Human-like artificial creatures

5. Belief-Desire-Intention

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Outline

1. Practical reasoning and Belief Desire Intention
2. Implementation
3. Jam, Jason, GOAL

Practical reasoning

- A model of decision making. Practical reasoning is a reasoning directed towards actions
  - what to do (**deliberative** reasoning)
  - how to do it (**means-ends** reasoning)
- Practical reasoning is not theoretical reasoning!
  - problem-solving vs. how to buy a ticket
- Limited computational resources
- The central concept of practical reasoning is a triad "belief – desire – intention"
  - the state of a BDI creature in any given moment is (Bel, Des, Int).
- Originally, Bratman offered a framework for assesment of an agent rationality
  - however, it is implementable
  - probably the first was the Procedural Reasoning System (Standford)

[Bratman, 1987]

Beliefs

- BDI architecture contains explicit representation of Beliefs, Desires, Intentions
- **Beliefs** represent information the agent has about its current environment ("environmental memory")
  - may be false

Intentions and desires

- Intentions present-directed (now) vs. future-directed vs. policy-based vs. ...
- **Intentions** are adopted / committed desires
  - **desires** are future agent's possibilities
  - intentions are states (of mind) that the agent has committed to trying to achieve
  - I've decided to drink a milk shake vs. I desire to drink a shake, but I'm fat.
- Intentions towards goals vs. towards means
- Intentions:
  - persist (but sometimes, intentions must be dropped)
  - drive means-ends reasoning
  - constrain future deliberation
  - influence beliefs upon which future practical reasoning is based

- The problem how often to reconsider intentions and eventually drop some is the problem of balancing between pro-active (goal-directed) and reactive (event driven) behaviour. Different types (static/dynamic) of environments require different types of reasoning

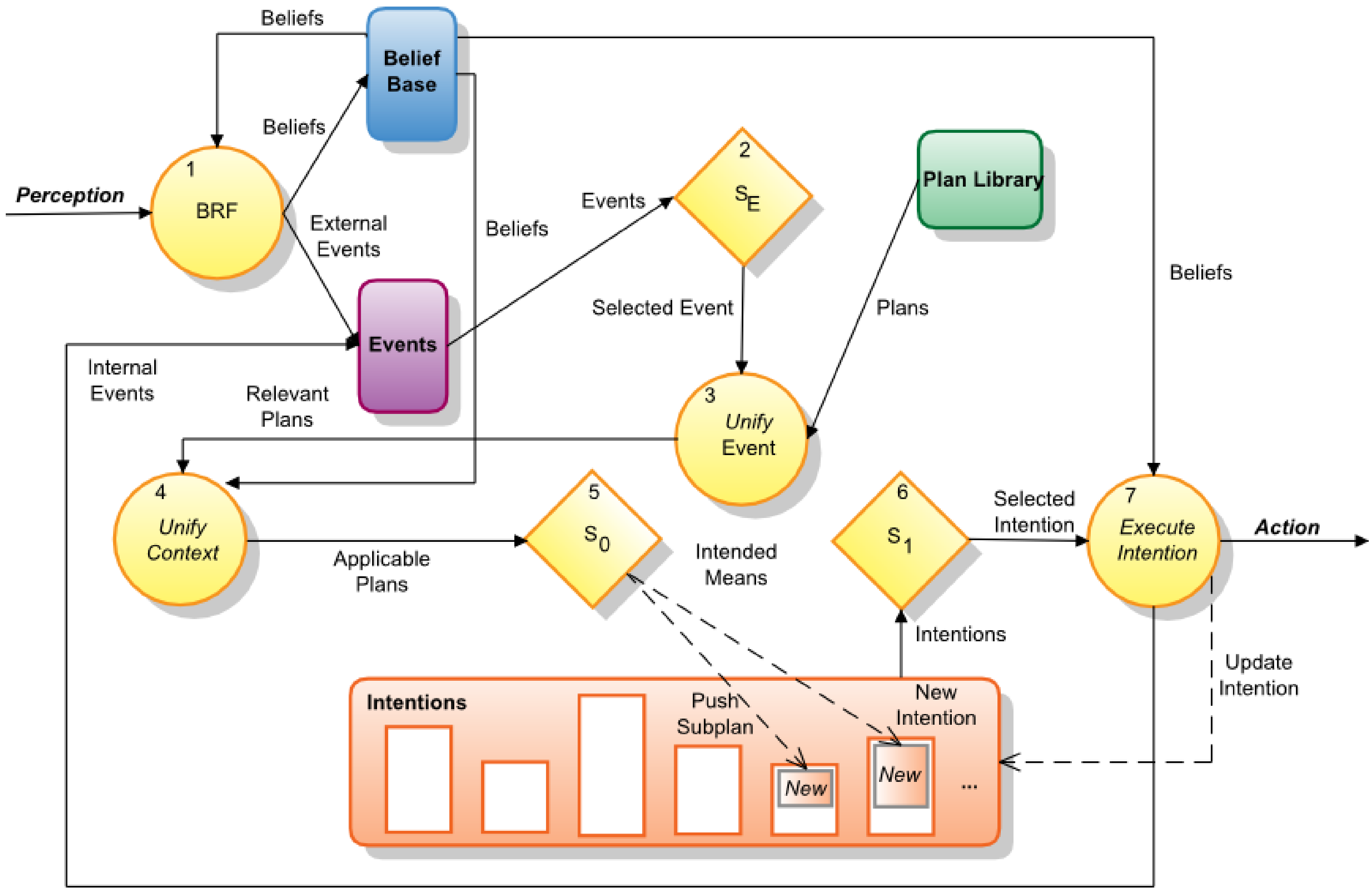
Abstract interpreter

- The state of a BDI agent in any given moment is (B, D, I)
  - current beliefs, desires, intentions

```
do
    // generate new possibilities
  options ← option-generator ( events, B, D, I )

    // select the best opportunities to perform
  selected-options ← deliberate( options, B, D, I )

    // adopt a selected opportunity as a subintention, or execute its actions
  I ← I ∪ selected-options[non-atomic]
  execute( selected-options[atomic] )

  get-new-external-events( )

  drop-successful-goals( B, D, I )
  drop-impossible-goals( B, D, I )

until quit
```

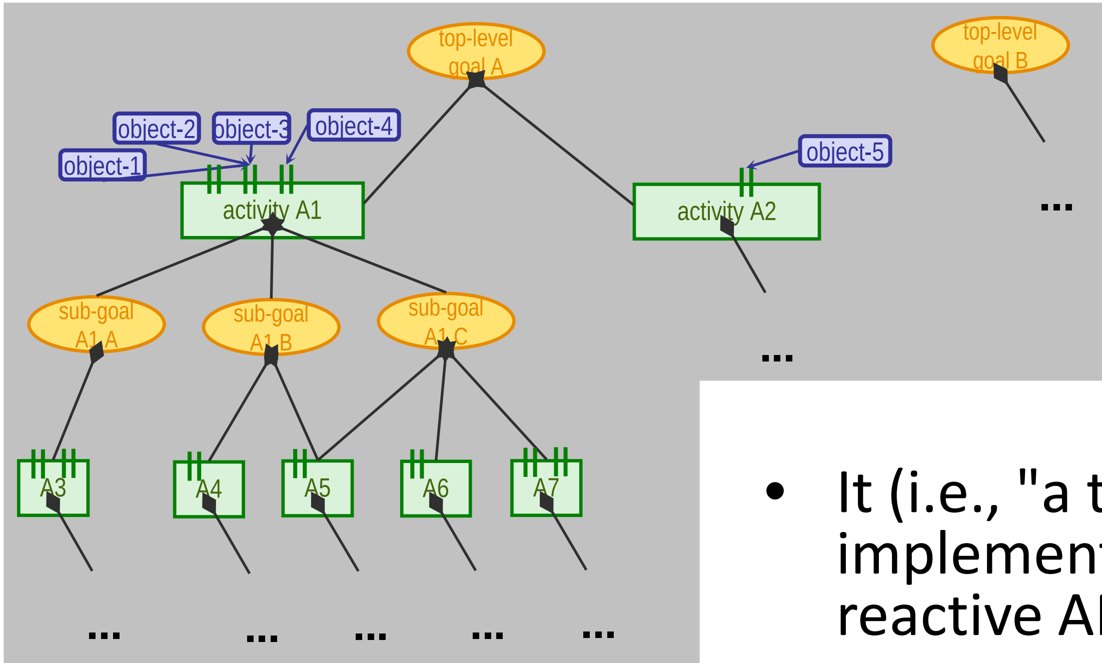
[Sing et al., 1999]

Abstract interpreter



BDI Interpreter – notes

- Typically operates with prescripted plans and an intentional stack
- Plans are stored structures that determines how to achieve an intention
  - preconditions: a body of the plan is believed to be an option whenever its invocation condition / precondition are satisfied
  - atomic actions
  - generation of a new goal that can be adopted as a subintention
  - means-ends are not performed typically
- Intentional stack holds all adopted intentions / subintentions
- Deliberation
  - with respect to the time-constrains
  - random, priorities or meta-level reasoning



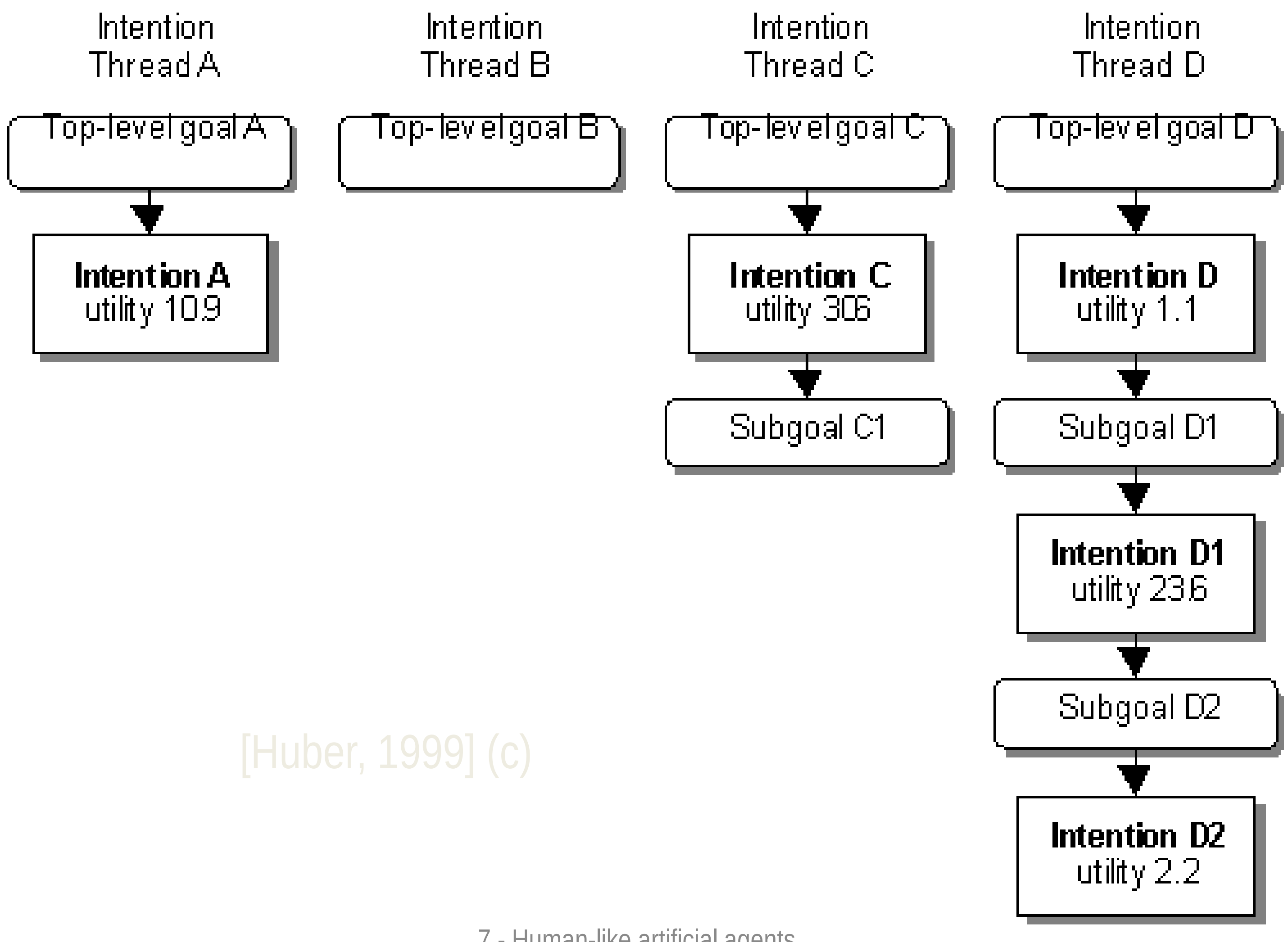
BDI Interpreter - notes

- It (i.e., "a typical BDI implementaion") resembles reactive AND-OR trees
- It is actually a robust reactive architecture
  - except of deliberation
- It operates only with present-directed intentions

- Jack, JAM, Jason

Is the creature able to answer the question what it is going to do this afternoon?

Jason / JAM intentional stack



JAM memory example

```
FACTS:
   FACT robot_status "Ok";
   FACT partner_status "Ok";
   FACT robot_initialized "False";
   FACT robot_localized "False";
   FACT robot_registered "False";
   FACT robot_position 10000 10000 0;
   FACT robot_location "Unknown";
   FACT self "CARMEL";
   FACT partner "BORIS";
   FACT object_found "False";
   FACT object_delivered "False";
   FACT communication_status "Ok";
   FACT plan_empty "False";
   FACT destination "Room4";
   FACT next_room "Room3";
   FACT next_node "Node12";
```

[Huber, 1999]

JAM plan example

[Huber, 1999]

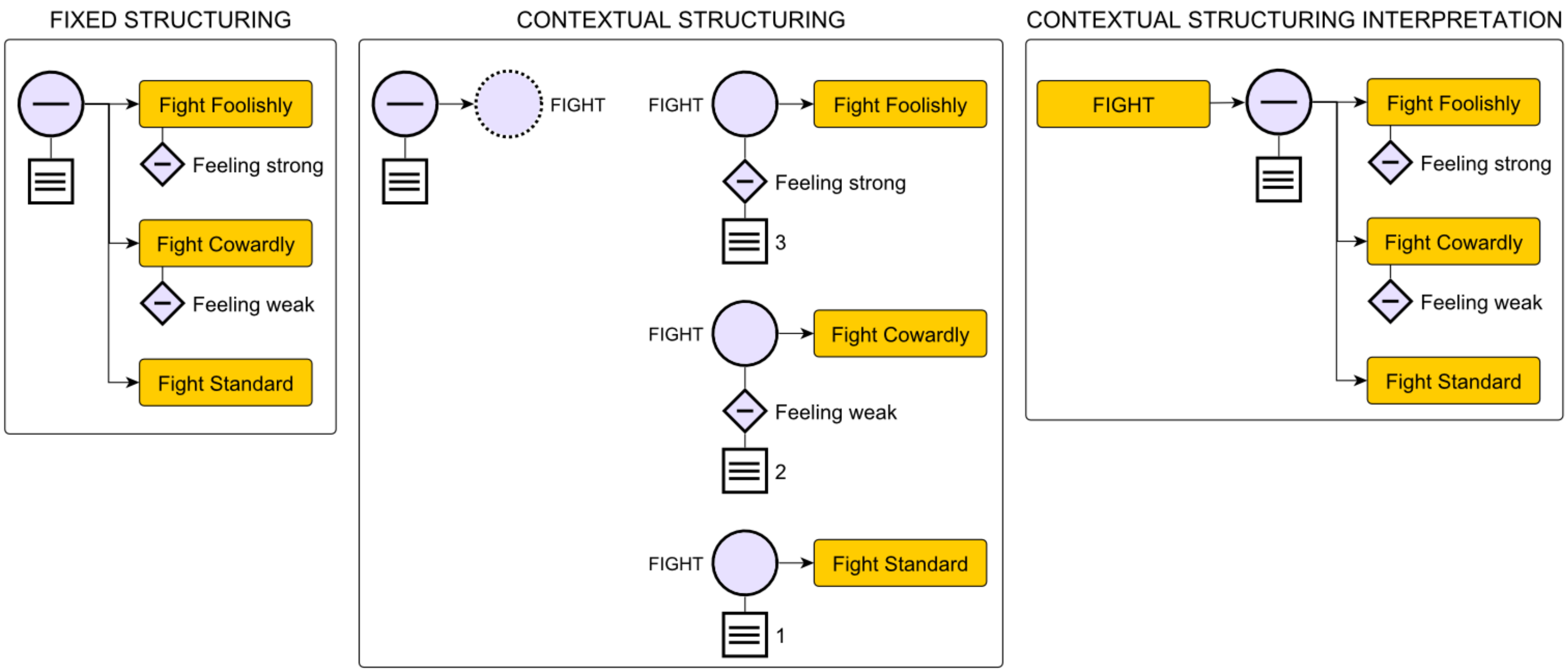
```
Plan: {
NAME:
        "Example plan"
DOCUMENTATION:
        "This is a nonsensical plan that shows all of the possible actions"
GOAL:
        ACHIEVE plan_example $distance;
PRECONDITION: (< $distance 50);
CONTEXT:
        RETRIEVE task_complete $STATUS;
        (== $STATUS “False”);
BODY:
        QUERY determine_task $task;
        FACT problem_solved $task $solved;
        OR
        {
            TEST (== $solved "YES");
            WAIT user_notified;
            RETRACT working_on_problem "True";
        }
        {
            TEST (== $solved "NO");
            ACHIEVE problem_decomposed;
       }
        ASSIGN $result (* 3 5);
        };
        UPDATE (task_complete) (task_complete "True");
FAILURE:
        UPDATE (plan_example_failed) (plan_example_failed "True");
        EXECUTE print "Example failed.  Bailing out"
ATTRIBUTES: "test 1 cpu-use 3.0";
EFFECTS:
        UPDATE (task_complete) (task_complete “True”);
•   }
```

Jason plan example

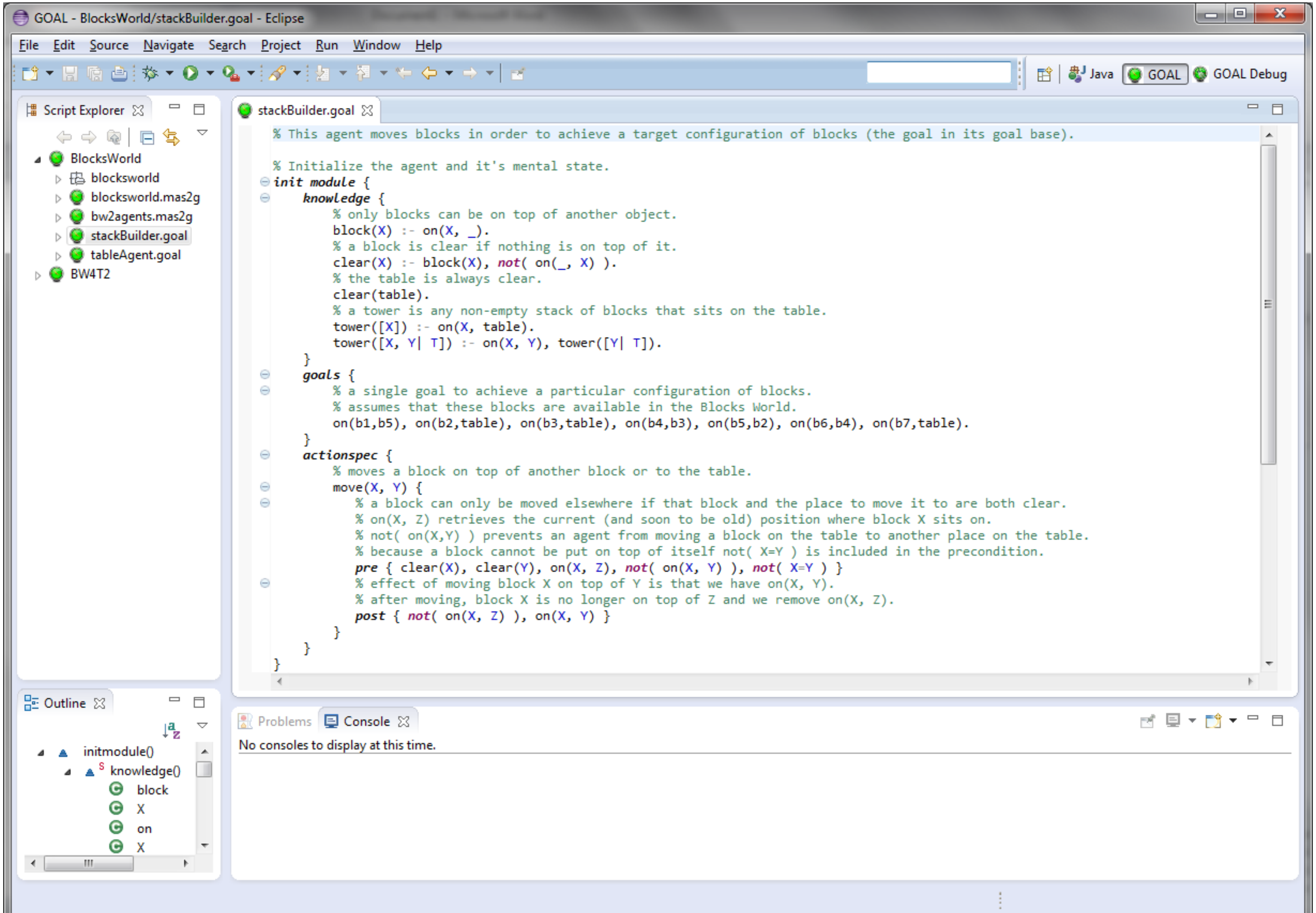
```
// in case I am in a dirty location
+dirty: true <- suck.

// in case I am in a clean location
+clean: pos(l) <- right.
+clean: pos(r) <- left.
```

What is actually the most interesting is “contextual plan invocation”.

=> Interesting "node type"



GOAL – Blocks world



GOAL – Blocks world

```
event module{
  program{
      forall bel(percept(on(X,Y)), on(X,Z), not(Y=Z)) do insert(on(X,Y), not(on(X,Z))).
  }
}
```

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

End.

References

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