BDI Agent Programming with AgentSpeak

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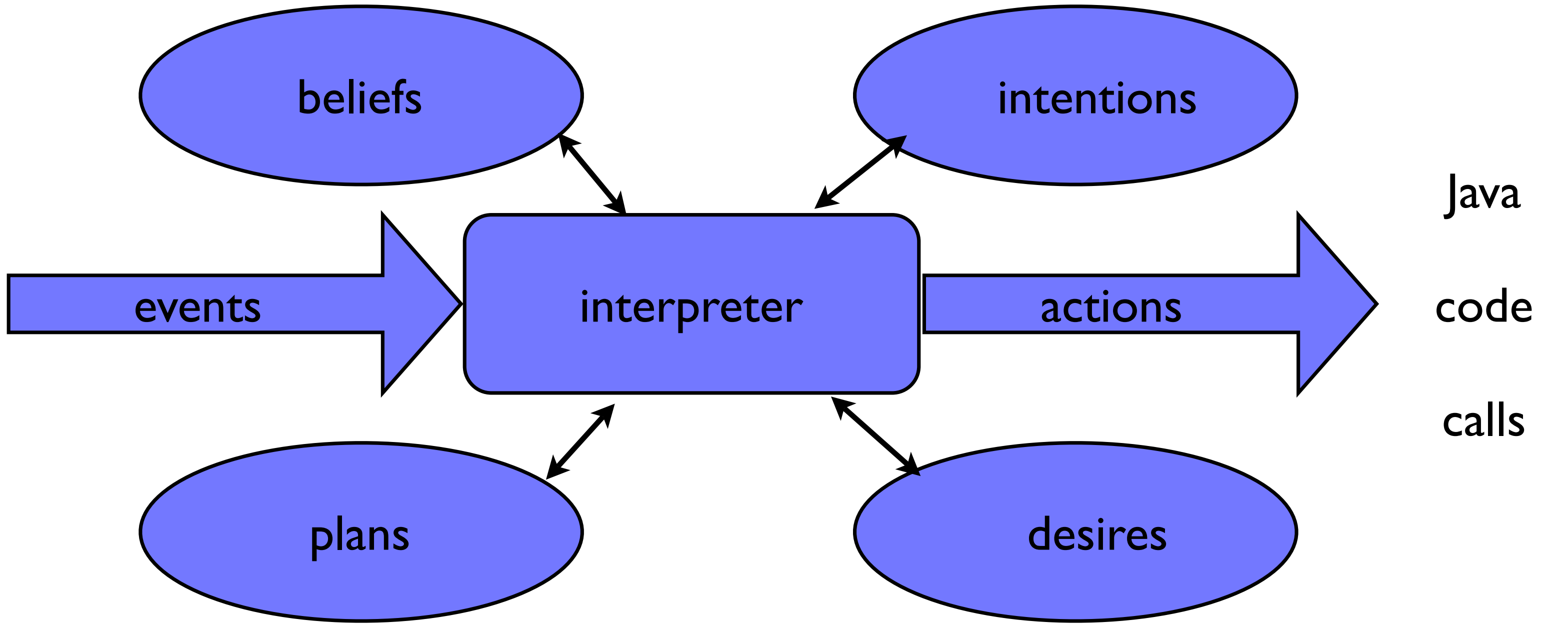
What is AgentSpeak?

- A simple but powerful programming language for building *rational agents*
- Based on the *belief-desire-intention* paradigm
- Intellectual heritage:
  - The Procedural Reasoning Systems (PRS)
    - developed at SRI in late 1980s
  - Logic Programming/Prolog

What is Jason?

- An implementation of AgentSpeak
- A development environment for AgentSpeak systems
- Implemented in Java, has lots of hooks to call Java code
- Comes with libraries and debugging tools
- Get “up and running” very quickly

The AgentSpeak/PRS Architecture



AgentSpeak Control Loop

- agent receives *events*, which are either
  - external (from the environment, from perceptual data)
  - internally generated
- tries to *handle* events by looking for *plans* that *match*
- the set of plans that match the event are *options/desires*
- chooses one plan from its desires to execute: becomes committed to it -- an *intention*
- as it executes a plan may generate new events that require handling

The AgentSpeak Architecture: Beliefs

- beliefs in AgentSpeak represent information the agent has about its environment
- they are represented *symbolically*
  - *ground atoms of first-order logic*

The AgentSpeak Architecture: Example Beliefs

open(valve32)

father(tom, michael)

father(lily, michael)

friend(michael, john)

at_location(michael, gunne)

on(blockA, blockB)

The AgentSpeak Architecture: Plans

- coded by developer offline, in advance
- give the agent information about
  - how to respond to events
  - how to achieve goals
- plan structure:
  - event
  - context
  - body

The AgentSpeak Architecture: Plan Structure

```
triggerCondition :
    context <-
      body.
```

The AgentSpeak Architecture: Plan Structure

- triggerCondition
  - is an *event* that the plan can *handle*
- context
  - defines the conditions under which the plan can be used
- body
  - defines the actions to be carried out if the plan is chosen

The AgentSpeak Architecture: Events

- +! *P*
  - new goal acquired -- “achieve *P*”
- -! *P*
  - goal *P* dropped
- + *B*
  - new belief *B*
- - *B*
  - belief *B* dropped

Hello World

- Set up an empty directory called “hello_world” in your workspace
- Create a new project, called hello_world
  - to do this, use the “new project” button on JEdit
  - Jason will create a template MAS folder

The Template MAS

```
/* Jason Project */

MAS hello_world {

    infrastructure: Centralised

    agents:
}
```

What does this say?

- It says that the system is called “hello_world”
- It says that currently, it contains no agents
- So let’s add some agents...

Add An Agent

- Use the button “add agent in project”
- Give it the name “hello”
- Again, Jason will produce a template with the “hello world” agent in
  - if it doesn’t type this in.

The Hello World Agent

```
// Agent hello in project hello_world.mas2j

/* Initial beliefs and rules */

/* Initial goals */

!start.

/* Plans */

+!start : true <- .print("hello world.").
```

About the Hello World Agent

- The agent has a single *initial goal:* !start
  - this goal is there when the agent starts up
- The exclamation mark says “this is a goal”
- There is a single plan, which says “if you have acquired the goal “start”, then print “hello world”
- Run the system by pressing the “play” button

Running and Debugging

- A console will open, which will show the output of all agents
- It should show:
  - [hello] hello world.
- Congratulations!
- Press the "debug" button on the console to see inside the agent's heads..
- Notice you have to explicitly *stop* the system from the jEdit console

Plans

- A plan has the form
  - `triggering_event : context <- body`
- meaning
  - if you see this "triggering_event"
  - and believe the "context" is true
  - then you can execute "body"

A More Complex Example

- Create a new project “factorial1”, with a single agent “factorial1”

The Agent “factorial1”

```
fact(0,1).

+fact(X,Y)
  :   X < 5
 <-  +fact(X+1, (X+1)*Y).

+fact(X,Y)
 :   X == 5
 <- .print("fact 5 == ", Y).
```

Initial Belief

- Initial belief says “the factorial of 0 is 1”

The First Rule

```
+fact(X,Y)
  :   X < 5
 <-  +fact(X+1, (X+1)*Y).
```

- If you acquire the belief that the factorial of X is Y, and X is less than 5, then *add the belief that the factorial of X+1 is (X+1)*Y*

The Second Rule

```
+fact(X,Y)
 :   X == 5
 <- .print("fact 5 == ", Y).
```

- If you acquire the belief that the factorial of X is Y, and X == 5, then print "fact ..."
- Notice the use of "==".
  - Don't use "=" as it means something different
- Run the program and explore the agent's mind

Inside the agent's mind

```
fact(5,120)[source(self)]
fact(4,24)[source(self)]
fact(3,6)[source(self)]
fact(2,2)[source(self)]
fact(1,1)[source(self)]
fact(0,1)[source(self)]
```

- Here are all the beliefs the agent has accumulated.
- [source(self)] is an *annotation*, indicating where the belief came from...
- we will see how to use these shortly

A Small Modification

- Modify the agent so that intermediate results are printed as they are generated

Internal Actions

- .print(...) is an *internal action*
- other internal actions:
  - .stopMAS() -- stop system running
  - .time(H,M,S) -- put time into vars H,M,S
  - .wait(X) -- pause for X milliseconds
  - .random(X) -- put random value into X (0 <= X <= 1)

Further Modifications

- Modify your solution so that after the value is printed, the system pauses 3 seconds and then terminates.
- You should see the console displayed for 3 secs then disappear...

A Data Driven Solution

- Notice that the solution we have developed is *data driven/ event driven*
- It is the arrival of a partial solution that causes another partial solution to be generated...
- We can also look at a *goal driven* solution

factorial2

- Create a new project, "factorial2", and within it a single agent "factorial2"

```
!print_fact(5).

+!print_fact(N)
   <- !fact(N,F);
      .print("Factorial of ", N, " is ", F).

+!fact(N,1) : N == 0.

+!fact(N,F) : N > 0
   <- !fact(N-1,F1);
      F = F1 * N.
```

factorial2

- Here the agent starts with a single *goal*, which is to print the factorial of 5
- The first rule says, if you have this as a goal, then
  - first compute the factorial of N
  - then print it
- The second and third rules say how to compute the factorial of N

Communication

- One agent is boring! Lets add more!
- We'll have an agent that knows how to compute factorial, and another that doesn't
- The expert will receive queries from the idiot and will respond to them

The .send(...) Action

- The basic mechanism for communication is the .send(...) action:

```
  .send(rcvr, type, content)
```

- Causes a message to be sent to agent called “rcvr”, with message type “type”, and content “content”

Example

- `.send(mjw, tell, fact(3,6))`
  - this will cause the agent mjw to add the belief `fact(3,6)`
- `.send(mjw,  achieve, go(10,10))`
  - causes `+!go(10,10)` to be added as an event for mjw
- Actually its more complicated than that: the recipient *annotates* with the *source*

The Client-Server

- Create a new project, “factorial3”, with 2 agents: idiot and expert

The Idiot Agent

```
// Agent idiot in project factorial3.mas2j


/* Initial goals */

!start.

/* Plans */

+!start : true
    <- .print("starting..");
    !query_factorial(2);
    !query_factorial(4);
    !query_factorial(6);
    !query_factorial(10).

+!query_factorial(X) : true <-
    .send(expert,tell, giveme(X)).

+fact(X,Y) : true <-
    .print("factorial ", X, " is ", Y, " thank you expert").
```

Another Modification

- Modify the idiot agent so that it:
  - starts by asking for the factorial of 0
  - as soon as it gets a reply for the factorial of X, waits 2 seconds and then asks for the factorial of X+1.
- You will have to kill this when it runs and runs...