  - Yes, then (potentially) select \texttt{move(X,table)}.
Order of Action Rules

- Action rules are executed by default in linear order.
- The first rule that fires is executed.

```plaintext
program{
    if bel(tower([Y|T])), a-goal(tower([X,Y|T])) then move(X,Y).
    if a-goal(tower([X|T])) then move(X,table).
}
```

- Default order can be changed to random.
- Arbitrary rule that is able to fire may be selected.

```plaintext
program[order=random]{
    if bel(tower([Y|T])), a-goal(tower([X,Y|T])) then move(X,Y).
    if a-goal(tower([X|T])) then move(X,table).
}
```
Summary

- Dynamics of goals
  - goal life cycle
  - adopting, dropping & suspending goals

- Action specification
  - pre- and postcondition
  - update beliefs
  - built-in actions for adopting/dropping goals

- Action selection
  - action rules with mental state condition