Controlling Intelligent Agents in Virtual World

The OpenCog Embodiment Component

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Outline

What is Opencog Embodiment Component?

Embodiment component (formerly called PetBrain)

Interface OpenCog for virtual world agents or robots

Embodiment Component Function

Goals:

- Environment where to teach and test OpenCog

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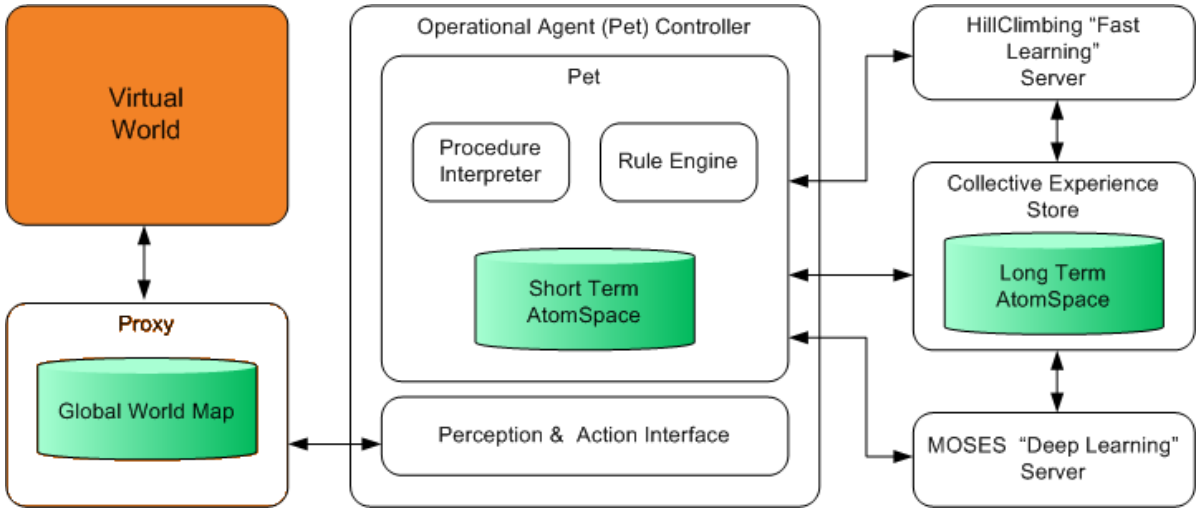
- Environment where to teach and test OpenCog
- Virtual World $\Rightarrow$ Easier than real world
- But robot interface as well (in development)

Embodiment Component Overview



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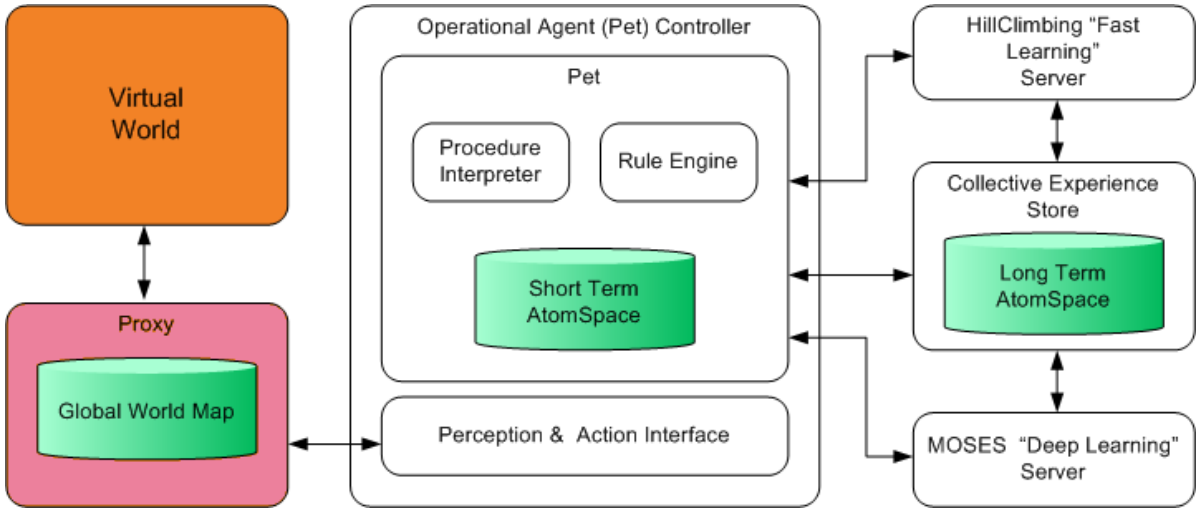

1. Proxy, interface between the virtual world and Embodiment

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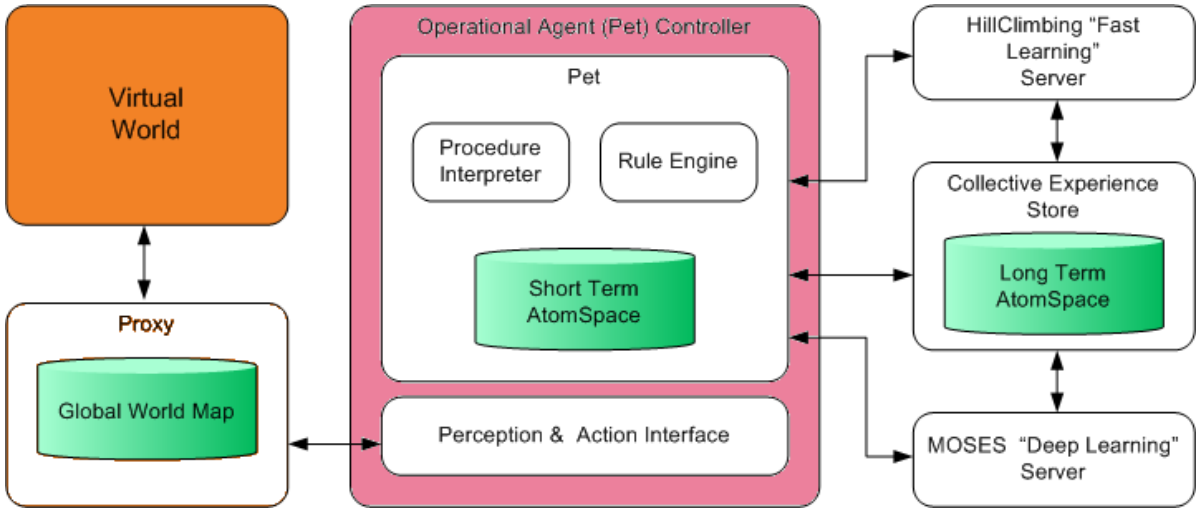

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2. Operational Agent (Pet) Controller (OPC), reactive brain

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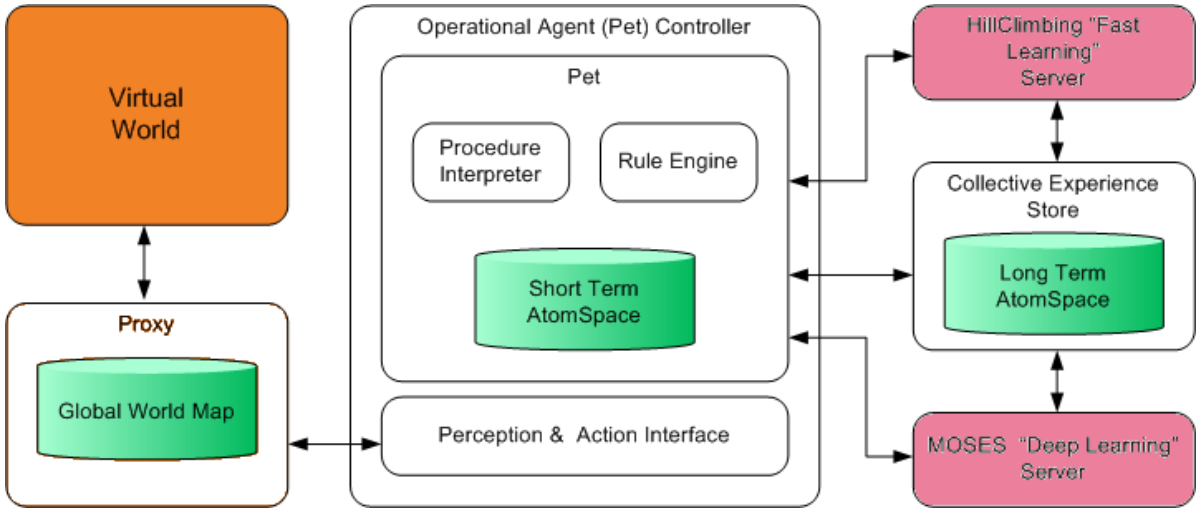

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3. Learning Server (LS), imitation learning for now

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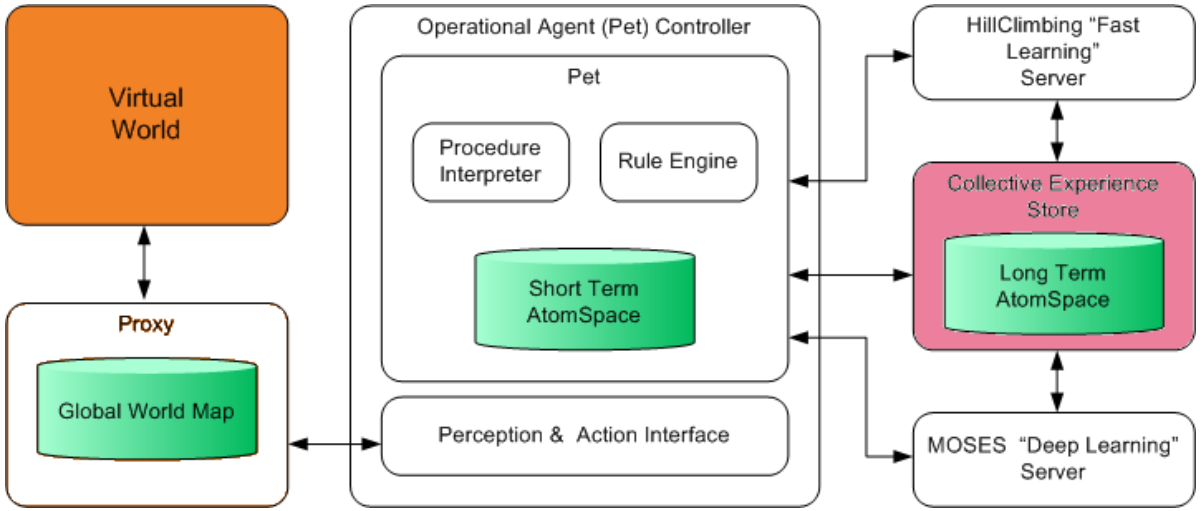

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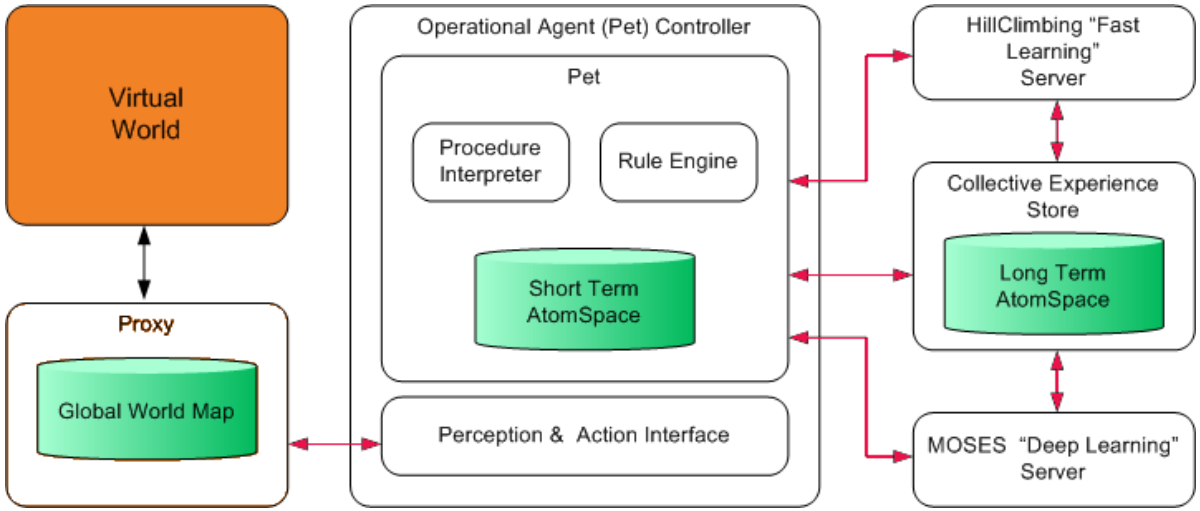

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2. Operational Agent (Pet) Controller (OPC), reactive brain
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4. Collective Experience Store (CES) (not implemented yet)
5. Router: communication with Sockets (distributed or not)

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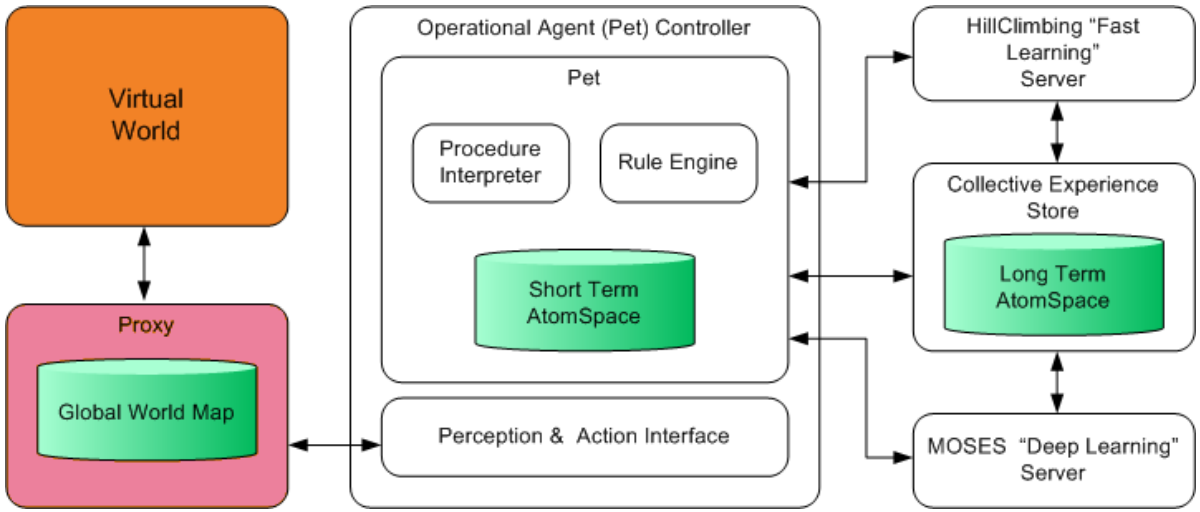
Embodiment Proxy



Proxy main function

Abstract away all details of interacting with a Virtual World

For the moment Embodiment Proxy for

- Multiverse (implemented)

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- Multiverse (implemented)

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- Nao Robot (in development)

Embodiment Proxy sub-functions

Proxy handles:

- Input stream of perceptual data

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  - Shared GWM for all agents
    $\Rightarrow$ reduce message traffic agents $\leftrightarrow$ virtual world

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- Input stream of perceptual data
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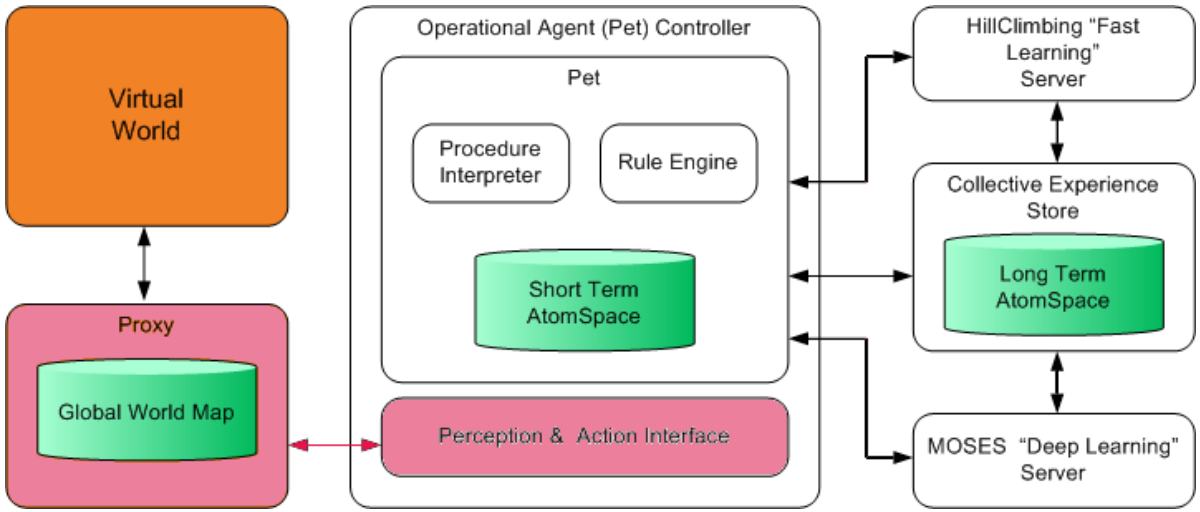
- Maintaining a Global World Map (GWM)
  - Shared GWM for all agents
    $\Rightarrow$ reduce message traffic agents $\leftrightarrow$ virtual world
- Commands from a human avatar
  - messages to the agents, order, queries
  - meta-commands (load agent, etc)

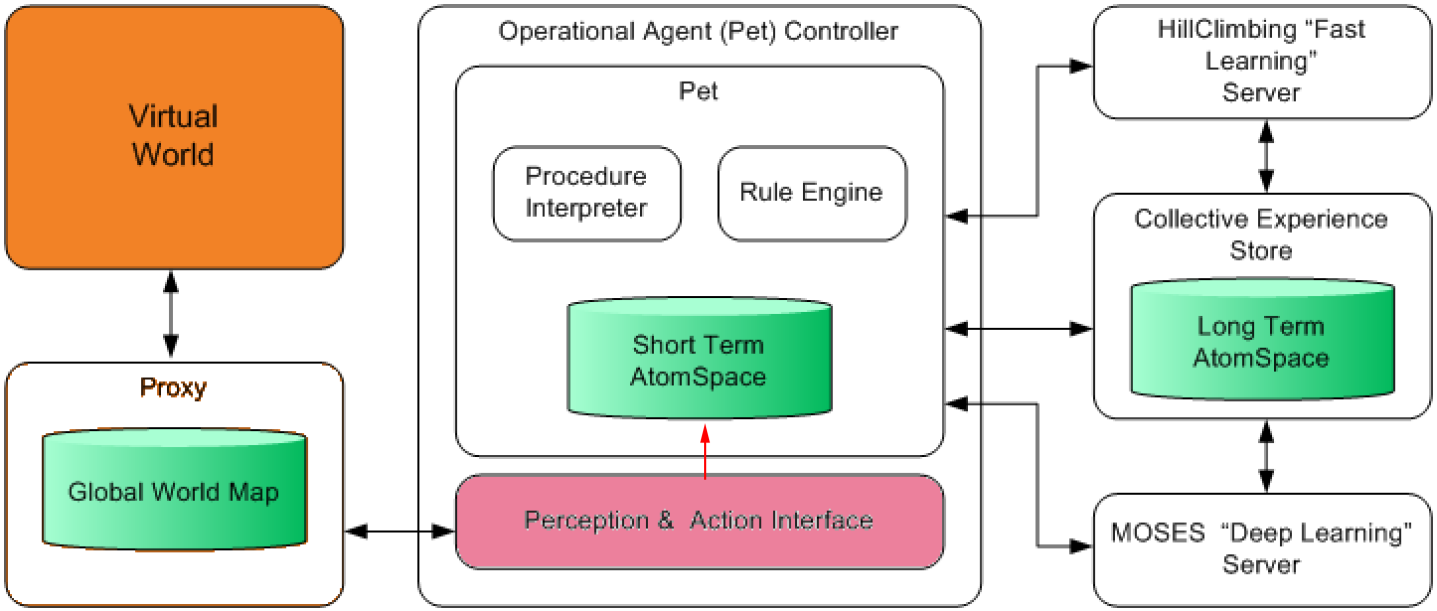
Embodiment Proxy ↔ PAI



Proxy communicates with the OPC by the intermediate of the Perception Action Interface.

Outline

Perception Action Interface Function



- Convert Perceptions coming from the Proxy into atoms in the agent's atomSpace

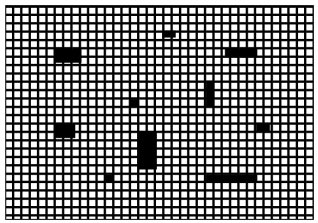
Perception Action Interface, perception → atoms

$\Rightarrow$ Proxy $\Rightarrow$ PAI $\Rightarrow$

```
AtTimeLink
    TimeNode: "15:32:24.182"
    EvaluationLink
        PredicateNode: "actionDone"
        ListLink
            AvatarNode: "owner"
            Node: "grab"
            ListLink
                ObjectNode: "ball_id"
```

1. Pet watches the avatar grabbing a ball
2. Proxy sends perception to PAI
3. PAI writes the perception into the Pet's atomSpace

Embodiment AtomSpace Extensions, Space and Time servers



- Space Server: SpaceMap wrapped in atom, associative container for fast retreival.
  - SpaceMap:
    - 2D Grid
    - Objects inside
    - Spacial functions and predicates, `distance`, `near`, ...

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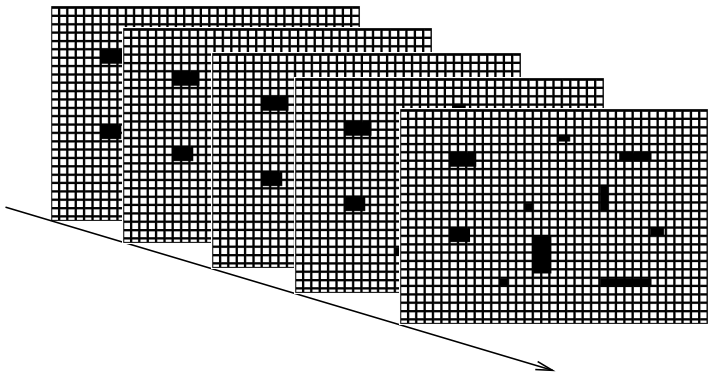
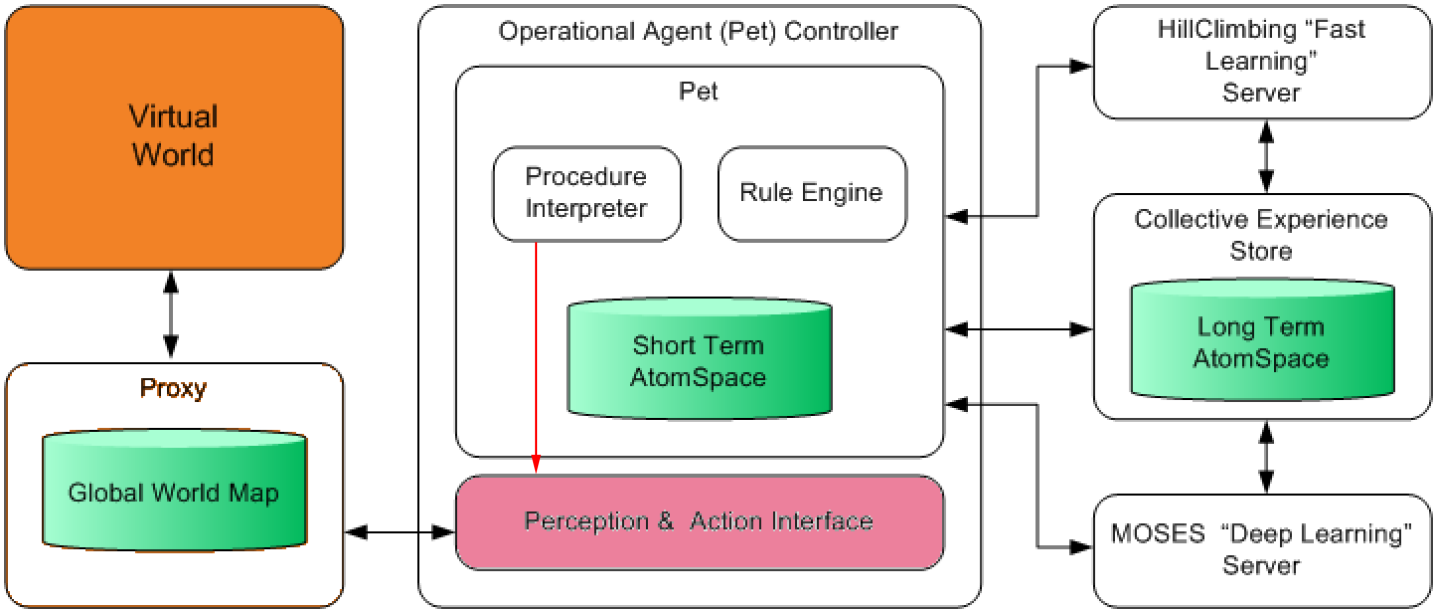


- Space Server: SpaceMap wrapped in atom, associative container for fast retreival.
  - SpaceMap:
    - 2D Grid
    - Objects inside
    - Spacial functions and predicates, `distance`, `near`, ...
- Time Server: indexing timestamped atoms for fast retrieval

Episodic memory

Combo interpreter actions to action plan



- Convert actions coming from the Combo interpreter into action plans (sequence of actions) to the Proxy

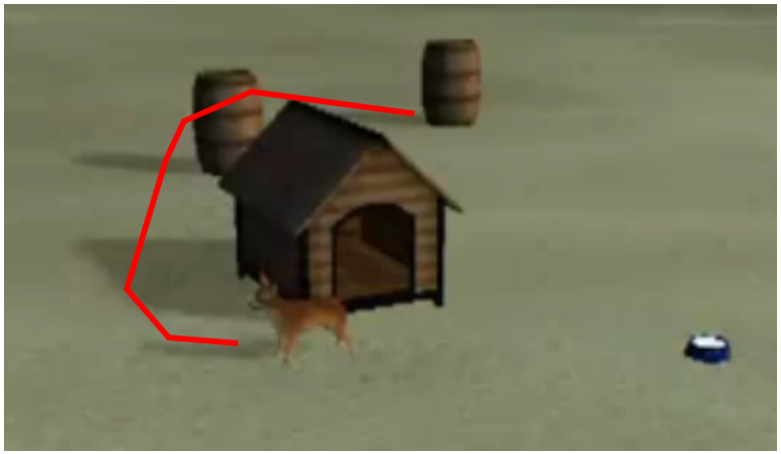
Combo interpreter actions to action plan

```
goto_obj(barrel2)
```

PAI⇓

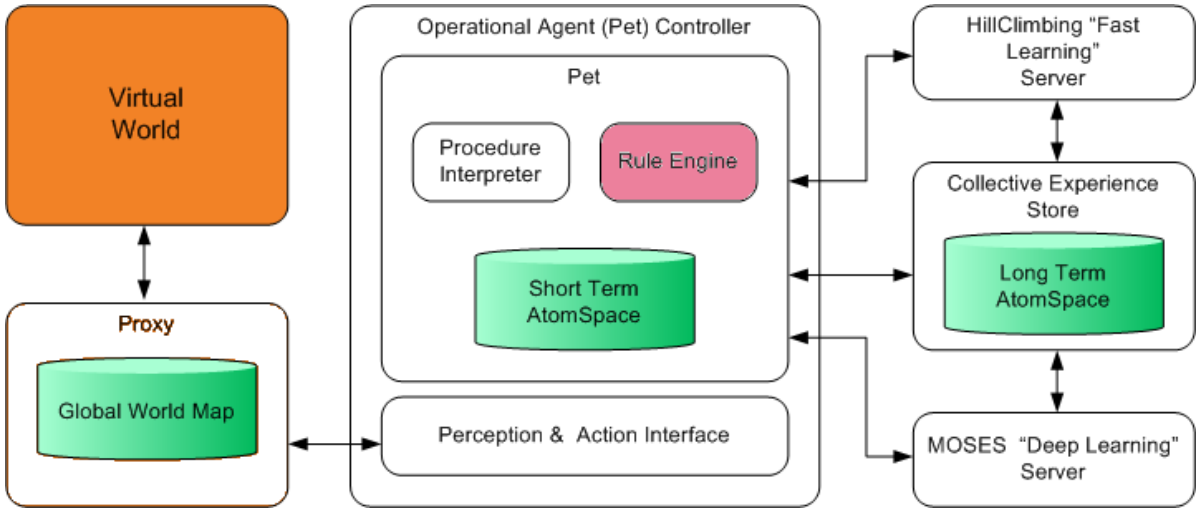
```
{walk(546, 453), walk(547, 451), ...}
```

Proxy⇓



1. Combo interpreter + PAI create action plan
2. PAI sends it to Proxy, which sends it to virtual world

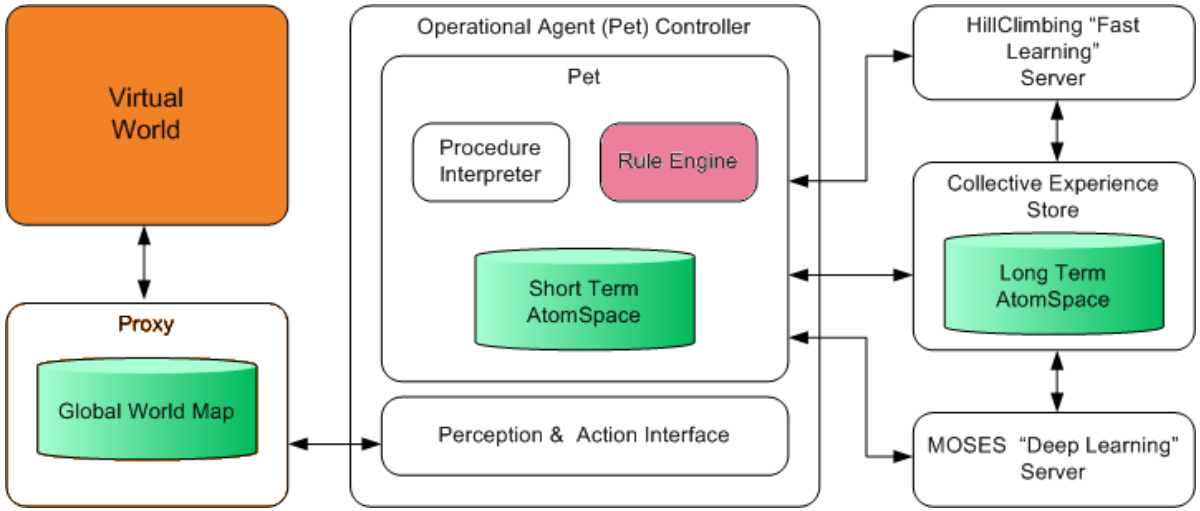
Rule Engine



Rule Engine Function

- Update agent's internal state. Example pet:
  - agent's feeling (hunger, happiness, . . .)
  - agent's relation (familiar_with, friend_of, . . .)

Rule Engine



Rule Engine Function

- Update agent's internal state. Example pet:
  - agent's feeling (hunger, happiness, . . .)
  - agent's relation (familiar_with, friend_of, . . .)
- Select next action to satisfy its goals. Example pet:
  - Fulfill needs (hunger, thirst, curiosity, etc)

Rule Engine, how it works?

For the moment it is really crude!

Rule Engine: Main loop

Evaluates a set of hard-coded rules to update state and choose next actions.

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   `has_eaten(self)` ⇒ `happiness<0.8>`

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   `has_eaten(self)` $\Rightarrow$ `happiness<0.8>`
2. Relation rule
   `has_licked(self X)` $\Rightarrow$ `familiar_with(self X)<0.9>`
3. Schema rule
   `is_hungry(self)` $\overset{0.6}{\Rightarrow}$ `goto_find_food()`

Rule Engine, how it works?

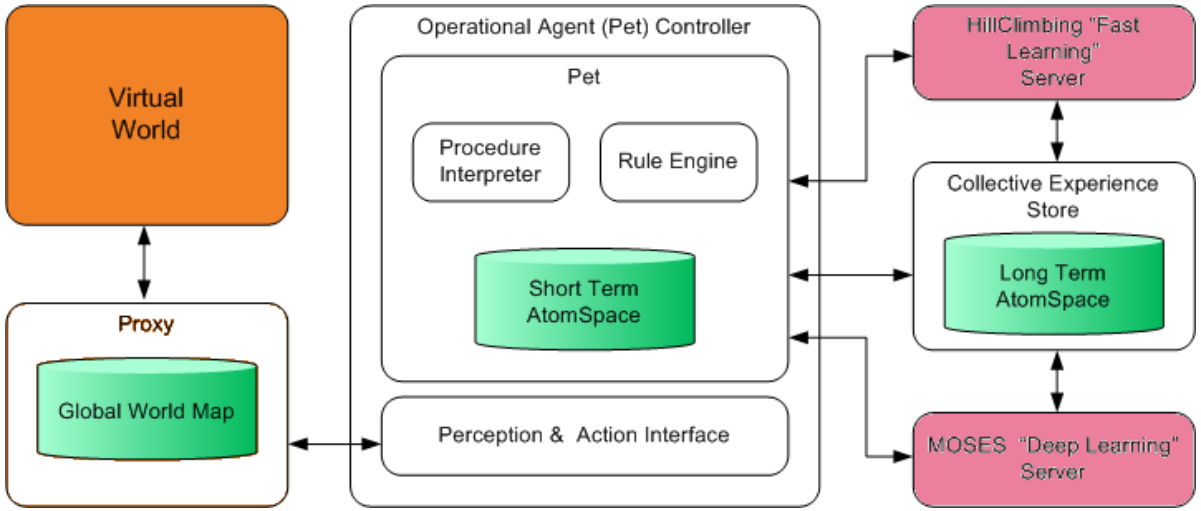
For the petBrain we have over 100 hard-coded rules!

- 21 feeling rules
- 10 relation rules
- 76 schema rules

+ rule to use tricks learned by imitation

Outline

Learning Server

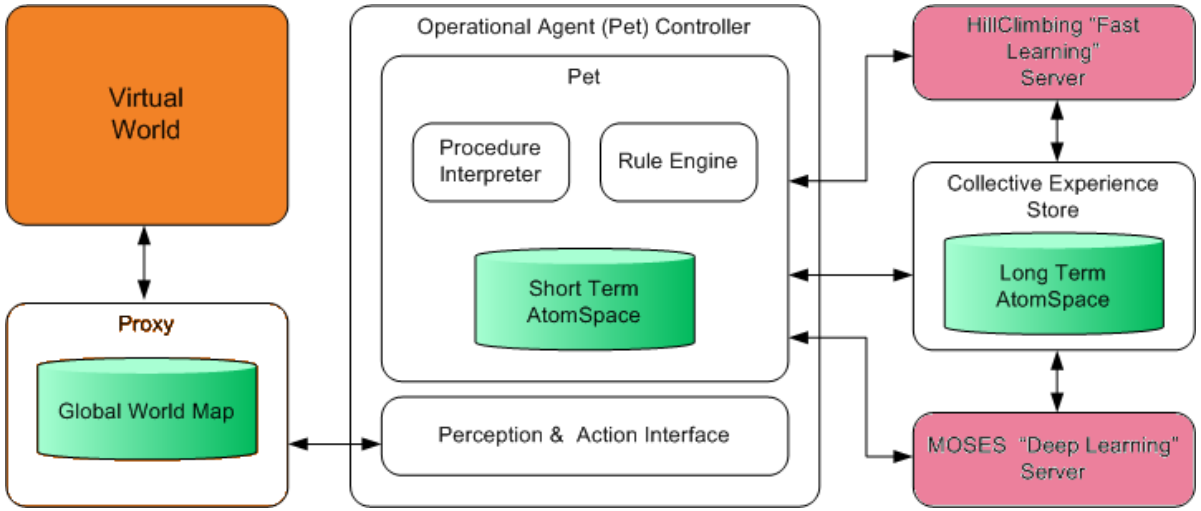


Lerning Server (LS) Function

Complex learning tasks (like imitation learning) run seperatly to not pertubate the agent's reactivity.

- Imitation Learning (Implemented)

Learning Server



Lerning Server (LS) Function

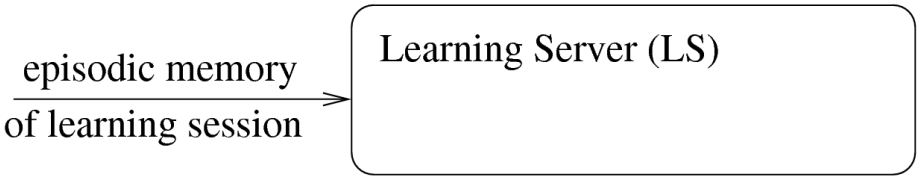
Complex learning tasks (like imitation learning) run seperatly to not pertubate the agent's reactivity.

- Imitation Learning (Implemented)
- Spontaneous Learning (not Implemented)

Imitation Learning

1. Pet's owner requests learning session and shows the trick

Imitation Learning



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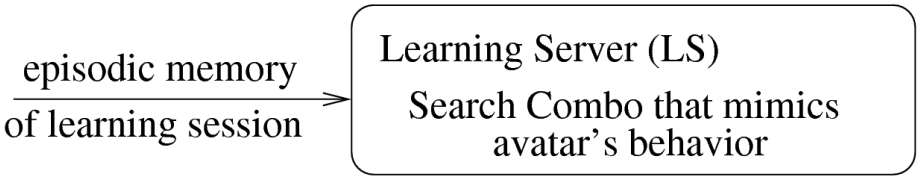
Imitation Learning



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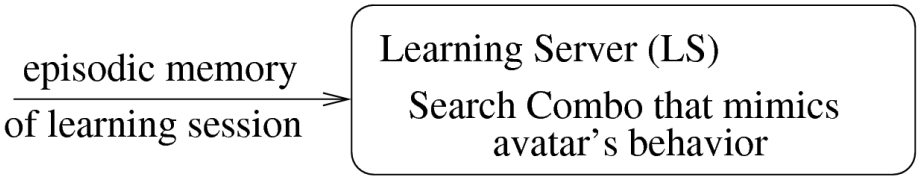

1. Pet's owner requests learning session and shows the trick
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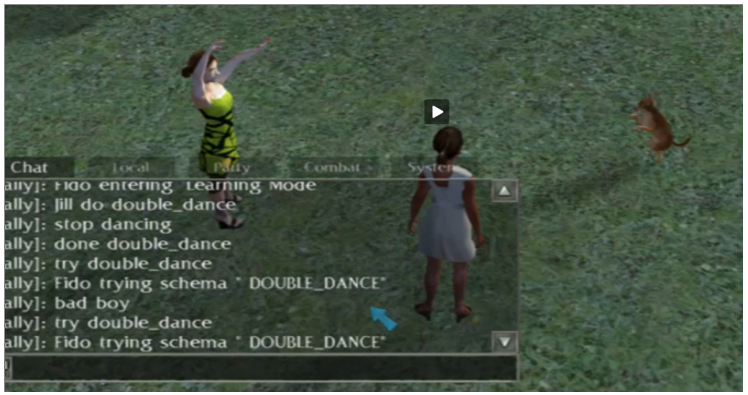
4. Each Combo candidate is run inside the imaginary world of that episodic memory, the result is compared with the avatar's behavior

Imitation Learning



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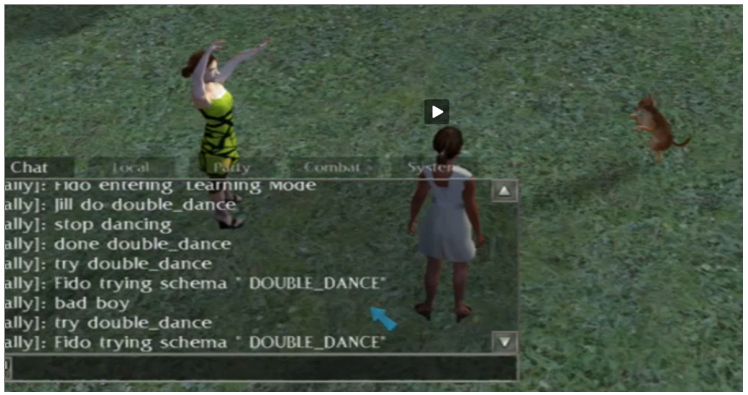
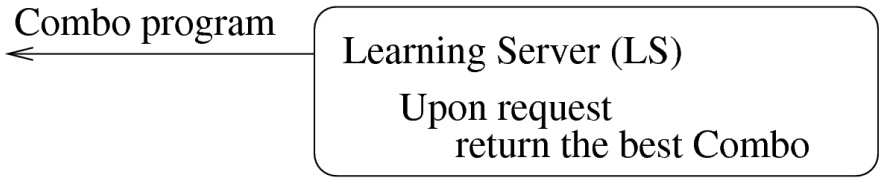
Imitation Learning





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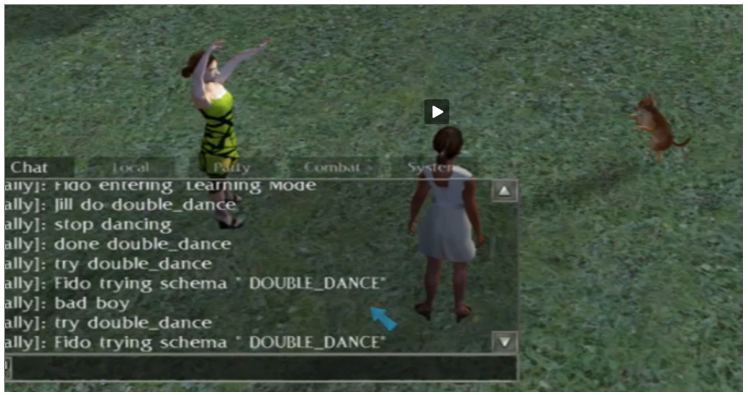
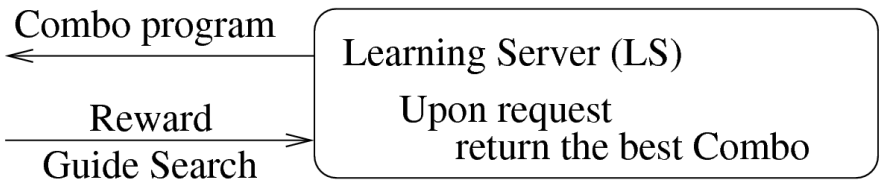
Imitation Learning





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3. Owner sends positive or negative reward to guide the search

Example of trick learning: Double dance

Dance in loop on cue

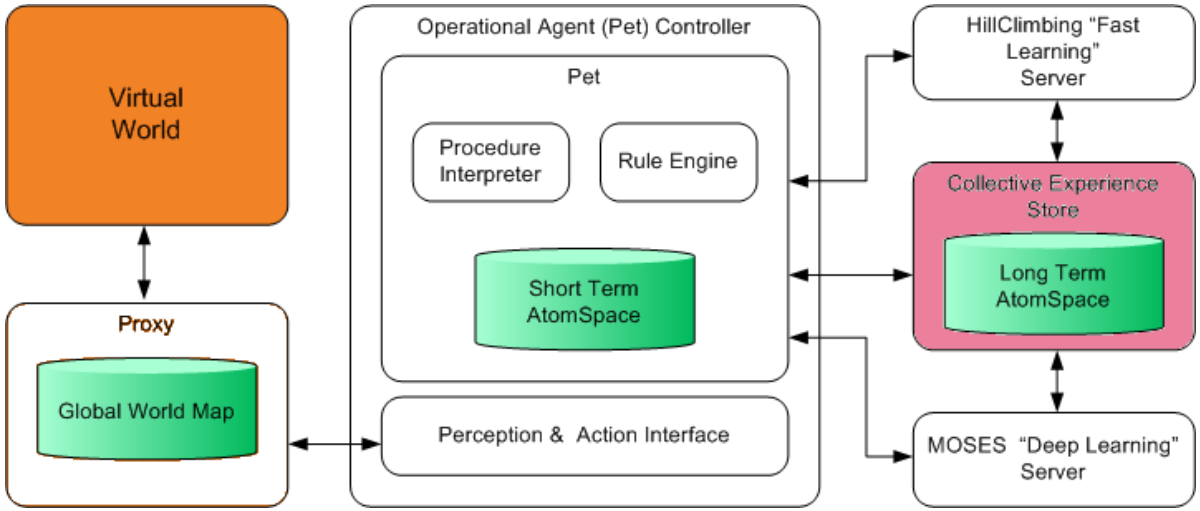
- Owner kicks left leg ⇒ tap dance
- Owner kicks right leg ⇒ lean rock dance

Combo to learn

```
boolean_while(not(says(owner "stop dancing"))
              action_if(last_action(owner "kickL")
                        tap_dance
                        lean_rock_dance))
```

Outline

Collective Experience Store (not implemented yet)



Collective Consciousness

All agents can put in common their knowledge. When one gets smarter everybody takes advantage of it.

Outline

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Conclusion

What has been done:

- Hard-coded behaviors
- Imitation learning
- but no spontaneous learning
- No language understanding yet (only commands)

Conclusion

What remains to be done:

- Spontaneous learning, concept creation, integrate Attention Allocation
- Transfer learning, Collective Experience Store
- Natural language processing and generation (in development)