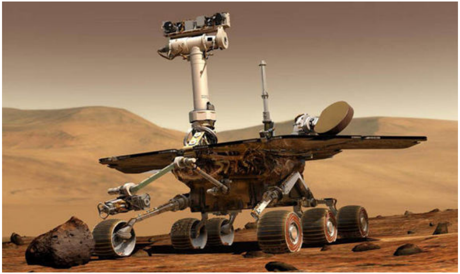
Nondeterministic Bigraphs and Their Use in Modelling Movement

Paulius Dilkas

School of Computing Science

2nd September 2018

Motivation



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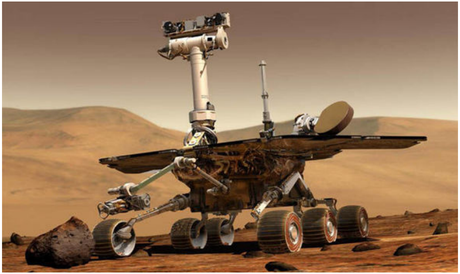

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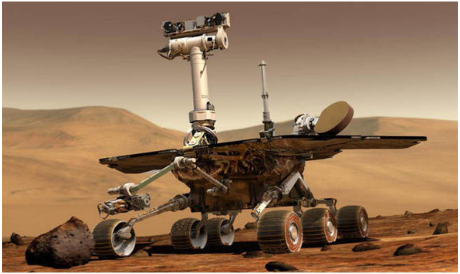

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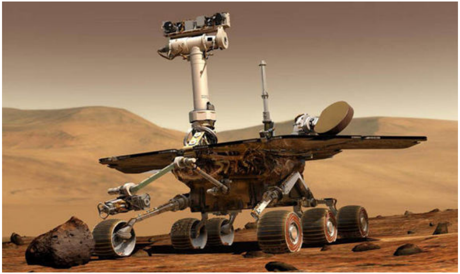
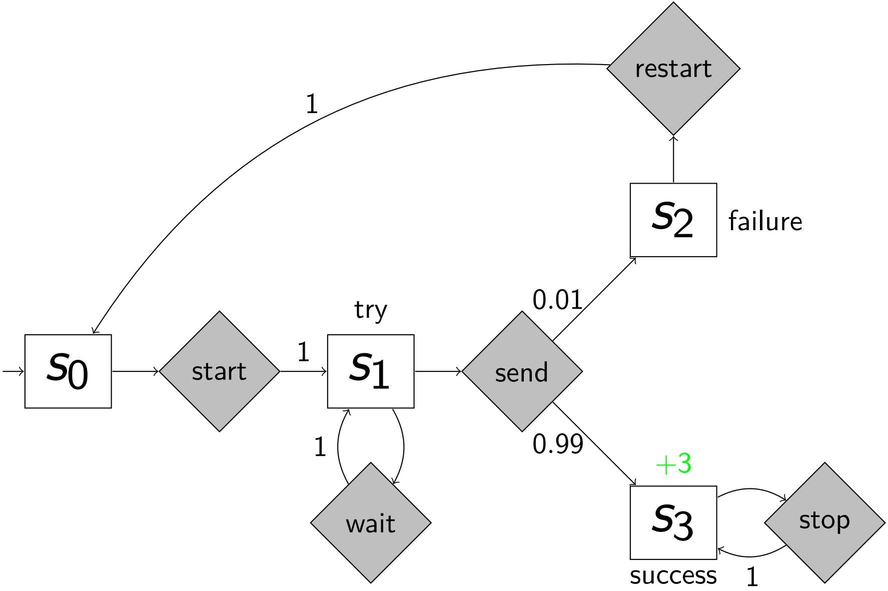


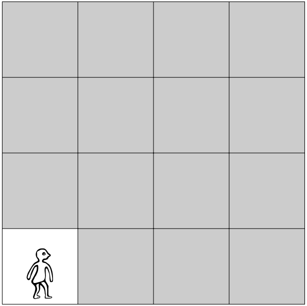
Markov Decision Process



Collecting Objects in a Grid

- Each cell is either visited or unvisited.
- When entering an unvisited cell, with probability p the agent receives an object.
- Once a set number of objects is collected, the agent heads home.

Collecting Objects in a Grid



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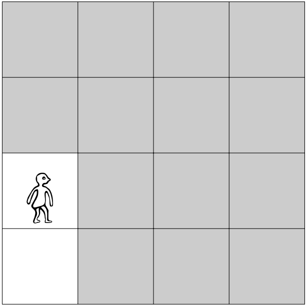

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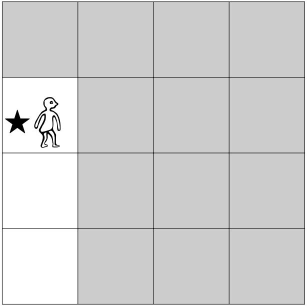

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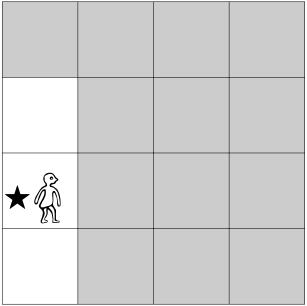

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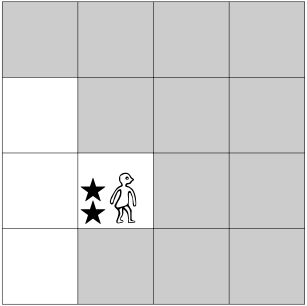

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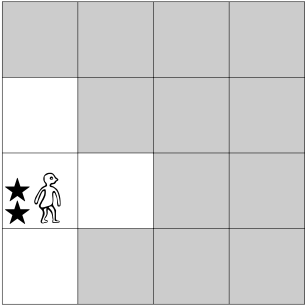

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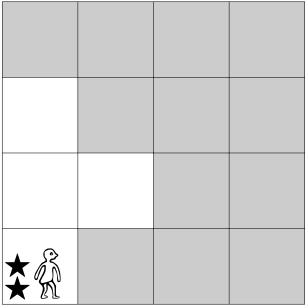

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  - `goal`: collected the required number of objects
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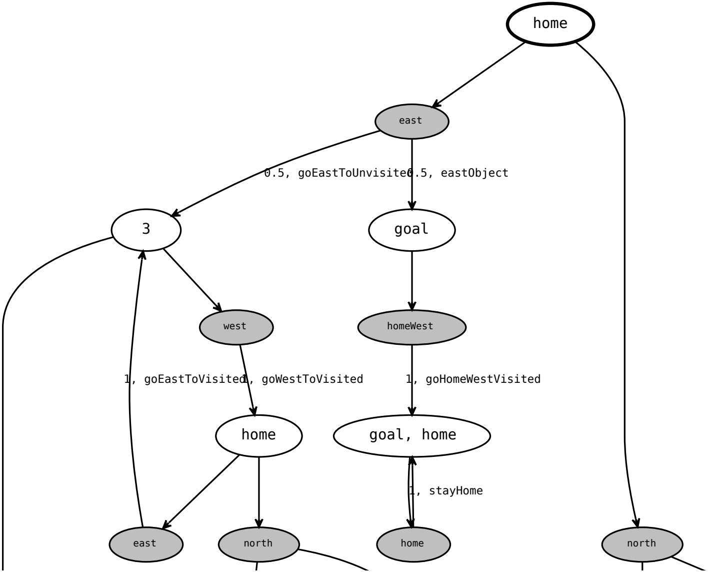
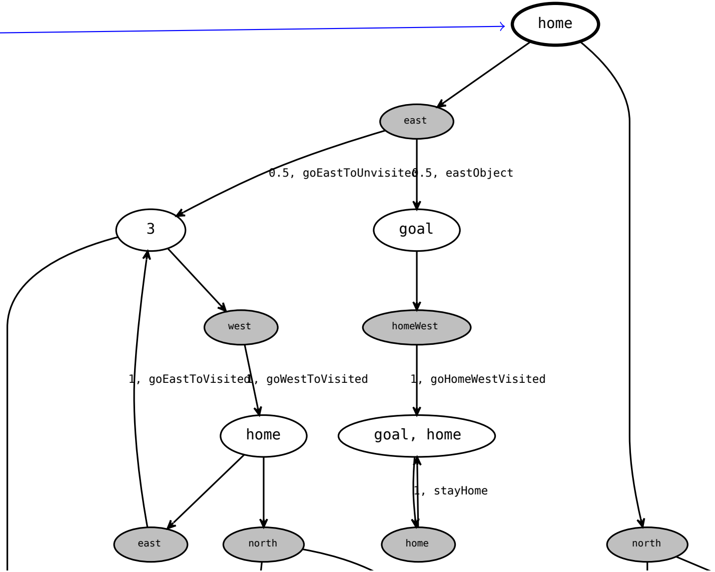
  - Priority 2: 3 rules for each direction
    - visited
    - unvisited
    - unvisited + object

Transition System



Transition System

- States



Transition System

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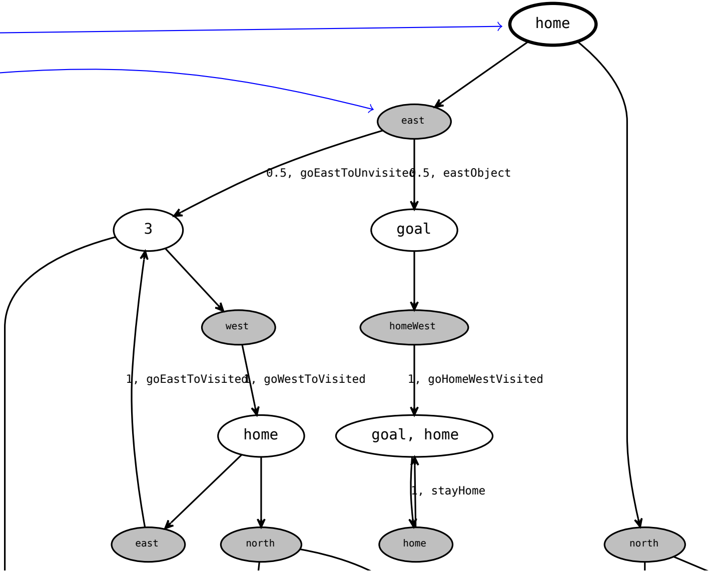
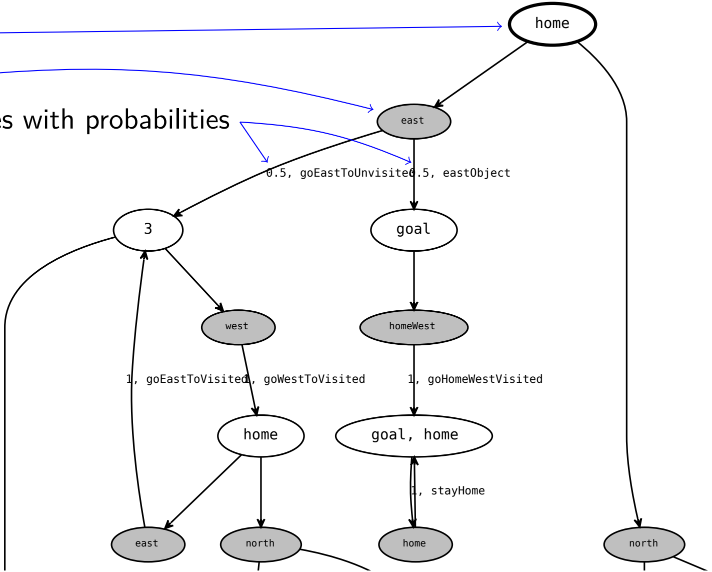
- Actions



Transition System

- States
- Actions
- Reaction rules with probabilities



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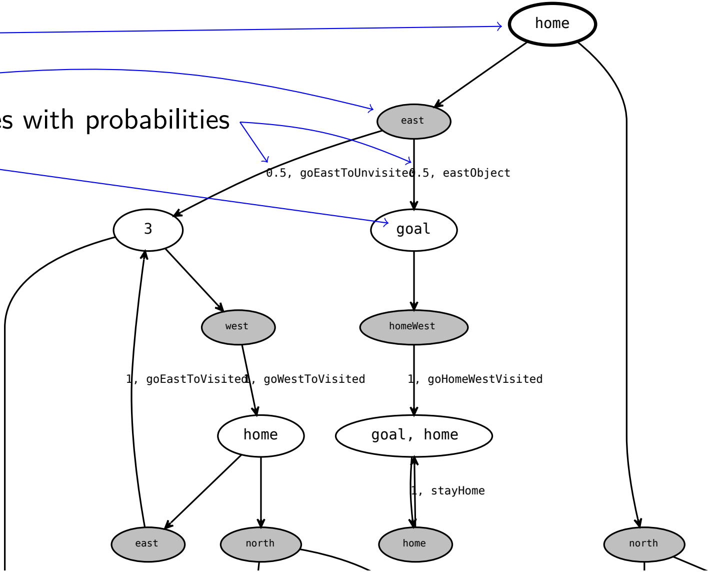

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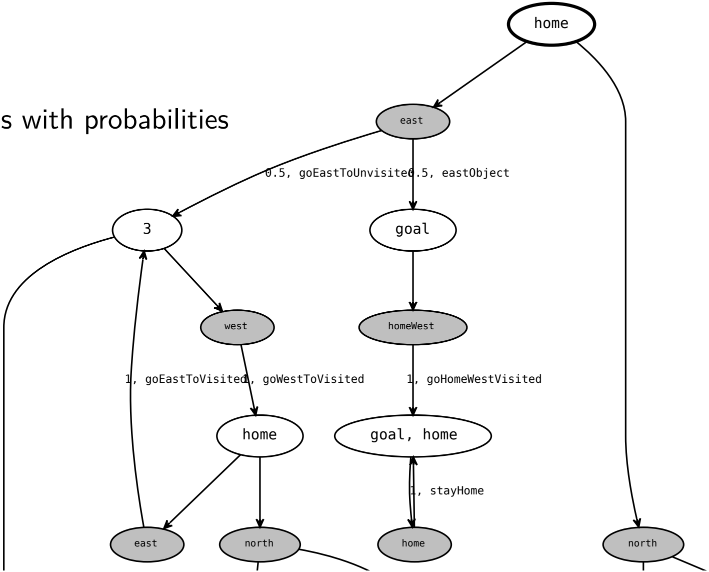

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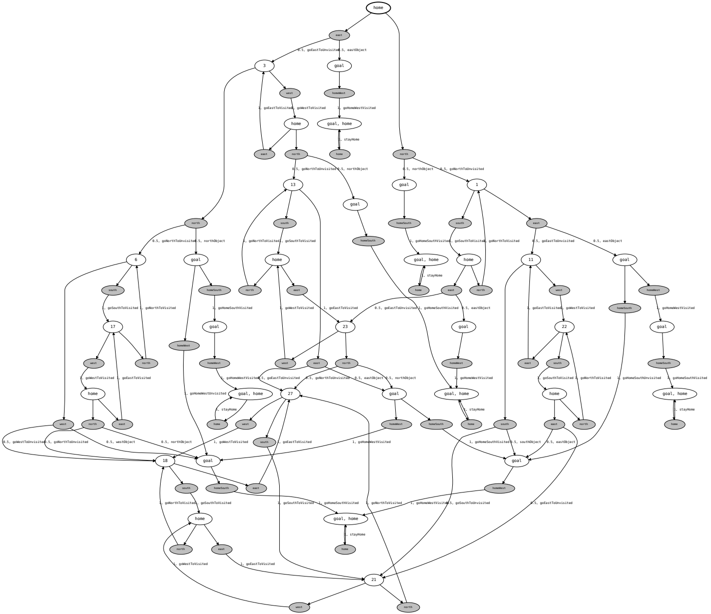

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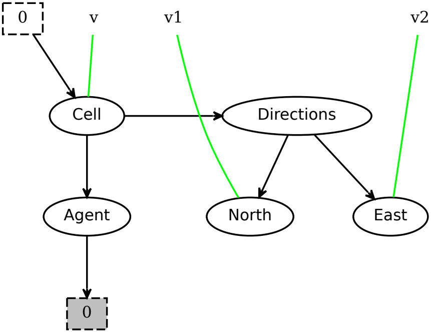
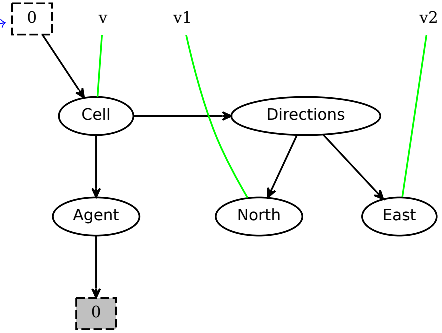
- Normalise probabilities per action
  - Caveat: one rule can sometimes be applied in multiple ways
  - In that case, each outcome is equally likely
- Either:
  - Breadth first search to generate the full transition system
  - Or select the next state randomly for a simulation

Bigraphs



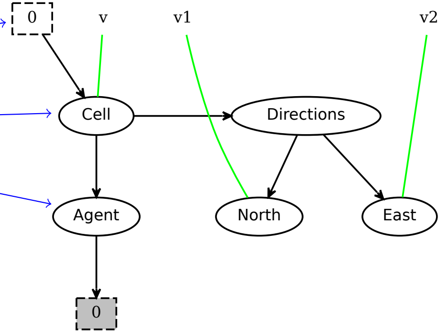
Bigraphs

- Region



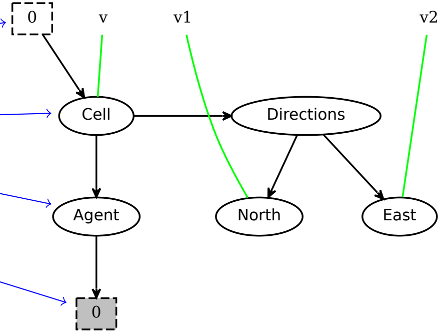
Bigraphs

- Region
- Nodes



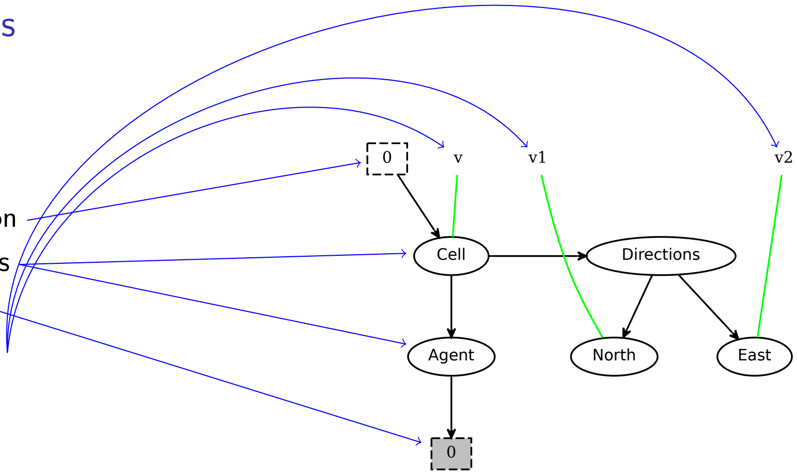
Bigraphs

- Region
- Nodes
- Site



Bigraphs

- Region
- Nodes
- Site
- Links



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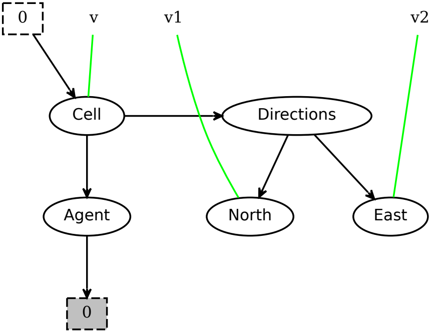
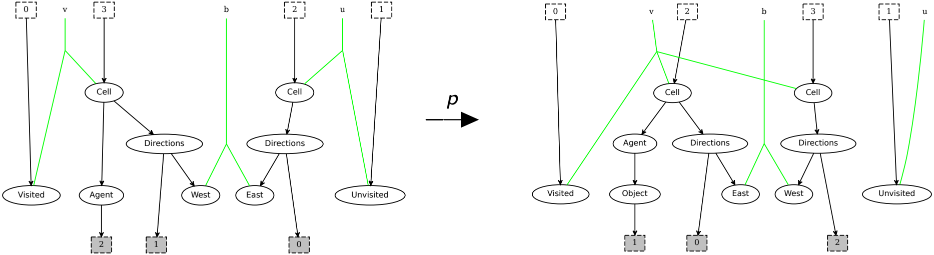


```
big home = Cell{v}.(Directions.(North{v1}
                              | East{v2})
                    | Agent);
```

Initial State

```
big initial = Visited{v}
           || Unvisited{u}
           # bottom left
           || Cell{v}.(Directions.(North{a}
                                 | East{b})
                     | Agent.1)
           # top left
           || Cell{u}.Directions.(East{c}
                                | South{a})
           # bottom right
           || Cell{u}.Directions.(North{d}
                                | West{b})
           # top right
           || Cell{u}.Directions.(West{c}
                                | South{d});
```

Reaction Rule: Go West and Collect an Object



A Tale of Schrödinger's Wall...

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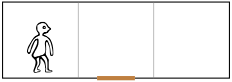

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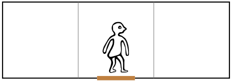

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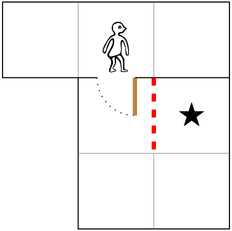

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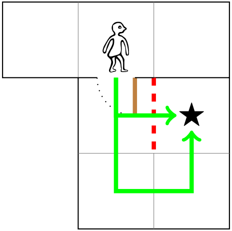

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  - Agent, Cell, Directions, Goal, Node
  - North, East, West, South
  - no Object, no Visited/Unvisited
- Reaction rules
  - Priority 1: generating the room (2 rules in 1 action)

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  - `Agent`, `Cell`, `Directions`, `Goal`, `Node`
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  - Priority 1: generating the room (2 rules in 1 action)
  - Priority 2: movement in 6 directions (including going in/out)
    - ⋆ each rule in a separate action

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  - `Agent`, `Cell`, `Directions`, `Goal`, `Node`
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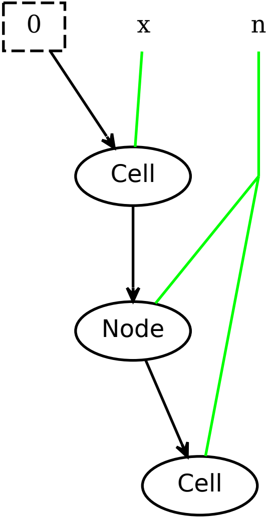
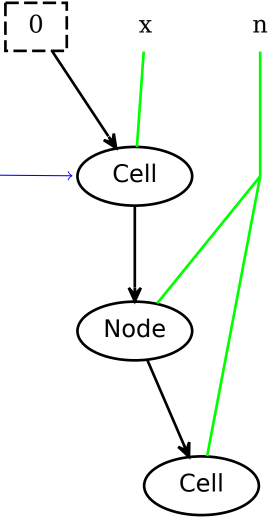
- Predicate
  - is `Agent` and `Goal` in the same cell?

The Main Idea



The Main Idea

- Outside the door



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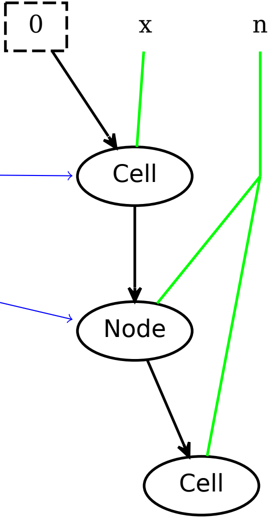
- Outside the door
- The room



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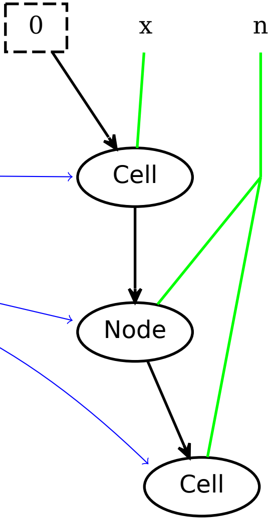
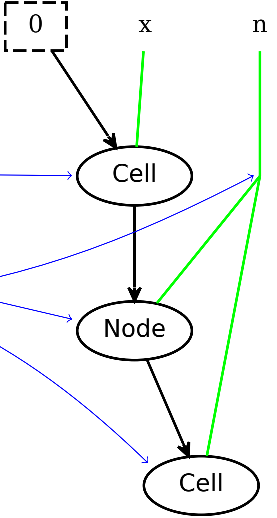
- Inside the door



The Main Idea

- Outside the door
- The room
- Inside the door
- Which cell is closest to the door?



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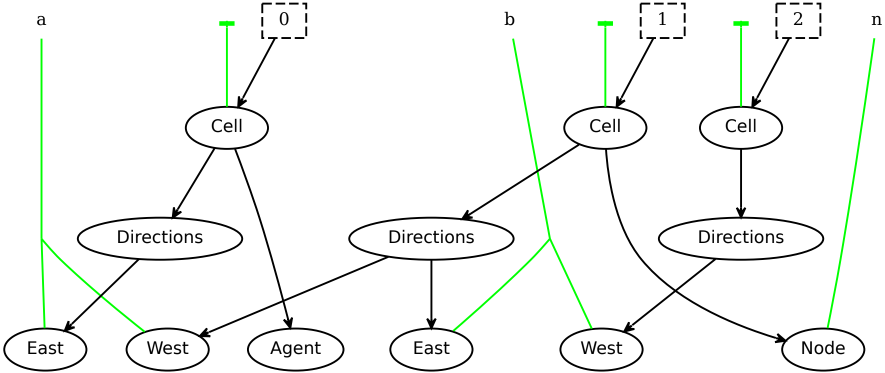
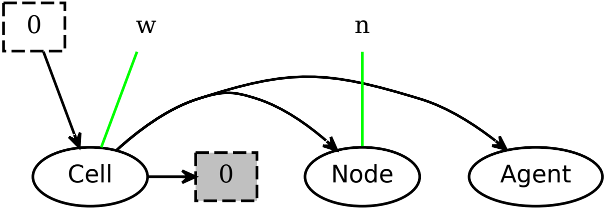


Opening the Door



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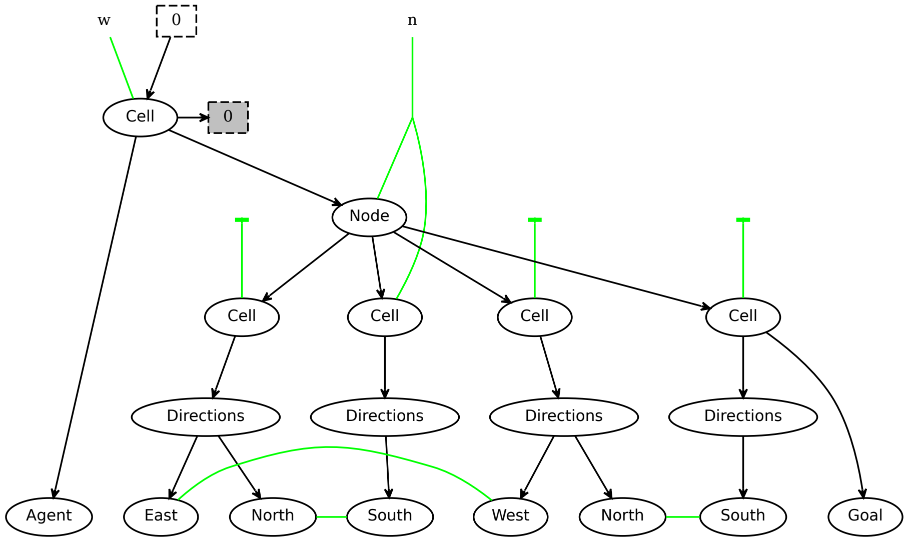
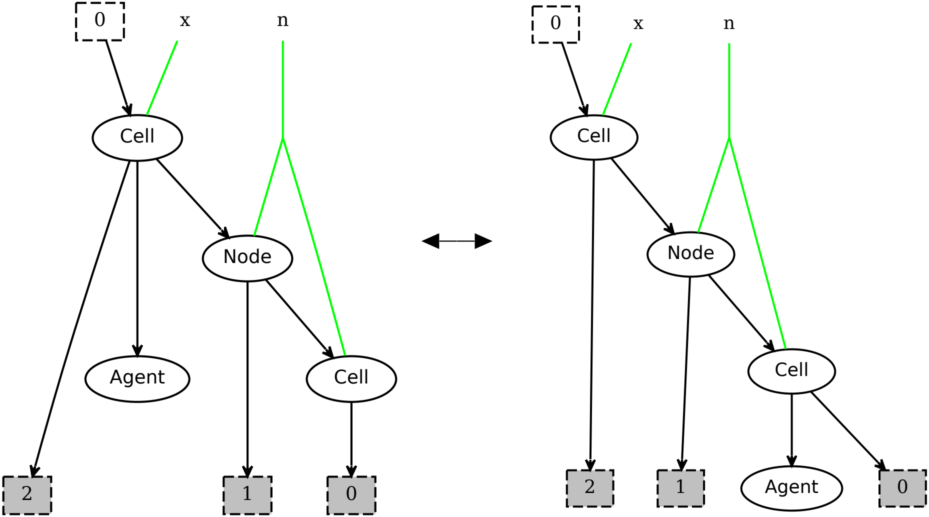


Entering/Leaving a Room



Entering/Leaving a Room

```
action goIn
  react goIn = Cell{x}.(Agent | Node{n}.(Cell{n}
                                       | id)
                      | id)
               -[1.0]->
               Cell{x}.(Node{n}.(Cell{n}.(Agent
                                        | id)
                               | id)
                      | id);
end
```

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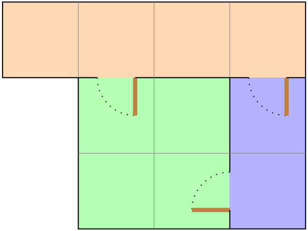

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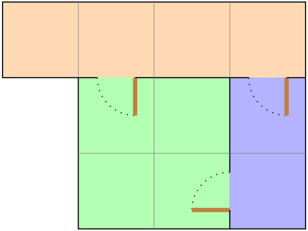

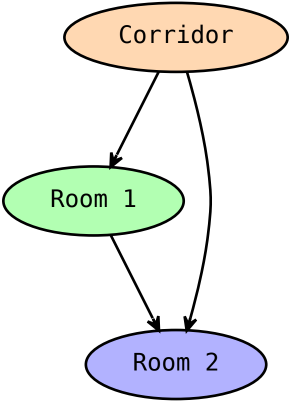

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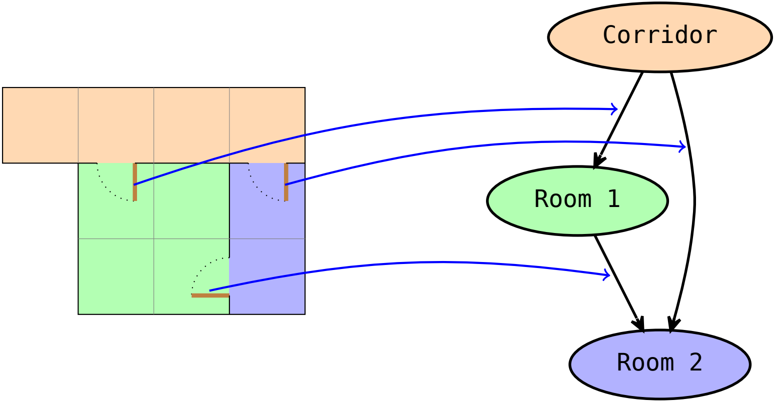

Conclusions

- + A direct visual representation of the modelled situation
- + Easy to represent complicated spatial structures and uncertainty about them
- + Succinct and easy to modify
- – Some simple ideas are impossible or hard to implement
- – Not every aspect of a model can be exported for quantitative analysis
- More work to be done on probabilistic space