Assignment 1

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Autonomous Software Agents - UNITN 2021/2022

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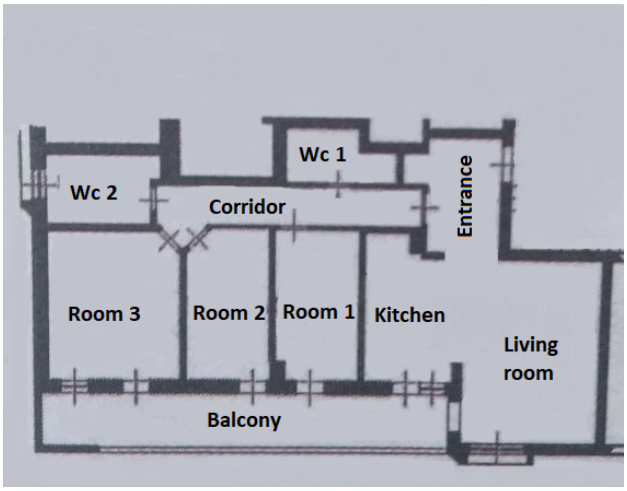
Introduction

In a smart home different appliances can execute specific tasks and are typically connected over a network so that residents can control them remotely through applications for mobile or tablet devices. The final goal is to provide convenience, security and energy efficiency while maintaining a low complexity over the whole process.

In this scenario it is possible to add a Multi-Agent System (MAS), a computational intelligence technique composed of multiple interactive intelligent agents in an environment, which will take autonomous decisions on behalf of the residents.
The key point is to model the smart appliances as agents and to optimize their decision making. These agents will communicate, interact and negotiate energy sources in order to maximize energy saving and comfort for the residents.

House description

The house is composed of only one floor. The main door leads to the entrance which is directly connected with the kitchen and the living room (there are no doors in between). From the entrance a door leads to the corridor which is connected to two bathrooms (Wc1 and Wc2) and three rooms (Room1, Room2 and Room3). The kitchen, the living room and each of the three rooms have a door that connects them to the balcony.



Rooms

All the windows and doors (which are made of glass and transparent and lead to the balcony) of the kitchen, living room and rooms 1-3 have roller shutters which are connected to the house agent.
Each room has a sensor which detects the level of illumination (low/normal/high) and if a person is inside.

Entrance

The entrance is directly connected with the kitchen and the living room and has two doors: the main door which connects the house with the outside and the door which leads to the corridor. There is also a closet and a light.

Kitchen

The kitchen has a door and a window on the side of the balcony (both with curtains). Starting from the door and following the wall: there is a fridge, a dishwasher, a sink, and furniture together with an oven, a smart speaker. Between the kitchen and the living room there is a table where people eat. There are two lights in the kitchen and two lights on top of the table.

Living Room

The living room has a door which leads to the balcony and a window. On the side of the window there is a sofa while on the other side there is Tv. There is one light in the room.

Corridor

The corridor has two lights: one on the side of the entrance and one on the side of Wc2.

Wc1

This bathroom has a toilet, a sink, a washing machine and a shower. There is no window but only a light.

Wc2

This bathroom has a toilet, a sink, a tub, a window and a light.

Rooms 1-2

Both rooms have the same layout with a wardrobe, a single bed, a table, a light and a transparent door which leads to the balcony and provides light.

Room 3

This room is bigger than rooms 1-2, it has a double bed, a wardrobe, a light, a window and a transparent door on the side of the balcony.

Balcony

It has only two lights.

Devices

For all the devices with a status connected - disconnected it means that the house agent can control it only when it is connected.

Lights

Lights provide illuminations to the house when it is too dark. Each one consumes 15 watts. The two lights in the kitchen are either both on or both off and can be considered as a single light of 30 watts (same applies for the lights on top of the table between the kitchen and the living room). The house agent can autonomously control them when they are connected.

Statuses:

- **On - Off**
- **Connected - Disconnected**

Possible actions:

- **turn_on**
- **turn_off**

Prerequisites to turn on the lights:

illumination_low AND **ligt_off** AND **person_inside** AND (**time>7pm** OR **roller_shutter_up**)

Prerequisites to turn off the lights:

not **person_inside** AND **light_on**
OR
person_inside AND not **person_awake** AND **light_off**

Roller Shutters

Roller shutters are used to lower/increase the level of light coming from the windows or doors. When they are connected, the house agent can autonomously control them.
Statuses:

- **Up - Half - Down**
- **Connected - Disconnected**

Possible actions:

- **set_up**
- **set_half**
- **set_down**

Prerequisites to set_half:
illumination_high AND **roller_shutter_up** AND **tv_on**
OR
illumination_low AND **roller_shutter_down** AND **person_inside** AND **time>7am** AND **time<7pm**

Prerequisites to set_up:
illumination_low AND **roller_shutter_half** AND **person_inside** AND **time>7am** AND **time<7pm**

Prerequisites to set_down:
illumination_high AND **roller_shutter_half** AND **tv_on**

Television

The television is used for leisure by the people and can be controlled by the house agent. It consumes 100 watts.

Statuses:
- **On - Off**
- **Connected - Disconnected**

Possible actions:
- **switch_on**
- **switch_off**

Prerequisites to switch_off:
for_2_minutes(not **person_inside**) AND **tv_on**

Washing Machine

The washing machine can detect the load of the clothes and can automatically start the washing cycle during peak electricity hours when no other high-consuming device is on (this helps to save electricity). It consumes 600 watts.

Statutes:
- **Off - Washing - Finished**
- **Empty - Half - Half_full - Full**
- **Connected - Disconnected**

Possible actions:
- **start_washing**

Prerequisites for start_washing:

(**washing_machine_half_full** OR **washing_machine_full**) AND **oven_off** AND (**dishwasher_off** OR **dishwasher_finished**) AND **time>7pm** AND **time<5am**

Dishwasher

The dishwasher is similar to the washing machine. It consumes 1300 watts.

Statutes:

- **Off - Washing - Finished**
- **Empty - Half - Half_full - Full**
- **Connected - Disconnected**

Possible actions:

- **start_washing**

Prerequisites for start_washing:

(**dishwasher_half_full** OR **dishwasher_full**) AND **oven_off** AND (**washing_machine_off** OR **washing_machine_finished**) AND **time>9pm** AND **time<5am**

Fridge

The fridge detects the overall number of supplies and the house agent can notify the residents when they are low. It consumes 130 watts.

Status:

- **Percentage of supplies**

Oven

The house agent cannot control the oven but it can check its status. It consumes 1600 watts.
Status:

- **On - Off**

Smart Speaker

Through the smart speaker people get notifications when other devices finish their work, when the supplies are low, when multiple high_consuming devices are on.
Status:

- **On - Off**

Possible actions:

- **Switch_on**
- **Switch_off**

- **Notify**

Prerequisite for notify:

washing_machine_finished OR **dishwasher_finished** OR **fridge_percentage<30%**

OR

oven_on AND **washing_machine_on**

OR

oven_on AND **dishwasher_on**

OR

dishwasher AND **washing_machine_on**

Metrics

Electricity

Electricity is cheaper during the “peak electricity hours” which are between 7 pm and 7 am. The house agent will switch power hungry devices to do their work during these hours in order to save money but not all devices can be on at the same time: the house can sustain only an amount of watt power (~2500 watt) at the same time. The safety switch will trip if this concurrent power limit is exceeded, so the house agent needs to take this into account.

Summary of power consumption of controlled devices:

15 lights	15 x 15 watts = 225 watts
2 tvs	2 x 100 watts = 200 watts
washing machine	600 watts
dishwasher	1500 watts
oven	1600 watts
fridge	130 watts
Total	**4255 watts**

In order to avoid the safety switch, only one device between the oven, the dishwasher and the washing machine can be on at the same time.

People

The residents of the house are John, Hannah, Elizabeth and Ezekiel.
John is out of home for work from 7 am to 6 pm while Hannah works from home from 8 am to 5 pm (both Monday-Friday). Elizabeth and Ezekiel are both students and are out of home from 7:30 am to 13 pm from Monday to Friday; sometimes they are out in the afternoon from 4 pm to 6 pm.
Usually on Sunday all the residents are at home while on Saturday the house is empty during the day.

Agents

Robot vacuum agent

This robot can autonomously move between rooms if the doors are open and clean the house. It can be configured in different ways such as the frequency of cleaning (daily, once every 2 days, etc), from which room to start, which path to follow (e.g. minimize the distance to travel or based on some order of the rooms), which rooms to exclude (if a person is inside and the cleaning hasn't started yet). The robot also manages its battery and goes autonomously to the charging station.

House agent

The house agent can autonomously control all controllable devices. Devices which are set to disconnected cannot be controlled but their statuses can be read.
The action performed on a device depends on its status and/or statutes of other devices and/or other information from the environment.
Actions (more specific triggerings are in the specific device section):

1. Turn on the lights when a person is an room with low illumination
2. Turn off the lights when no one is in the room or when everyone inside the room is sleeping.
3. Lower the roller shutters if the illumination is too high in the room and the tv is on.
4. Raise the shutters if the illumination is too low during day-time.
5. Switch off the television if no one has been in the room for 2 minutes.
6. Start the washing machine from 7pm to 5am if it's full or half full and no other high consuming power device is on (washing machine has precedence over dishwasher).
7. Start the dishwasher from 9pm to 5am if it's full or half full and no other high consuming power device is on.
8. Notify if the supplies of the fridge are lower than 30%.
9. Notify if the washing machine or the dishwasher finished their cycle.
10. Notify if two high consuming power devices are on at the same time (and possibly turn off the least important one?).