Domotic Hardware Infrastructure in PERSONA Project

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The domotic hardware infrastructure of PERSONA project is described. PERSONA aims to help elderly people at home, and this paper shows the hardware selection process and describes the specific hardware development carried out to minimize both the final price of the product and the visual impact in a real home. To do it, three generic types of PCB, that interfaces all the sensors and actuators with the communication transceiver, have been designed and implemented in order to minimize production costs. Also other specific devices have been carried out to cover the specifications of functionality of the project.

1. Introduction

PERSONA EU Project (Perceptive Spaces prOmoting iNdependent Aging)[1] is an EU-funded research project (FP6) that started in 2007. It belongs to AAL (Ambient Assisted Living) and aims to help elderly people at home in the loose of skills due to the normal aging process. This help is carried out by providing a set of services that includes the development of technology (hardware and software). The main technology involved in this IP EU project involves the development of a specific Middleware, a specific Communications System (also inside and outside home) and a Hardware Infrastructure [1].

PERSONA EU project is divided in 4 main areas: business (tries to find a place in market for the outcome of the project), social (specifies the needs of the elderly people), technical (implements the solution) and ethical.

This document just faces the work developed in the areas of Sensors and Actuators, that is, the domotic hardware infrastructure of PERSONA EU Project.

Thus, the main work issued in this part of the project consists in finding and developing appropriate hardware (find devices, develop boards) in order to fit the

[1] Work funded by the EU FP6 projects PERSONA (contract N. IST-045459).

specifications proposed in the Social are of this project, taking into account that the project should be installed in real homes.

The hardware involved in this project belongs to different classes, and mainly, we have identified 5 types of devices:

- Sensors: security and environmental sensors.
- Actuators: security and environmental actuators.
- User Devices: multimedia devices information (video, audio, graphics, etc.) as TV, screens, speakers, etc.; and Data devices: the use of more information than multimedia (Personal Mobile Devices, computers, IP cameras, servers, etc.)
- Specific Devices (Health care devices and other specific devices)
- Smart Textiles

This document reflects the necessity of installing a set of devices in an existing and usually old flat. So, there are some physical aspects to be taken into consideration, as there live elderly people (usually just one), where the environment should not be changed radically. Thus, PERSONA should avoid installing wires and placing wires or other objects on the ground and on the walls for both not increasing the probability of falling down and not changing the environment where the elderly lives, when possible.

Following this idea, the project should focus its efforts in placing wireless devices. Wireless devices not only from the point of view of their communications, but also from the point of view of their power supply. Thus, they should have a long life battery included in them.

Another key aspect to be taken into consideration is the final cost of the project, from the point of view of the user, since it is expected that PERSONA will be a final product in the market. To do it, we decided to create a set of PCB to connect the sensor/actuator and a transceiver (together with a microcontroller) that communicates the data to the PERSONA Central System. As homes have different sizes, walls, etc. Zigbee was chosen as the communication system, since it allows multihop communications by creating a mesh network, and it has low power consumption (from now on, the set sensor/actuator + PCB + microcontroller + transceiver is called Device). This solution had very good results respecting the final price since there exist a wide quantity of devices with no communication issues, cheaper and allowing that the specific communication protocol of the project could be programmed without being constrained by any device provider. Therefore, we chose (when possible) totally wireless devices (also linked with the previous aspect) to decrease the price of an installation, and trying to choose always cheaper devices in market.

That was the most important issue concerning hardware respecting other similar EU projects as, for instance, AMIGO[2], ASK-IT[3] and SOPRANO[4]: it was needed to develop new hardware that allows a low-cost integration of generic de-

vices (usually sensors/actuators) found in market in the same communication network.

The overall system has not still installed in a real home, and for that reason we cannot report feedback from real users, but it has been tested in a Living Lab with successful results from users using it during several hours. We also expect good results in real homes. The chosen cities are San Vicente de Raspeig (Alicante, Spain) and Odense (Denmark).

This document is structured in three chapters: an introduction, the list of devices used and the PCB designed.

2. List of devices

A PERSONA Device is composed by a PERSONA ZigBee communication system (transceiver + microcontroller) and a sensor/actuator. The sensor/actuator can be a commercial one or it has been created specially for this project, but the most majority are commercial, since its final price is lower.

The final list of sensors, actuators and specific designs is exposed in the following subsections.

2.1. Security sensors

- **Smoke Sensor**: optical on/off sensor that detect if there is smoke.
- **Carbon Monoxide Sensor (CO):** on/off sensor that detects CO.
- **Gas Sensor**: on/off sensor that detects gas.

2.2. Environmental sensors

- **Motion Detector**: on/off PIR sensor that detects motion.
- **Magnetic Contact Transmitter (Door, Window & Fridge):** Passive sensor that detects if the entry home door or a window or the fridge is open/close.
- **Faucet State Sensor**. On/off magnetic flow switch.
- **Home Appliances State Sensor**: It detects if some device is switched on. It is a plug interface of the device to the power grid. For instance, it is used to not forget any device switched on when sleeping.
- **Temperature/Humidity Sensor**: Digital sensor that provides the temperature and humidity inside home.

- **Water Detector (floor):** Infrared sensor that detects flooding.
- **Glass Break Detector:** Vibration sensor that detects if a window is broken.

2.3. Actuators

- **Switch on/off any device**. Interface of a It switches on/off a device. It is a plug interface of the device to the power grid.
- **Controllable Heater System**: Controls electronically the heater system of a home by applying voltage to it.
- **Blinds Actuator**: Motor that open/close blinds.
- **Curtain Actuator**: Motor that open/close curtains.
- **Water Actuator**: Motor that opens/closes the general faucet of the home.
- **Siren**: It activates a sound alarm.
- **Light Actuator & Detector**: It is a dimmer that controls any light at home. It can switch on/off any alight and provide its intensity.

2.4. Specific Designs

- **Electronic Weight**: electronic weight adaptable to wireless communications.
- **Bracelet:** it detects when the elderly falls down and the activity done with one hand (for controlling mobility exercises). It also will have included a tracking system to localize the elderly at home (this option can be used to control abnormal behaviour), a vibrator to inform about events and a panic button.
- **Beltclip:** it can measure the movement activity of the elderly and can control when the elderly falls down. Both the bracelet and the belt will complement each other the information regarding the falling down problem.

3. Designed PCB

To allow a low cost project, it was necessary to create a common platform to integrate all of them. To allow it, there were designed three kind of boards (PCB) that complied the general specifications of the majority of the sensors and actuators of a domotic project. That is, on/off sensors and actuators that may need a 230V power supply or battery supply.

This section is divided into two parts: the first one refers to generic PCB, valid for every domotic project, and the second one are specific PCB designs needed to carry out specific devices of this project.

3.1. Generic PCB

Mainly, the sensors and actuators, depending on their power consumption, can be categorized in two classes: low power consumption (batteries are enough) and 230V power consumption (typically motors, actuators and specific sensors). It is mandatory that low power consumption devices need to maintain the same batteries, at least, during one year.

There are three standard PERSONA ZigBee Boards: 230V Sensors for sensors that need wired supply, Portable sensors for sensor that has a low power consumption and Pure Relay Actuator for actuators. As actuators usually need much more power consumption than sensors, their generic PCB should not include the possibility of connecting a battery (just 230V).

3.1.1. 230V Sensors Board

This group of devices is composed of sensors that, due to its power consumption and/or voltage supply type and value, can not work properly with batteries. The sensors can be active (needs of power supply) or passive, and most of them have relay outputs.

All the active sensors connected to this board operate at 12V DC.

The Microcontroller reads the information from the sensors, through Pull-up resistors connected to one of its input ports, and sends the collected data by means of its ZigBee Transceiver. In addition the board implements 2 analogic inputs at port 0.

Smoke Sensor, carbon Monoxide Sensor (CO), Gas Sensor, Motion Detector, Faucet State Sensor, Home Appliances State Sensor and Glass Break Detector are the sensors that use this PCB.

Schematic Design

The 230V Sensors Board has three parts: the 12V DC power supply (the usual sensors working voltage), the 3.3V DC power supply and the Microcontroller.

This board is directly connected to the 230V AC electric grid. The Power Supply unit is based on a 12V Transformer and supplies two power lines: a 3.3V (100mA) line to supply the microcontroller and a 12V (300mA) line to supply the sensors.

The 12V DC power supply is composed by a 12V transformer to reduce the voltage and to isolate the electric grid from the rest of the circuit, a rectifier bridge to transform the alternating current into a continuous one, a filter stage to eliminate all the current alternating components, and finally a regulation stage to improve the stability and output impedance of the power supply output signal. This signal is routed to an 8 pin clamp connector where the sensors are connected to obtain the supply they need. A fuse protects the board against peaks of current.

The 3.3V DC power supply is done by a regulator that, from 12V DC, provides a stable 3.3V DC signal to supply the microcontroller.

Finally, a 40-pin socket is included to connect the ZigBee transceiver. This socket connects it to the external sensors connector composed by 5 digital inputs and 2 analog inputs.

In addition to the above parts, the board includes an ON/OFF switch, a RESET Button connected to the microcontroller reset pin and three LEDs to show the state of the board: On/Off, Network status and Transmitting or Receiving.

3.1.2. Portable Sensors

This board is designed for the sensors that work properly with batteries and do not need to be connected permanently to the electric grid. These sensors are those that are supplied at 3.3V or do not need power supply (passive). All of them have relay outputs except the Temperature and Humidity sensor that communicates with the microcontroller using a digital protocol similar to the I2C.

Magnetic Contact Transmitter, Temperature/Humidity Sensor, Water Detector (floor) and the Electronic Weight are those that use this PCB.

However, in order to be prepared for new ‘portable’ sensors and/or actuators in the future, the board is designed to manage up to three ‘portable’ sensors, one ‘portable’ analog sensor and two ‘portable’ actuators. In this way, this board can be used as a universal interface to connect devices to the PERSONA System, with a 150mA maximum total current consumption.

The Microcontroller reads the information from the sensors, through Pull-up resistors connected to its Port 1 inputs, and sends the data by means of its ZigBee Transceiver.

Schematic Design

The Portable Sensors Board is divided into three parts, the 3.3V DC Batteries power supply, the sensors connection and the Microcontroller.

The board is power supply with two AAA 1.5V Batteries that provide 3V DC. The 3.3V DC signal is obtained by a charge pump voltage regulator that, from a

minimum of 1.8V DC, provides a stable 3.3V DC signal to supply the microcontroller.

In addition to the above parts, the board includes an ON/OFF switch, a RESET Button connected to the microcontroller reset pin and three LEDS to show the state of the board.

3.1.3. Pure Relay Actuators

This group of devices is composed of actuators that work as a switch, that is, are managed through a relay. In general, these actuators are motors that manage blinds, doors, curtains, etc. and relays that switch on/of the home appliances..

The Microcontroller is the responsible for receiving the orders from the central system and to activate the actuators through the relays integrated in the PCBs.

All the actuators use this PCB.

Schematic Design

The Pure Relay Actuators board has four parts: the 12V DC power supply (the usual power supply of the used actuators), the 3.3V DC power supply, the relay management and the Microcontroller.

This board is directly connected to the 230V AC electric grid. The Power Supply unit is based on a 12V Transformer and supplies two power lines: a 3.3V (100mA) line to supply the microcontroller and a 12V (300mA) line to supply the actuators.

The 12V DC power supply is composed by a 12V transformer, to reduce the voltage and isolate the electric grid from the rest of the circuit, a rectifier bridge to transform the alternating current into a continuous one, a filter stage to eliminate all the current alternating components, and finally a regulation stage to improve the stability and output impedance of the power supply output signal. This signal is routed to an 8 pin clamp connector where the sensors are connected to obtain the supply they need. A fuse protects the board against peaks of current.

The 3.3V DC power supply is done by a regulator that, from 12V DC, provides a stable 3.3V DC signal to supply the microcontroller.

The relay control circuit is composed of two independent relay outputs, which allow the switching of two different loads.

Each relay is activated by the microcontroller, and each relay output is configurable through a load selector, which allows the load to be switched in 3 different ways:

- Open circuit/12V Power supply: for loads that must be supplied with 12V voltage.

- Open circuit/230V Power supply: for loads that must be supplied with 12V voltage.
- Open circuit/Short circuit: for loads that only need to short-circuit their pins.

The output configuration is selectable by moving two jumpers for each output, in the relative positions 12V, 230V, ACT.

3.2. Specific PCB

This section describes the specific PCB designs of PERSONA project, not included in the previous section.

3.2.1. Switch on/off any device board

This board is an actuator by itself. It switches on/off any device that operates at 230V AC, 12V DC or has a relay input to be controlled (like home boilers).

3.2.2. Light Actuator & Detector

This board as an sensor and actuator. It detects the state of the light, switch on/off the light and change light intensity (dimmer).

This board is the responsible for managing the light of the home according to the user preferences. The Light Actuator board can be integrated at the wall, inside the electric boxes, or at the floor thanks to the plastic box where is placed.

References

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