UNIVERSITÀ DEGLI STUDI DI TRENTO

DIPARTIMENTO DI INGEGNERIA e SCIENZA DELL'INFORMAZIONE

Master in Artificial Intelligence Systems

Autonomous Software Agents
Final Project

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1 Introduction

The house is spread over two floors. The two parts of the house are connected by stairs placed in the middle. Each room of the house is connected to the other rooms by a door. Each room of the house has at least one window, except for the wine cellar, also each room is equipped with lighting.

The house is equipped with several devices, each of which has a specific function. The devices can be controlled remotely and they consume utilities. Devices can be controlled directly by residents or through an intelligent agent that can redirect requests or schedule tasks.

There is a house agent that can control almost all the devices, moreover in the house there is a planning agent (the vacuum cleaner). The planning agent is important because it has to achieve his goal using the best plan. In particular, for this house the planning agents are two vacuum cleaners, one for the ground floor and one for the first floor. It is important to say that the vacuum cleaner of the first floor can not go on the ground floor, it is the same for the other vacuum cleaner.

2 House description and Blueprint

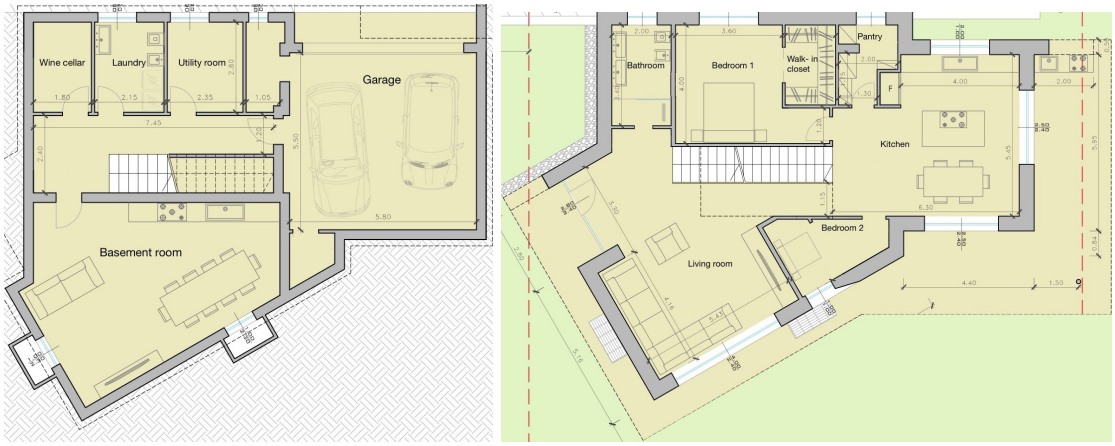


Figure 1: Blueprint of the house

At the ground level we have the basement room, the wine cellar, the laundry, the utility room and the garage. There are stairs in the middle of the ground level that leads to the upper floor. On the first floor we have the living room, a bathroom, two bedrooms a kitchen and a pantry.

One of the limitations of this implementation is that there is a daily schedule and it can be implemented with more scenarios with different agents.

3 Rooms

3.1 Basement room

The basement room is placed on the ground level. In the basement room there are two windows with curtains, a couch, a TV and a small kitchen. In the kitchen there are a table, a stove top, a fridge and an oven. This room has a main light above the table and it has an independent thermostat.

3.2 Wine cellar

The wine cellar is placed near the laundry and the stairs. It is used to store the wine. This room is not heated and there is a main light in the middle of the room.

3.3 Laundry

The laundry is between the wine cellar and the utility room. In this room there are a washing machine and a dryer. This room is not heated and there is the main light in the middle of the room.

3.4 Utility room

The utility room is placed beside the laundry. It is used to store some utility tools. There is a small light in the middle of the room. It is not heated.

3.5 Garage

The garage is used to park the cars. It is not heated. There is a main light in the middle of the garage.

3.6 Living room

The living room is placed at the first floor and it is an open space area. In this room there are two couches, a TV and a big window. There is a main light above the couches. It has an independent thermostat.

3.7 Bathroom

In the bathroom there are a sink, a toilet, and a shower. It has an independent thermostat and there is the main light in the middle of the room, moreover there is a small light above the sink.

3.8 Bedroom 1

In bedroom 1 there are a bed, a big desk with a PC and a small window with curtains. It has an independent thermostat. Beside there is the walk-in closet that is used for the wardrobe.

3.9 Bedroom 2

In bedroom 2 there are a bed, a wardrobe, a desk and a small window with curtains. It has an independent thermostat.

3.10 Kitchen

In the kitchen there are a table, a stove top, a fridge and an oven. In the middle of the room there is the main light. In this room there are three windows. It has an independent thermostat.

3.11 Pantry

This room is placed beside the kitchen. It is used to store supplies. There is a small window and it has an independent thermostat.

4 Devices

4.1 Solar panels

The solar panels are placed on the roof of the house. They produce electricity from 7.00 to 20.00 if it is sunny and 0KW at night. When the panel is on it is producing electricity. The actions that can be performed are turning off or turning on the panels. In addition, you can choose whether the panel should accumulate or sell energy. For example, if there is no sun and the panel does not produce electricity, it is a good idea to turn it off. The panel can be paired with a virtual assistant and can be controlled remotely.
The solar panel has two statuses:

- on: the solar panel is on
  In addition, if it is on, you can choose whether the panel should accumulate or sell energy, in fact the solar panel has two functions:
  - sell: the solar panel sells the electricity
  - store: the solar panel stores the electricity
- off: the solar panel is off

The solar panel can be controlled by the house agent, in fact it has the control of this device.

4.2 Vacuum cleaner first floor and ground floor

The vacuum cleaner is useful for cleaning the house. The vacuum cleaner of the first floor can clean only on the first floor of the house. The vacuum cleaner of the ground floor can clean only the ground floor.
The statuses of the vacuum cleaner are:

- on: the vacuum cleaner is on
- off: the vacuum cleaner is off

Moreover, the actions that can do are:

- Clean: if it detects a dirty room it will clean the room.
- moveTo: it can move from a room to another, but the two rooms have to be adjacent.

The vacuum cleaner of the first floor has to clean these rooms: living room, bathroom, bedroom 1, bedroom 2, kitchen, walk-in-closet and the pantry. The vacuum cleaner of the ground floor has to clean these rooms: basement room, wine-cellar, laundry, utility room, hallway and the garage.

4.3 Security camera

The security cameras are placed outside the house. The house has four security cameras: camera nord, camera sud, camera est and camera ovest. They are useful for the security of the house. The cameras are on from 00.00 to 7.00.
The camera has two statuses:

- on: the camera is on
  In addition, if it is on, you can choose whether the camera should record or not the video, in fact the camera has two methods:
  - recordVideo: the camera records the video
  - not recordVideo: the camera does not record the video
- off: the camera is off

The camera can be controlled by the house agent, in fact it has the control of this device. The camera consumes 10W.

4.4 Lights

Lights provide illumination to the rooms. The statuses of the lights are:

- on: the light is on
- off: the light is off

The methods of the light are:

- switchOnLight: the light will turn on.
- switchOffLight: the light will turn off.

The main light consumes 25W and the small light consumes 15W.

4.5 Smart curtains

The smart curtains are placed on every window. Smart curtains are regular curtains, except fitted with a motor and allowing remote access within house agent that control the placement of the curtains depending on need. By default, the curtains will close at 00.15 and open at 7.00.
The statuses of the curtains are:

- opened: the curtain is open
- closed: the curtain is close

The methods of the curtains are:

- openCurtain: the curtain will open.
- closeCurtain: the curtain will close.

The house agent has the complete control of this device. The curtain consumes 5W.

4.6 Thermostat

The thermostat is useful for temperature control of the rooms. It has a sensor for detecting the temperature, so if the temperature is too low the thermostat will be turned on, instead if the temperature is ok it will be turned off.
The statuses of the thermostat are:

- on: the thermostat is on. By default, the temperature is set to 20°.
- off: the thermostat is off.

The method of the thermostat is:

- setTemperature: you can set the temperature of the room.

The house agent has the complete control of this device.

4.7 Washing machine

The statuses of the washing machine are:

- on: the washing machine is on.
- off: the washing machine is off.

The methods of the washing machine are:

- switchOnWashingMachine: it will switch on the washing machine.
- switchOffWashingMachine: it will switch off the washing machine.

When the washing program finishes, it sends a notification to the virtual assistant, who reports it to the resident. The washing machine agent has the complete control of this device. The washing machine consumes 1000W.

4.8 Dryer

The statuses of the dryer are:

- on: the dryer is on.
- off: the dryer is off.

The methods of the dryer are:

- switchOnDryer: it will switch on the dryer.
- switchOffDryer: it will switch off the dryer.

When the drying program finishes, it sends a notification to the virtual assistant, who reports it to the resident. The dryer agent has the complete control of this device. The dryer consumes 2000W.

4.9 Smart doors

Every door in the house is a smart door. The statuses of the door are:

- unlocked: the door is unlocked.
- locked: the door is locked.

The methods of the door are:

- openDoor: it will unlock the door.
- closeDoor: it will lock the door.

5 Metrics

5.1 Vacuum cleaner

The vacuum cleaner of the first floor takes 1h and 15 minutes to clean the living room, 1h to clean the bathroom, 1h to clean the bedroom 2, 1h and 20 minutes to clean the bedroom 1, 1h to clean the pantry and 2h to clean the kitchen. The vacuum cleaner of the ground floor takes 45 minutes to clean the wine cellar, 1h to clean the laundry, 1h to clean the utility room, 1h and 20 minutes to clean the basement room, 1h to clean the garage and 45 minutes to clean the hallway.

5.2 Electricity Cost

During the day, if it is sunny the solar panels will provide free energy to the house, instead during the night they will not provide energy. Different devices have different consumption of electricity, in the section Devices is reported the consumption for each device.

6 People

The people that live in the house are Jack, Mary and their son John. They stay mostly on the first floor of the house. Parents have their personal room, which is bedroom 1, and John has his personal room, which is bedroom 2. Mary and John leave the house at 9.00 and return at 16.00 every day from Monday to Friday. Instead, Jack leaves the house at 8.00 and stays away until 18.00. At the weekend they are usually not at home. The action that they can do is:

- moveTo: they will move from a room to another, but only if the rooms are adjacent

Moreover, they can control all the devices of the house.

7 Agents

7.1 Vacuum cleaner agent

The vacuum cleaner can move autonomously among all the rooms of his floor and clean them daily. It can only move among adjacent rooms, so if the planning tells to the vacuum cleaner to go from a room to another

room not adjacent the PDDL will find a plan to do that. In the house there are two vacuum cleaners, one for the ground floor and one for the first floor. It is important to say that the vacuum cleaner agent and the house agent communicate because if there is someone in the room the vacuum cleaner will have to skip this room. If there is someone in the room, the planning will fail, then it tries to replan.

7.2 Door agent

It locks the doors at night, by default at 00.15. It can control all the door of the house.

7.3 Washing machine agent

The washing machine agent has the control of the washing machine.

7.4 Dryer agent

The dryer agent has the control of the dryer.

7.5 Room agent

The room agent can detect if there is someone in the room, if so it will send this information to the house agent

8 House agents

8.1 Virtual assistant

It can control every device in the house. Through the virtual assistant the resident can control the lights, the curtains, security cameras, solar panels and so on. It is important because it triggers default events such as turning on the lights when there is someone in the room, starting the recording of the cameras at 00.15 and so on. These events will be explained better in the section Scenario. It also has the function to report to the residents notifications of the devices. Every agent of the house has sensors that can perceive changes in the environment and update the agent's internal knowledge representation. Then, the agent shares the changes and the new knowledge with the HouseAgent, so that the HouseAgent can handle better whatever happens in the house.

9 Planning agent

The planning agent is the vacuum cleaner agent. The domain of the agent is the house, in particular the two floors of the house, in fact for each floor there is a vacuum cleaner. Specifically, the domains of the vacuum cleaner are the different rooms of the house. The problem with this planning agent is that it has to clean all the rooms. For this problem I decided to divide the main goal into sub-problems, so instead of treating the house as a whole, I decided to focus on single rooms.

10 Implementation

10.1 Sensors and agent perception

The agent knows all the rooms on his floor, the assumptions taken are that all the rooms are dirty and the fact that the vacuum cleaner can move only among adjacent rooms. Before starting the actions, the agent will check the preconditions of the PDDL and if they are satisfied it will formulate a plan to clean and suck the room. When an action is performed automatically the belief set of the agent will be updated.

10.2 Agents acting in a shared environment

The vacuum cleaner agent is autonomous and do not interference with other agents. The actions that the agent can perform are:

- SuckAndClean: it allows the agent to move from a room to another, but these rooms have to be adjacent or the action will fail. Moreover, it will trigger the action of Clean and Suck, so that the vacuum cleaner will clean and suck all the rooms of the house.
- Clean: this action allows the agent to clean a room, it is important to say that if a room was already cleaned this action will not be triggered, in fact in the preconditions of the action SuckAndClean there is the effect of the action Clean, so the vacuum cleaner is able to understand autonomously if a room is clean or dirty.
- Suck: this action allows the agent to suck a room, it is important to say that if a room was already sucked this action will not be triggered, as specified above.
- switchVacuumCleaner: it allows the agent to turn on or turn off, the choice depends on the actual state of the agent, so that the effect will be the opposite.

All the agents of the environment act to achieve their specified goal. In particular, to achieve the goal, we use an intention. All the agents are implemented following the intention - goal pattern.

10.3 Agent interaction and coordination

The agent will perform autonomously the actions to reach his goal. As specified before, I decided to subdivide the goal in sub-goals to simplify the domain problem.

Moreover, I implemented the communication between agents. In particular, the coordination between the WashingMachineAgent and the DryerAgent, so that when the washing machine finishes the program it will send all the laundry to the dryer and the dryer will start to dry.

It is done by using the MessageDispatcher and the Postman. The MessageDispatcher has the task to send messages as goals from one agent to another. Instead, the Postman will notify the agent that has received a new message

10.4 Scenario 1

In this scenario is reported a daily routine of the agents and people of the house. In particular, it is a one day schedule. This is the main scenario and it is a complex scenario, a simplified version of this scenario

is proposed in scenario 2. The house agent is useful because it triggers default events and procedures of different agents, moreover it is also reported the behaviour of specific agents. The agent assists residents by taking autonomous decisions, while still being responsive to resident's behaviours. The methods used in this scenario are (in chronological order, I decided to omit redundant methods):

- switchOffLight(): this method turn off the light object
- closeDoor(): this method lock the door object
- switchOnCamera(): this method turn on the camera object
- recordVideo(): this method allows the camera object to record the video
- switchOffThermostat(): this method turns off the thermostat object
- closeCurtain(): this method closes the curtain object
- switchOnThermostat(): this method turns off the thermostat object
- setTemperature(): this set the temperature of the thermostat object
- switchOnLight(): this turns on the light object
- openCurtain(): this opens the curtain object
- switchOnSolarPanel(): this method turns on the solar panel object
- openDoor(): this method unlocks the door object
- not-recordVideo(): this method stops the camera object recording video
- switchOffCamera(): this method turns off the camera object
- storeEnergy(): this method allows the solar panel object to store the energy
- sellEnergy(): this method allows the solar panel object to sell the energy
- moveTo(): this method allows a person to move from a room to an adjacent room
- switchOnWashingMachine(): this method turns on the washing machine object
- switchOffWashingMachine(): this method turns off the washing machine object
- switchOffDryer(): this method turns off the dryer object
- switchOffSolarPanel(): this method turns off the solar panel oject

Then I used PDDL plan to achieve the goal of the vacuum cleaner planning agent. In particular, I used the function moveTo() to move the vacuum cleaner into a room and clean it. Here, I report an example of a snippet of code:

- postSubGoal(new RetryGoal({ goal: new PlanningGoal({ goal: ['set status vacuum cleaner first floor on'] }) }))

- postSubGoal(new RetryGoal({ goal: new PlanningGoal({ goal: ['goal: ['CleanAndSuck vacuum cleaner first floor bathroom'] }) }))

10.5 Scenario 1: Logs

The full logs are reported on the GitHub repository for simplicity of reading.

10.6 Scenario 2

This is a secondary scenario and it is a simple simulation. In this scenario I propose a daily routine of the planning agent, moreover I added the communication between agents. In particular, the communication between the washing machine agent and the dryer agent using the message dispatcher and the postman. Specifically, when the status of the washing machine is off (so that the device has finished washing the laundry), it sends a message to the dryer so it can start drying the laundry. The methods used in this scenario are:

- switchOnWashingMachine(): this method turns on the washing machine
- switchOffWashingMachine(): this method turns off the washing machine and it triggers the message dispatcher. It reports to the dryer that the washing machine has finished washing the laundry and it triggers the start of the dryer so it can start drying the laundry.

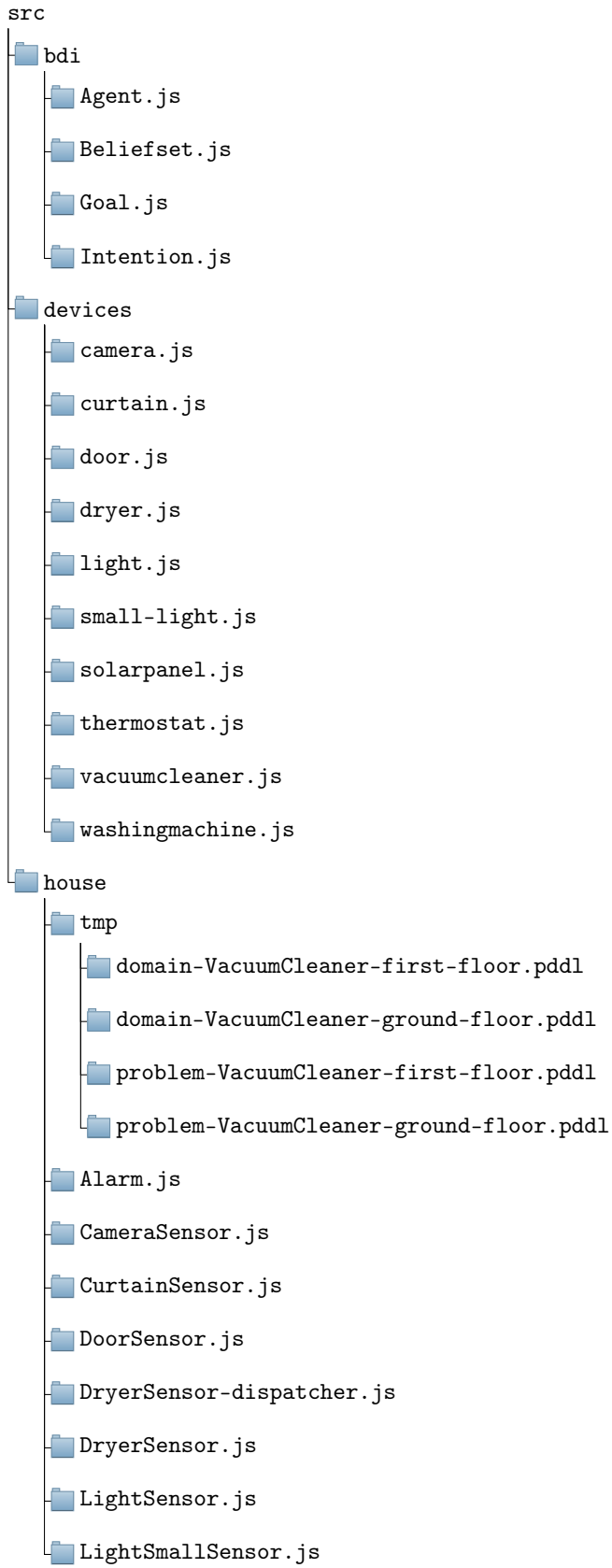
10.7 Scenario 2: Logs

The full logs are reported on the GitHub repository for simplicity of reading.

11 GitHub repository

This is the link to the GitHub repository: `https://github.com/davidelobba/ASA_project`

12 Source code organization




src
house
LightSmallSensor.js
scenario1.js
scenario2.js
SolarpanelSensor.js
ThermostatSensor.js
WashingMachineSensor-dispatcher.js
WashingMachineSensor.js
pddl
actions
pddlActionGoal.js
pddlActionIntention.js
validateEffectsandPreconditions.js
OnlinePlanner.js
PddlDomain.js
PddlProblem.js
PlanningGoal.js
people
person.js
utils
Clock.js
dispatcher.js
keypress.js
Observable.js
scenario1.log
scenario2.log
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