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Collaborative Project of the 7th Framework Programme

1st Prototype Description

v.1

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www.BrainAble.org

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1 Document Purposes

The document aims to describe the functionality, technologies and structure implemented in the 1st BrainAble prototype, due in M12.

As foreseen in the project work plan, this prototype will be installed at FPING and ANET for the tests with the end users.

The document explains the first prototype structure in detail, including supplemental work that also addresses goals of BrainAble and could lead to various improvements later in the project. It should be mentioned that in this first version the system is able to control well defined applications.

2 BrainAble First Prototype description

The first prototype of BrainAble had to be ready in M12 and demonstrate the proof of concept of BrainAble.

This deliverable globally describes the functionalities and features of this prototype; detailed information on the different technologies used by the partners, and the interfaces between the different components within the project are to be found in deliverables 2.3 (Interfacing of Technologies), D3.3 (First BCI system available) and D4.2 (VR environments and elements, first prototype).

This first prototype is also called the ***Starting Environment*** and it contains applications of the following:

- VR system
- Social Services
- Smart Home

The goal of the first prototype is to implement an architecture that easily allows an adaptation and extension to different applications within the main fields of BrainAble. Beside this, this first prototype provides the following functionality in what is called the inner environment, which means controlling and communication to the closed environment, and what is called the outer environment, in this first prototype, the social interfaces to the outer world.

Hence, the consortium defined the following functionality:

- IPC (Inter Process Communication) between all the modules
  - BCI-UDPXML protocol for the interface AmI-BCI
  - VR-UDPXML protocol for the interface VR-AmI
  - URC-HTTP protocol for the interface URC-AmI
- Virtual Reality
  - Turn Light On/Off
  - Turn TV On/Off
  - Navigation in a virtual room

- Control of home automation devices
  - Turn Lamp On/Off
  - Turn TV On/Off
  - Channel Up/Down
  - Volume Up/Down
- Brain Computer Interface
  - Matrix interface
  - Hex-O-Spell interface
- Social capabilities
  - Micro-blogging

Those functionalities cover the expected services of, on one hand, the inner environment by means of the home automation control and, on the other hand, the outer environment through the micro-blogging functionalities.

Inner environment and outer environment does not include the complete set of functionalities because the goal of this first prototype is only to show a proof-of-concept of BrainAble. For example, if a user navigates to the smart home control system, then some of the smart home control options will not result in any real world change (such as opening a door).

The functionalities presented are controlled via the user interface. The consortium agreed to concentrate on two different user interfaces: the Hex-O-Select user interface and the Mask user interface both described in the deliverable D2.2.

2.1 General structure

An abstract version of the general structure is shown in the following figure.

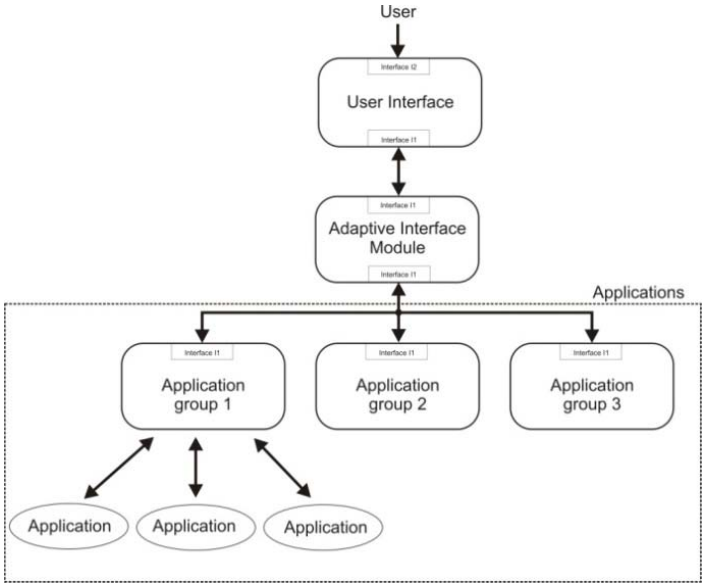

Figure 1. Abstract BrainAble structure

The user controls the application via the BNCI system and the User Interface (UI). Therefore, the Adaptive Interface Module (AIM) is the interface between the UI and the application groups. In the first year prototype, there is only one application group which is the Ambient Intelligence (AmI) that makes the decision whether forwarding the commands to the correspondent single application. Indeed, the AmI captures user behaviour and further user specific information and suggests possible commands according to the current context, that is, all the current status surrounding the user.

A more specific structural overview of BrainAble first prototype and interfaces between the different blocks is shown in Figure 2 . Hence, all three applications are controlled via the AmI block. In general, the first BrainAble prototype includes the following blocks:

- B1: User interface
- B2: Adaptive Interface Module:
- B3: Ambient intelligence including Context Awareness Module and the Domotic devices block
- B4: Virtual Reality including the navigation in the VR, the interaction with VR objects and avatar expression
- B5: UCH block containing the target adaptors for interfacing existing technology of Social Networks and Home Automation Devices, Environment Sensory Network and Urban Devices
- B6: Social Networks like Twitter
- B7: Home Automation Devices, Environment Sensory Network and Urban Devices

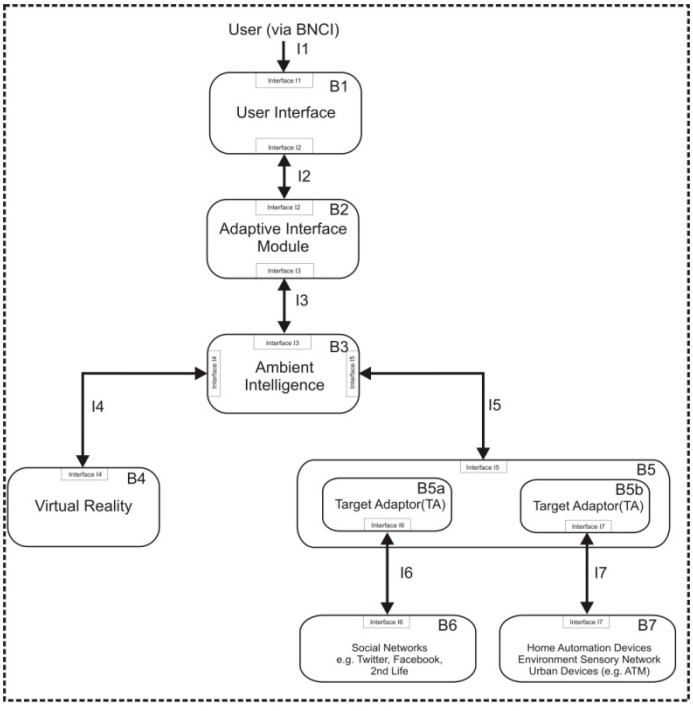

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Figure 2: General BrainAble prototype I structure

In Figure 2, I1 is the interface between the UI and the user. Hence, the user selects some items via BNCI system on the UI, which forwards the selection to the AIM. Therefore the definition of the interface I2 is required. The AIM block then communicates with the applications by sending commands and information to the AmIBlock and retrieving system information and data on how to set up the UI. The AmIBlock then distributes the commands to the VR block, the SN block and the Home Automation block with I4 and I5 and respectively and also retrieves information about their functionality. Regarding the SN and the Home Automation block, the AmI block holds a connection to the UCH block which incorporates target adapters (TA) to the existing technology of SNs and Home Automation, Environmental Sensory Network and Urban Devices.

2.2 Module description

2.2.1 B1: User Interface

There are two versions of the user interface, one is the Hex–O– Select UI and the other is a matrix based User interface in which the different options (ICONs) are arranged in a matrix as it is know from a P300 BCI. Additional information can be found in D2.2 and D3.3.

Nevertheless, it should be mentioned that the UI is just a tool which is used by the users to select the commands *e.g.* to control the home environment or to navigate in a virtual environment. User's actions are captured by the BNCI system, which includes the analysis of all EEG and non – EEG data. This BNCI system then provides information about the selection to the UI so that at the UI there can be a feedback given to the user.

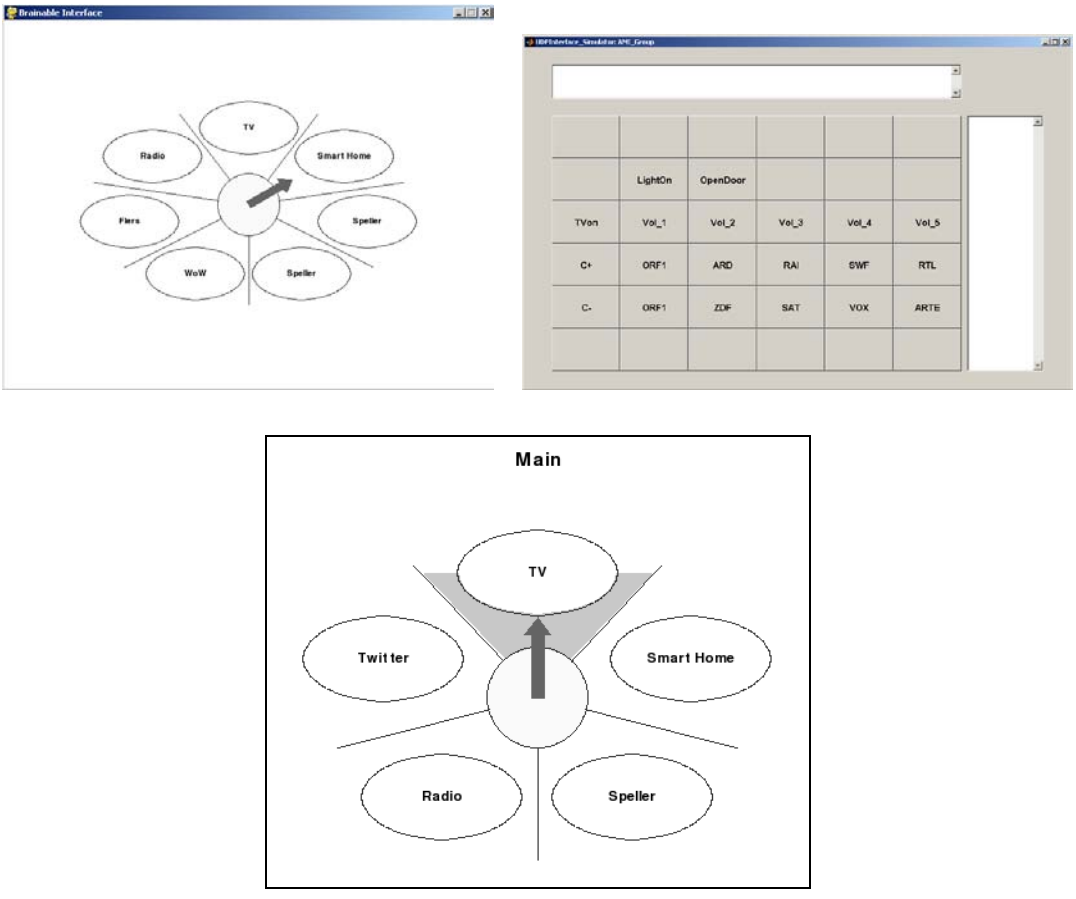

Figure 3. The top panel shows the HOS and Matrix interfaces alongside each other. The bottom panel shows an a newer version of HOW in which one of the options (TV) is highlighted.

The starting environment – that is, the main interface that users see when they launch the system and manage applications – is called Hex-O-Select (HOS). This central interface allow users to switch between different applications using different brain signals and other physiological inputs.

It was decided to base the design of this HOS interface on the Hex-O-Spell system that has been used for various low bandwidth applications, including BCIs. It was recently seen many other examples of research that adapts Hex-O-Spell for other types of BCI applications (some were presented at the TOBI Workshop II in Rome, for example), and so we are pleased with our choice of a central interface design.

Figure 3 presents the main interface for HOS. Users see a screen with a central hub and some options placed radially around it. An arrow extends from the central hub into the area that represents a different option. In Figure 3, the highlighted option is “TV”. The arrow slowly rotates clockwise, and the length of the arrow reflects the strength of the signal the user is sending. If the arrow exceeds a certain threshold (which is reflected as a long arrow), then the HOS interface launches the associated option.

For example, our current prototype can use real or simulated ERD activity, and can launch some applications. If a user wanted to launch Twitter, s/he would wait for the arrow to move to the Twitter region in the left side of the screen, then could imagine (or perform) hand movements when the arrow is in the Twitter region. This would cause the arrow to extend past the selection threshold, and HOS would launch Twitter. Additional details of the currently available functions, including a video, will be presented.

For the moment, users can use Hex-O-Select (HOS) to launch four BCI applications: World of Warcraft, a web browser, an SSVEP avatar control system, and a speller. Users could then control these applications with a BCI. HOS can also launch any application on a computer and send network commands to control devices.

HOS can accept input from three sources: a BCI based on ERD activity, a keyboard, or simulated data. We have tested HOS with different users with ERD activity and confirmed that we can launch the above applications. We have a video showing one someone using Hex-O-Select.

2.2.2 B2: Adaptive Interface Module

The AIM is the interface module merges the functionality of different control groups so that it can be controlled by one user interface. Furthermore it merges all the information the single control groups are sending via UDP and provides one description file that is readable by the UIs. The AIM block can also receive such description files online and it will support the UI with the updates so that the ambient intelligence block can adapt the UI via the AIM module.

On the other side, the AIM module gets the information from the user interface which item or command was selected by the user via the user interface. The AIM block than translates this information into the command have the correct syntax and send the information to the corresponding control group.

2.2.3 B3: Ambient Intelligent

The AmIblock serves as an interface block that connects the VR, SN and the Domotic Devices to the UI via the AIM. This is due to the fact that the intelligence has to adapt the system to the user's needs (Context-Awareness Module). Therefore the AmIblock will send information how to update the UI frequently if necessary. In this first prototype, the user interface is fixed by an initially defined setup description. Although "intelligence" in terms of context awareness will be added to the system in the further development steps, the system has to be prepared already in the first year prototype so that it is extendable to these needs.

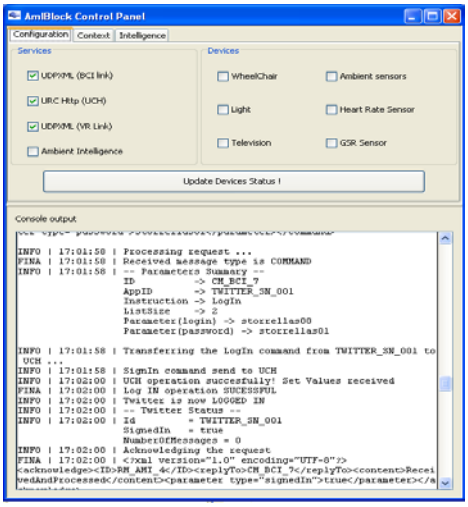

Figure 4. AmIBlock screenshot

Figure 4 presents the architecture foreseen for the AmIBlock. In particular, the CSM and the CAM that are explained below.

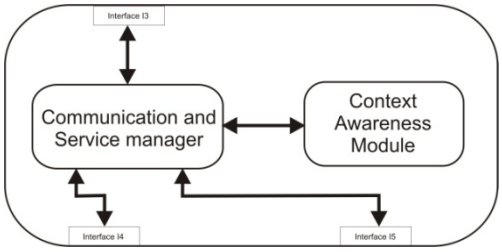

Figure 5: Structure of the AmI

The ***Communication and Service Manager*** (CSM) will receive the commands from the BNCI and proceed on forwarding data, interconnecting service blocks and supplying information for contextual processing.

The ***Context-Awareness Module*** *(CAM)* includes the algorithms to process the information coming from different sorts of sources so that it obtains or recognise the context. The sources of information to be used in order to infer the context are sensors from the *Environment Sensory Network* and the Affective and Physiological sensors perceiving the status of the user. For this prototype the variables (dark blue) shown in Figure 6 define the users context. Likewise, incoming events from Social Network and VR services as well as

user selections and inputs will be useful to detect user's intentions, preferences and thus act proactively and provide feedback.

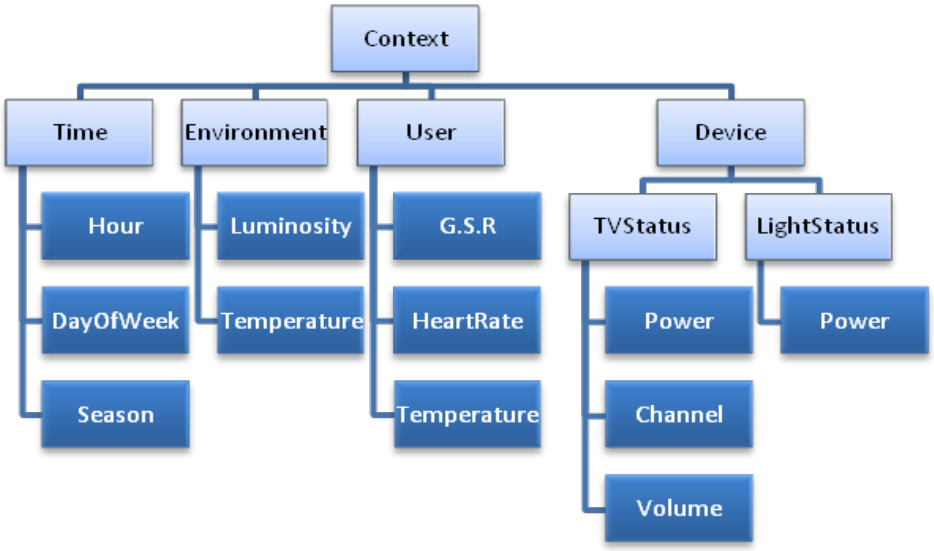

Figure 6: Variables defining the context (dark blue).

The CAM will include 2 context aware services

- **Automatic triggers:** based on pre-programmed rules the users home domotic devices react automatically when a particular context is encountered. An example of a rule could be: "When the user is sleeping turn off the light" with sleeping defined from the context variables as "G.S.R less than 3, and heart rate less than 80 ".

- **Personalised adaptation:** The system learns the user's particular habits and provides decision support in the form of easily accessible shortcut items in the BCI interface. The shortcut items are dependent on the context and the most appropriate commands are presented first. The AmI learns via the users repeated actions in specific contextual situations. For example, the system may learn that the user watches TV at 8pm and will present the "Turn TV On" at 8pm in the shortcut panel. Learning were done via machine learning techniques. In this prototype a Basian approach is used. Figure 7 shows an example of a probability model learnt by the system, showing a preference for watching TV on the weekend.

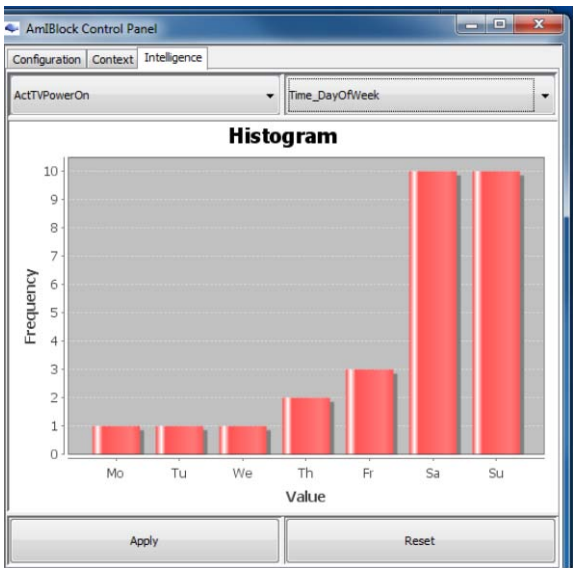

Figure 7: Probability of the days of the week given the command is TV ON

2.2.4 B4: Virtual Reality

Virtual Reality plays an important role in the BrainAble prototype since it allows the user to navigate in a virtual world and interact with the elements present in it. VR creates a user-centric virtual environment and tools for home automation control and BCI training.

Three different functionalities were included in the VR for this first prototype:

In-Home Virtual Navigation: it is used as training for him to get familiar with the BCI and at the same time it allows the user to have a navigation experience in an open space. In addition, the navigation allows the user to access to control the home devices which have a virtual representation. Once the user has selected a device, the BCI interface will change to the selected device control panel.

Home Automation Virtually Controlled: The user can select directly the device control (e.g. TV) via the BCI interface. Then, the VR accommodates the representation to the device current status along with moving the virtual representation of the user beside to the actuated device.

World of Warcraft: Users can play the popular online game World of Warcraft (WoW) using an ERD BCI. Users can simultaneously use keyboard or mouse commands, and hence this system is a hybrid BCI. We have tested our system with several users and developed a video. D3.3 has further details.

Figure 8: VR screenshot

2.2.5 B5a: Social Networks

The functionality of this block is to provide access to social applications for the user through the BCI interface. In this first prototype, the social applications envisaged are related to the micro-blogging service.

BrainAble aims at providing new ways of communication to disabled and giving them additional chances of sharing experiences with both disabled and non-disabled. Such integration will be tackled mainly by these social functionalities and is translated, in this first prototype, into giving them access to chat with people of any kind. For this reason, the micro-blogging service will be integrated into one of the most popular social networks: Twitter.

For a description of the available functionalities in each of the social networks applications we refer to deliverable D5.2.

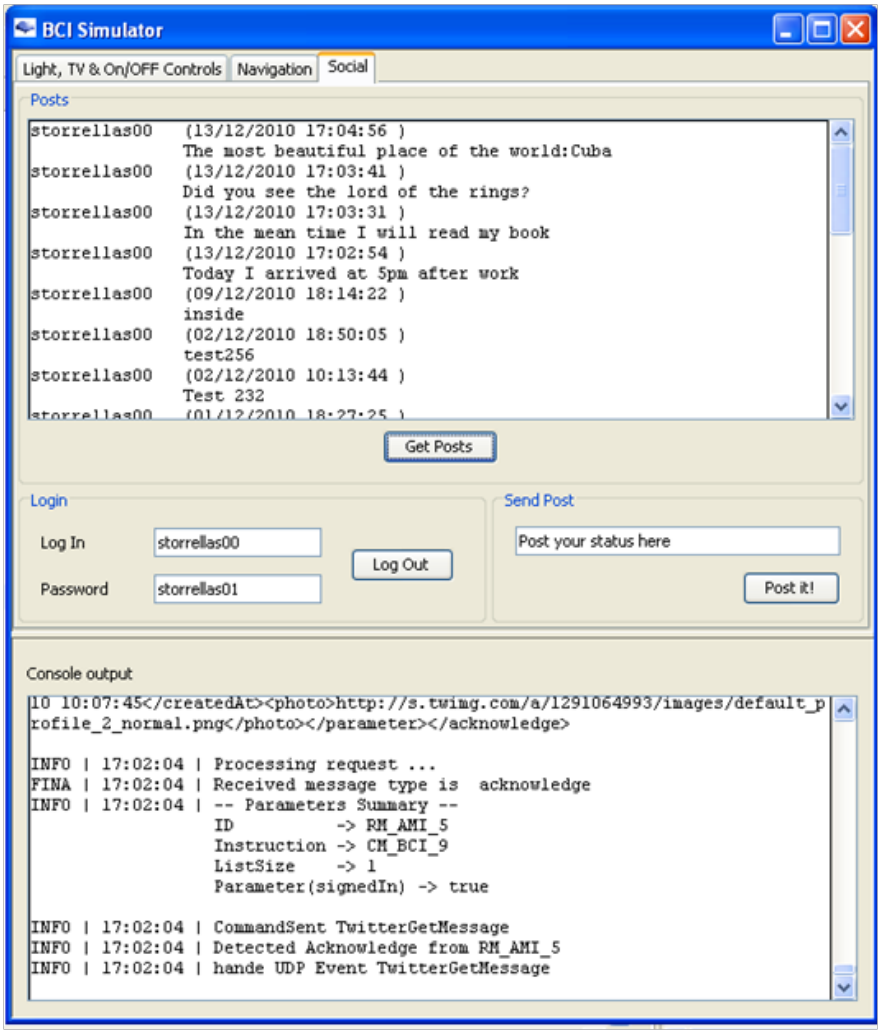

Figure 9: Micro-blogging service

2.2.6 B5b: Home Automation and Device Manager

The home automation services are controlled directly by this block which represents the domotic devices, environmental sensors and urban devices available in the BrainAble system. So far, the foreseen controllable devices for this first year prototype are:

- Light
- TV

The AmI needs to have devices able to sense the current context in order to act accordingly. In this first prototype, the sensor available is dedicated to capture environmental parameters:

- Temperature
- Humidity
- Light

This list may be extended or changed during the remaining duration of the project. The functionalities and examples of the devices used are available in deliverable D5.2.

Figure 10: Light and TV equipment for the First prototype

Figure 11: Weather sensor (Temperature, Humidity and Light)