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Monitor and Behaviour Analysis

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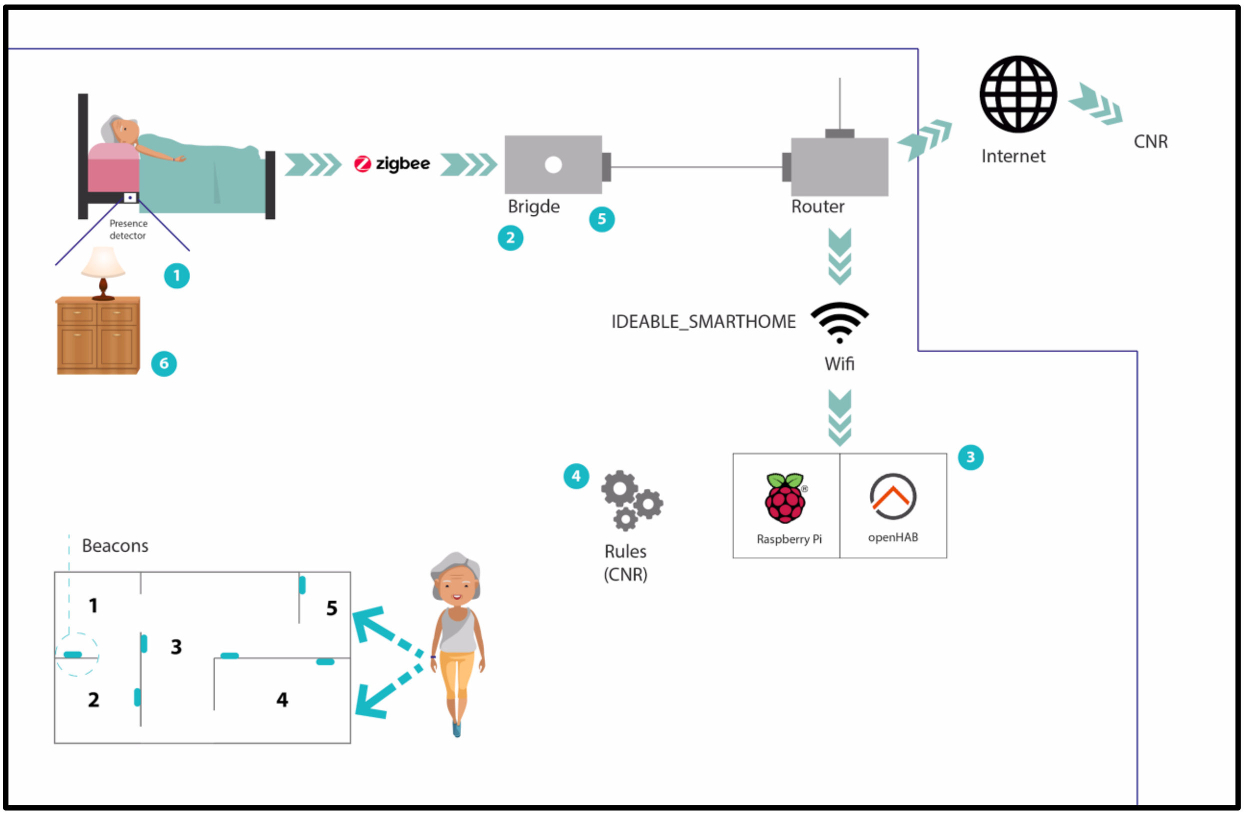
Contents

The project PETAL is cofunded by the Active and Assisted Living Programme (AAL-2016) and the following National Authorities and R&D programs in Italy, Spain, Austria and Romania.

1. INTRODUCTION

The PETAL project aims to offer a support for elderly users who lives alone, in order to help them and their families, by using a "PETAL Smart Home". The "PETAL Smart Home" is a monitorized house that will increase the elderly's autonomy and assists them in their daily activities. This monitoring will be done by using different electronic devices that will be installed in the elderlies houses, and a cognitive stimulation platform will also be used.



The main objective of this delivery is to describe the different devices that have been selected to create this "PETAL Smart Home".

With that architecture we plan to monitor some of the most possible use cases:

- Lights to the bathroom are automatically turned on when getting up from bed at night.
- The intensity from the light bulbs is changed to be more active when the user reports low emotional status.

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- When the system detects that the users has left the house, all the lights are switched off. The entrace lights are automatically turned on when opening the main door.

2. PETAL SMART HOME

A "PETAL Smart Home" will be a Home that provides support for elderly users who live alone and need some kind of support. This support will be provided by some electronic devices, which have to be selected. Below is a first selection of these devices.

2.1. Home Automation Software

2.1.1. Introduction

The Home automation software can facilitate control of common appliances or other electronic devices found in a home, such as turning lights on when movement is detected.

2.1.2. More significant options

There are many softwares supporting Home Automation that can be used for this project, some of them developed by open source code and others are commercial, written in different programming languages, …. and other characteristics that have been analyzed.

After analyzing those characteristics, three options for the Petal project have been identified:

- **Home Assistant**

Home Assistant is an open source home automation platform designed to be easily deployed on almost any machine that can run Python 3, from a Raspberry Pi to a network-attached storage (NAS) device, and it even ships with a Docker container to make deploying on other systems a breeze.

It can work in different modalities:

  - Home control: Responsible for collecting information and storing devices.
  - Home automation triggers commands based on user configurations.

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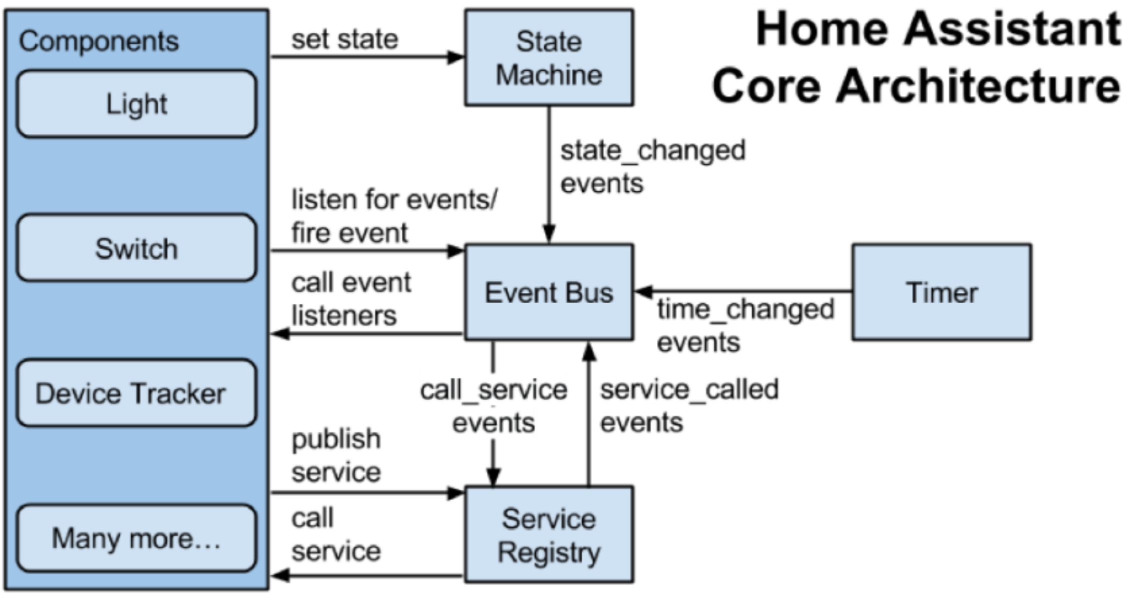
- Smart home triggers based on past user behaviour.

The core architecture of the Home Assistant:



Home Assistant is released under an MIT license.

- **OpenHAB**

OpenHAB (Open Home Automation Bus) is one of the best-known framework for smart homes. Written in Java, openHAB is portable across most major operating systems and even runs nicely on the Raspberry Pi. Supporting hundreds of devices, openHAB is designed to be device-agnostic while making it easier for developers to add their own devices or plugins to the system. OpenHAB also ships iOS and Android apps for device control, as well as design tools so you can create your own UI (user interface) for your home system.

By using this framework dimensions such as Temperature, Intensity, Pressure and others can be monitored.

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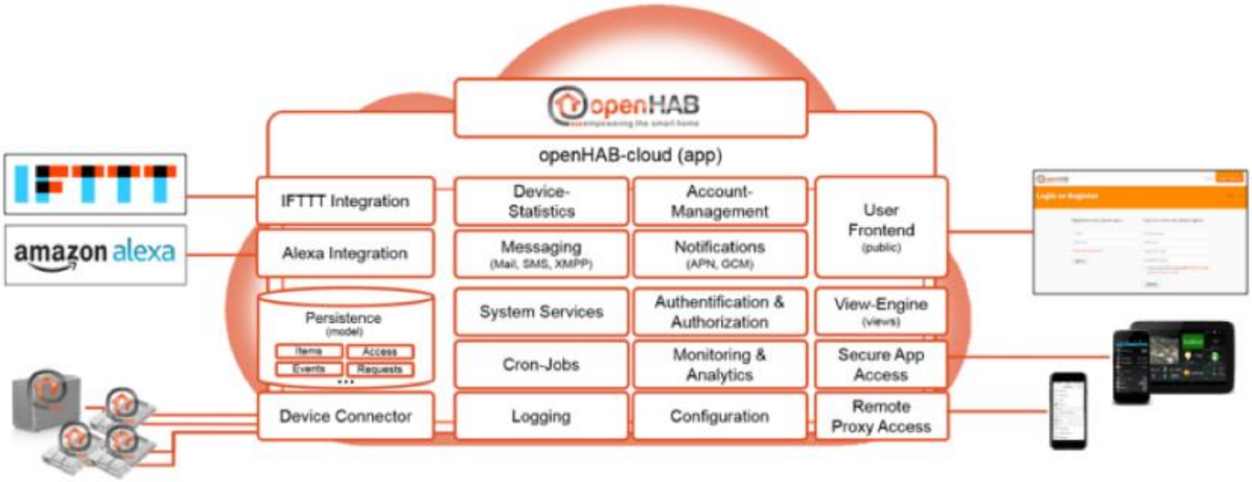
The core architecture of OpenHAB:



OpenHAB is released under the Eclipse Public License.

- **<u>Domoticz</u>**

Domoticz is a home automation system with a pretty wide library of supported devices, ranging from weather stations to smoke detectors to remote controls, and a large number of additional third-party integrations are documented on the project's website. It is designed with an HTML5 frontend, making it accessible from desktop browsers and most modern smartphones, and is lightweight, running on many low-power devices like the Raspberry Pi.

By using this framework things like temperature, rain, wind and others can be monitored

The architecture of Domoticz makes difficult to build applications on it.

2.1.3. Selected option: OpenHab

The selected option for the project PETAL is the OpenHab framework because:

- The main reason is that is an open source code. The followings are some of the advantages of opting for this open source software:
    - Lesser hardware costs.

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- High-quality software.
- No vendor lock-in.
- Integrated management.
- Simple license management.
- Lower software costs.
- Abundant support.
- Scaling and consolidating.

- It is written in Java.
- It is released under the Eclipse Public License.
- It supports the Philips Hue lamps (which will be used in the Petal Smart Home.

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2.2. Environmental Sensors

2.2.1. Introduction

A sensor is a device that is used to detect that something is present or has changed.

There are many sensors that can be used for different purposes, even for home automation. In this section a selection of these sensors is provided.

2.2.2. Types of sensors

- **Temperature Sensors**

  Sensor that is used to measure the temperature of a place.
  Example: Minew S1 Temperature sensor and Philips Hue Sensor.

- **Lux Sensors**

  Lux sensors measure the luminosity and can be used to trigger various functions range from cross-validating movements to turn the lights on if it becomes too dark.
  Example: Minew E6 Light Sensor and Philips Hue Sensor

- **Pressure Sensors**

  A pressure sensor is a device for pressure measurement, specially indicated for detecting when a person lies at bed or gets up in the morning.

- **Proximity Sensor**

  A Proximity Sensor is a non-contact type sensor that detects the presence of an object. Proximity Sensors can be implemented using different techniques like Optical (like Infrared or Laser), Ultrasonic, Hall Effect, Capacitive, etc.
  Example: INGICS proximity detector.

- **Humidity Sensors**

  A humidity sensor senses, measures and reports the relative humidity in the air.
  Example: Minew S1 Humidity sensor.

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- **Gas Sensors**

  A sensor that can detect gas leaks at home can be very useful for older people.

- **Presence Sensors**

  A presence sensor detects the presence of the user in one room or space at home. Example: Philips Hue motion sensor and INGICS Human detection sensor.

- **Motion Sensors for objects**

  A presence sensor detects the presence of the user in one room or space at home. And attached to objects it may detect the using of some objects like remote controls, pills boxes, etc.
  Examples: INGICS iBS01G Beacon for moving/vibration detection and Minew E8 with Accelerometer.

- **Opening / closing Sensors**

  A sensor that detects opening and closing of doors and windows will let us use the lights and relate them to this event.
  Example: INGICS iBS01H Beacon with magnet sensor (Hall IC) for open/close detection.

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2.2.3. Some selected sensors

For the PETAL project we will select many of the sensors amongst those indicated before, but some of them have already been selected as the the **Philips Hue Sensor**, which can measure the temperature and proximity parameters.

This sensor:

- Automatically switches lights, for example when a person enters a room.
- Day and night settings > It is possible to set different light settings for day and night.
- Integrated daylight sensor > It allows users to turn on the lights or change the light sensibility by using the Philips Hue app.
- It easily integrates with all the Philips Hue family devices, that will be used in the PETAL project.
- Place it where it matters > No cables, so it can be placed anywhere at home.
- Requires a Philips Hue bridge > This product requires a connection to the Philips Hue bridge.

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Technical Specifications

The switch

IP rating	IP42
Minimal battery lifetime	2 year(s)
Mounting options	freestanding
Software upgradeable	when connected to Hue bridge
Sensor depth	20 mm
Sensor height	55 mm
Sensor width	55 mm
Zigbee Light link	protocol IEEE 802.15.4

What's in the box

Bridge	No
Ethernet network cable	No
Power adapter	No
Hue bulbs	No
Hue dimmer switch	No
Hue white bulbs	No

Guarantee

2 years	Yes

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2.3. Indoor positioning

2.3.1. Introduction

Apart from using the presence sensors, this system may be integrated with a complementary indoor positioning system (IPS) which is a system to locate objects or people inside a building using lights, radio waves, magnetic fields, acoustic signals, or other sensory information collected by mobile devices.

2.3.2. Characteristics

- **Applicability and precision**

Due to the signal attenuation caused by construction materials, the satellite based Global Positioning System (GPS) loses significant power indoors affecting the required coverage for receivers. In addition, the multiple reflections at surfaces cause multi-path propagation serving for uncontrollable errors. Similar effects are degrading all known solutions for indoor locating which uses electromagnetic waves from indoor transmitters to indoor receivers. A bundle of physical and mathematical methods are applied to compensate for these problems. Promising direction radiofrequency positioning error correction opened by the use of alternative sources of navigational information, such as inertial measurement unit (IMU), monocular camera Simultaneous localization and mapping (SLAM) and WiFi SLAM. Integration of data from various navigation systems with different physical principles can increase the accuracy and robustness of the overall solution.

- **Relation to GPS**

Global navigation satellite systems (GPS or GNSS) are generally not suitable to establish indoor locations, since microwaves will be attenuated and scattered by roofs, walls and other objects. However, in order to make positioning signals ubiquitous, integration between GPS and indoor positioning can be made.

- **Locating and positioning**

While most current IPS are able to detect the location of an object, they are so coarse that they cannot be used to detect the orientation or direction of an object.

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- **Locating and tracking**

  One of the methods to thrive for sufficient operational suitability is "tracking". Whether a sequence of locations determined form a trajectory from the first to the most actual location.

- **Non-radio technologies**

  Non-radio technologies can be used for positioning without using the existing wireless infrastructure. This can provide increased accuracy at the expense of costly equipment and installations.

- **Wireless technologies**

  Any wireless technology can be used for locating. Many different systems take advantage of existing wireless infrastructure for indoor positioning.

2.3.3. PETAL Positioning System

The PETAL positioning system will have to allow to determine elders position within their homes by using multi-platform devices.

The way that it will have to work is that each time a Bluetooth/WiFi-enabled device conducts a scan of nearby devices, it will receive a unique identifier and a signal strength that correlates with the distance to that device. A compilation of these different signals can be compiled into a fingerprint which can be used to uniquely classify the current location of that device. The basis of this system is to catalog all the fingerprints about the Wifi routers in the area and then classify them according to their location.

So, the basis of this system for PETAL is to catalog all the fingerprints about the Wifi routers in the area (MAC addresses and signal values) and then classify them according to their location. This is goingo to be done using a software App that collects those fingerprints described before, and then compute the location.

The system will have the following components:

- Data storage server
- Machine learning server

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- Openhab binding for gathering fingerprints from Bluetooth scanners

There are two modes of localization that can be implemented, active and passive scanning. In this case, the **passive scanning** will be used. In passive scanning the scanner will report the classified location of the devices that it scans. This mode requires having multiple Bluetooth scanners for better accuracy. No software is needed on the device that is being tracked (i.e: smart band or beacon).

Finally, to collect sensor data and then classify that sensor data **a machine learning algorithm** will be used. Classification is done by splitting the original data into two datasets - 70% of the original data goes towards learning and 30% goes towards testing. The learning data is composed of unique identifiers and signal values (Bluetooth signals) and a label of the location where the signals were evaluated.

The learning data is fed into a machine learning algorithm that can do classification with probability.

An **example** of a learning algorithm is the Extended Naive Bayes. The basic question we want to answer is what is P(location$_y$) for each of the N possible locations that have been learned? In each location there are M sensor data that are specified by MAC$_x$ (the x bluetooh MAC address). Assuming each device is independent, the probability of the location can be given by the product.

$$P(location_y) = \Pi_{i=1}^{M} P(location_y|mac_x)$$

In pratice we just need to determine P(location$_y$|MAC$_x$) for each y location and MAC$_x$.

$$P(location_y|mac_x) = \frac{P(mac_x|location_y)P(location_y)}{P(mac_x|location_y)P(location_y) + P(mac_x|\neg location_y)P(\neg location_y)}$$

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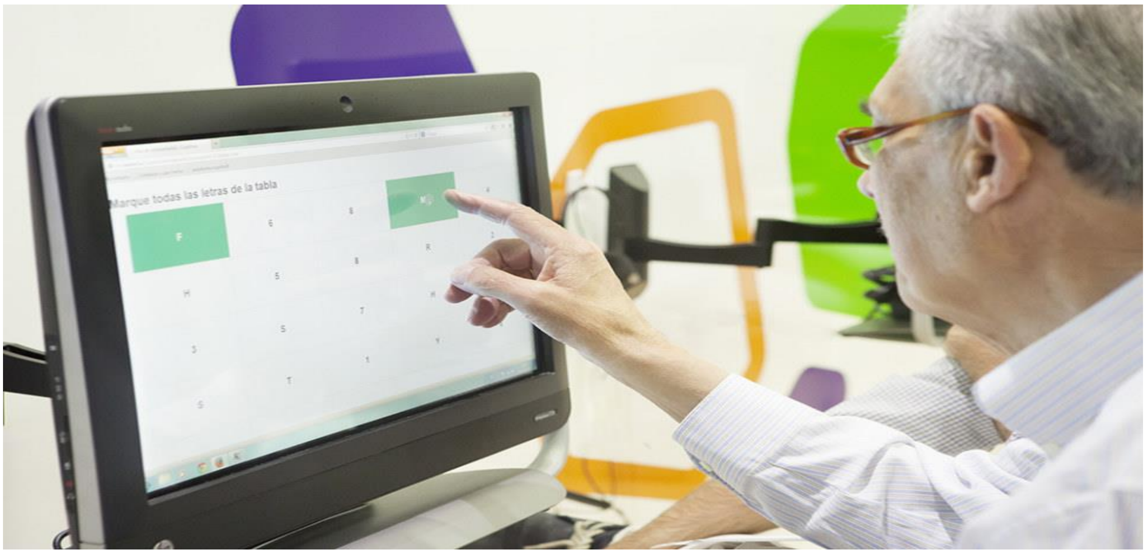
2.4. Mementia

Mementia is part of the elderly care platform Kwido, and it is used as a cognitive stimulation tool which offers psychologists and therapists a broad range of possibilities through a methodology designed specifically for seniors.

Mementia is a multi-device platform which provides an environment to help reinforce therapies and improve adherence to treatment. Using a tablet app, an elderly user can carry out individually designed training exercises, whilst professionals can monitor data to evaluate performance, keep users informed and notify relatives of their progress.



The principal characteristics of Mementia, focused on professional use, are:

- Customization for each elderly user, with individual cognitive level, exercise complexity, objectives and specific games itinerary.
- 48 activities installed, with 8,000 exercises to work on skills such as memory, calculus, executive functions, language, orientation and attention.
- Tool for psychologists and therapists to create their own games.
- Compatibility with multiple devices.
- Real-time information on variables such as, amongst others, general cognitive index, emotional state or self-assessment.

In 2017, Grupo SSI carried out a 6 month pilot study in which it tested the Kwido-Mementia platform with elderly users of Bilbao Council's Home Care Service.

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The tests were coordinated by Itziar Álvarez a PhD student at the University of the Basque Country and Head of the RD&I Unit. Kwido-Mementia was used by 43 test participants (88% of them women and with an average age of 81.4) to carry out cognitive training at home.

The results from the study reveal that Kwido-Mementia is a useful tool for improving different areas of cognitive ability such as visuospatial memory, perceptual ability and perceptual reasoning. Online use was shown to be potentially very effective when done at home and with minimal supervision. This could make it a cost effective option compared with traditional training methods.

The system is designed to be used both on tablets at home and by professionals who come to perform care tasks. And by using games and an initial questionnaire it is able to analyse the initial cognitive level of the person, automatically assign a complete training plan adapted to the elderly person and analyse possible cognitive impairments from that moment on. It even provides information on self-perception of the game and possible changes of emotional state.

Apart from publishing these results in Kwido's webpage and presenting them in different events such as the 24th Spanish National Psychogeriatrics Congress http://www.kwido.com/blog/study-kwido-mementia/ it has also been presented in the"International Journal of Aging Research (IJOAR)" http://escipub.com/ijoar-2018-08-0301/

2.5. Tablet as the device to interact with older adults

The optimal device for playing these serious games is an Android 10" tablet because of its usability for older adults people that have not used the Internet before. In addition, a safe launcher may be used for receiving some of the alerts generated by the PETAL system.

2.6. Hardware home gateway

2.6.1. Introduction

For developing a home automation product, often a standalone product sending data to a server is not enough. Due to battery and protocol limitations, the data from a sensor or sensors present in a home has been routed through an IoT (internet of things) gateway.

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2.6.2. *Characteristics and options*

To select the most suitable gateway for the IoT home automation, the following characteristics has to be considered:

- Communication protocols supported
- Real-time capabilities
- **MQTT**, CoAP, and HTTPS support
- Security and configuration
- Modularity

To incorporate a gateway, the following options can be considered:

- Either create a gateway from the ground up using existing hardware stacks for prototyping (using Raspberry Pi, etc). Then, when a PoC is validated, an own custom hardware can be created.
- Or, an existing gateway modules such as Rigado Cascade-500 IoT Gateway can be used. These gateways are extremely easy to customize and connect with the cloud services and devices. However, they may or may not offer the same level of support that you need to build certain features.

Ideable is considering the Rigado Cascade Edge as a service gateway to implement all these requirements:

- Containerized edge environment
- Ubuntu Core OS with simple 'Snap' application packaging system to make it easier for developers to build and maintain applications at the edge
- Secure multi-application environment
- Easily and securely install and run multiple IoT applications on a single gateway
- Easy device connectivity
- APIs to gather data from common sensors and beacons – requiring no device or protocol expertise
- Cloud integration agents
- Integrate with major cloud providers quickly and easily using code samples

More info about this IoT gateway at https://www.rigado.com/products/iot-edge-as-a-service/

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3. CONCLUSIONS

For the "PETAL Smart Home" in order to support users monitoring and behaviour analysis the following devices and softwares are currently planned to be used:

- OpenHab framework as a Home Automation Software.
- Philips Hub Sensor for the measurement of temperature and proximity.
- An indoor positioning system developed and trained for the project
- An IoT gateway, like Rigado IoT Gateway.
- Kwido Mementia as the cognitive stimulation platform.
- An Android 10" tablet with a launcher used in kiosk mode for a safer user experience.
- Mementia elderly care platform will be used as a cognitive stimulation solution integrated with the rules engine offered by CNR.

As a conclusion, we are proposing a wide variety of sensors for detecting different situations, so the system can be as customizable as possible. A high number of sensors will let us detect as many situations as possible and personalize them to each type of end users, depending on their requirements for each case. Concerning positioning, as we can mix the using of motion and presence sensors again with indoor passive positioning, we can offer support for each user and the combination of different approaches will also give us more accuracy during the positioning phase. The proposed PETAL positioning system is also an innovative approach for positioning as it is less intrusive than other ones, with fewer devices (just some bluetooth scanners) for an entire home and requires wearing only a passive and cheaper wristband or even beacon.

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4. REFERENCES

- Home Assistant: www.home-assistant.io
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- Find: www.internalpositioning.com
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- Rigado gateway: https://www.rigado.com/products/iot-edge-as-a-service/
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