Overall Approach

HOPE system can be modelled as a distributed system where many agents (subsystem located in each patient 's home) are connected to a main agent, the HOPE server, using IP communication due to Internet access is currently insured everywhere in Europe. So that, HOPE can be split up into two main blocks: the **Server Block** and the **Home Block** which represent the main agent and every subsystem at each patient's home respectively. On one hand, HOPE at Home Block covers functionalities associated to each patient's environment monitoring, indicating alarms if necessary, and is a friendly and accessible interface between patient and services or applications provided by the system. Thus, the Home Block offers:

- Data acquisition from environmental sensors at patient 's house
- Synchronization with main database located at HOPE Server Block, for updating either information about patient 's house environmental conditions in main database or updating application or service parameters at Home local database.
- Easy interfaces, using voice messages, for communicating with the patient.

Main objectives or functions can be modelled like different blocks or components that can be observed in Figure 1.

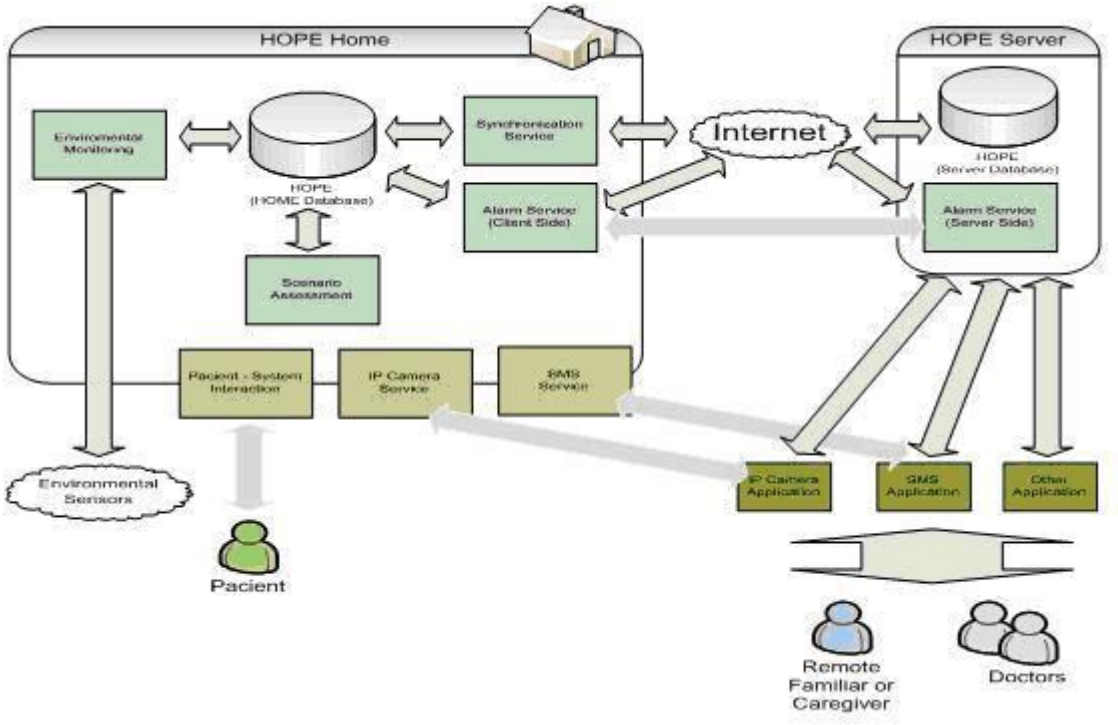

Figure 1: HOPE System Architecture

On the other hand, HOPE Server Block is responsible for the common functionalities provided by the HOPE system, including the following ones:

- Storage all information from any Home System
- Environmental data assessment to identify the most appropriated scenario
- Indicate an alarm as soon as possible in case of environmental condition assessment identifies any dangerous scenario
- Send SMS to inform the relatives, doctors and caregivers
- Give interfaces to relatives and doctors to access to the different services offered by HOPE

Methodology

From the very beginning of the project the technical team had designed the whole system architecture and the logic on which the system would be based. The system was divided in several subsystems that collaborate with each other, and each partner was responsible to develop one or more subsystems. The initial strategy focused on the client-server approach. Data retrieved from the environmental and health sensors are stored both in client and server sides, in order to ensure the integrity of the collected data and avoid the leak of information that may be critical for the action undertaken from the Multi Criteria Decision Making service.

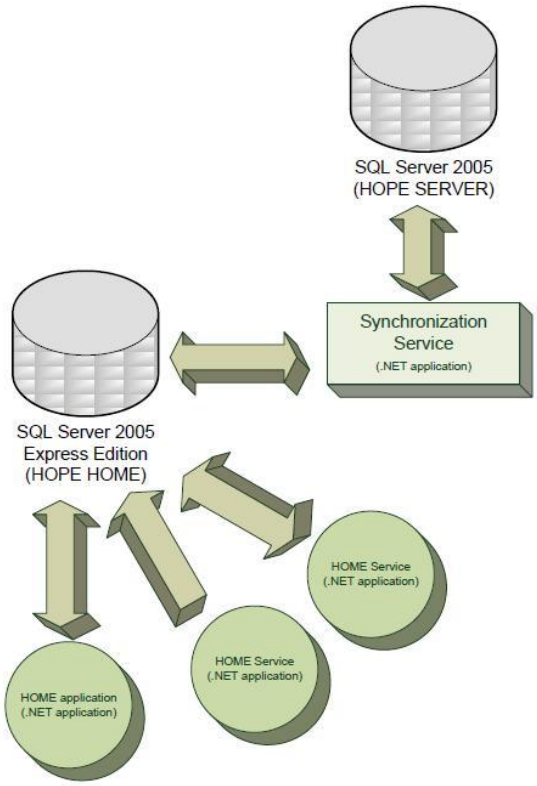

Figure 2: Client-Server Approach

The project required also the development of a methodology in order to identify some of the basic uses of the HOPE prototype. The methodology of constructing **Scenarios** provided a means of mapping user perspectives and requirements, while **Use Cases** provided an outline of the information consumed and produced during key episodes within a scenario.

Technology used

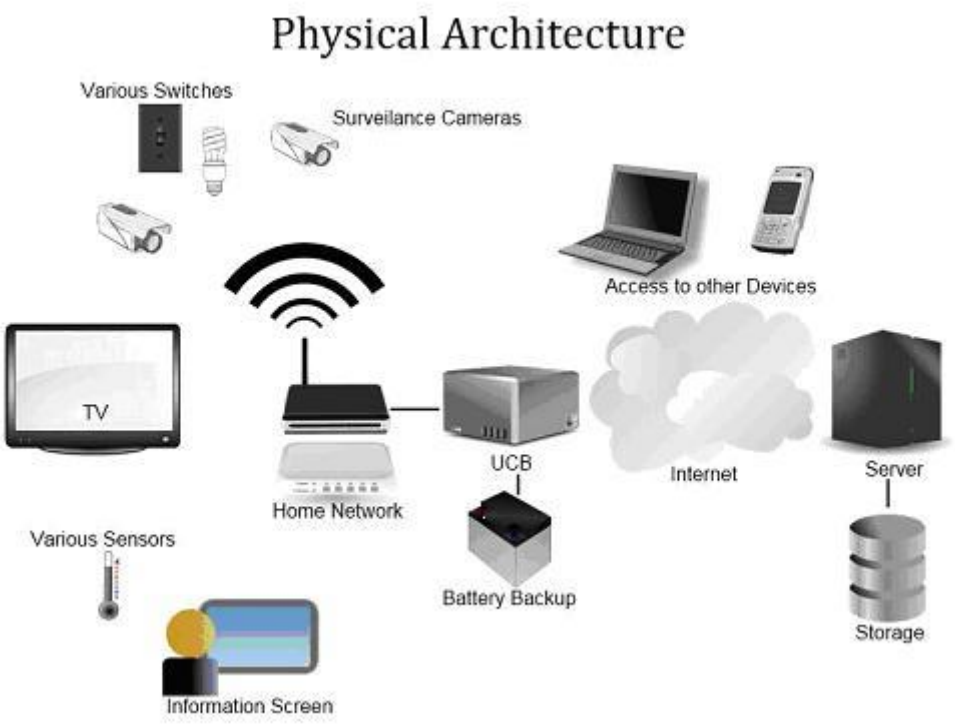

Figure 3: Physical Architecture

Figure 4 illustrates the physical architecture of the HOPE System. From left to right we have the various HOPE peripherals that include sensors, switches, cameras, monitors, etc., the home network appliances responsible for the wired or wireless connection of the peripherals with the UCB, the UCB itself connected to the server and remote storage via the internet, and an example of other devices that will interact with the system via the internet.

The networking medium differs according to the device connected. The connection between home and server is normally over the internet via a DSL connection with static IP. The router, switch and the UCB are naturally by connected via Ethernet or Wi-Fi. Wi-Fi or Ethernet may also be used for connecting the cameras. Every other sensor and switch will be connected to HOPE via the **ZigBee** network.

There are three different types of ZigBee devices which are all included in the HOPE System design:

✓ZigBee coordinator (ZC): The most capable device, the coordinator forms the root of the network tree and might bridge to other networks. There is exactly one ZigBee coordinator in each network since it is the device that starts the network originally. It is able to store information about the network, including acting as the Trust Centre & repository for security keys. This will be connected to the HOPE System Engine.
✓ZigBee Router (ZR): As well as running an application function, a router can act as an intermediate, passing on data from other devices. It will be embedded inside one of the sensors.
✓ZigBee End Device (ZED): Contains just enough functionality to talk to the parent node (either the coordinator or a router); it cannot relay data from other devices. This relationship allows the node to be asleep for a significant amount of time thereby giving long battery life.

To continue with the communication architecture, let's discus the connection between the UCB and the sensors

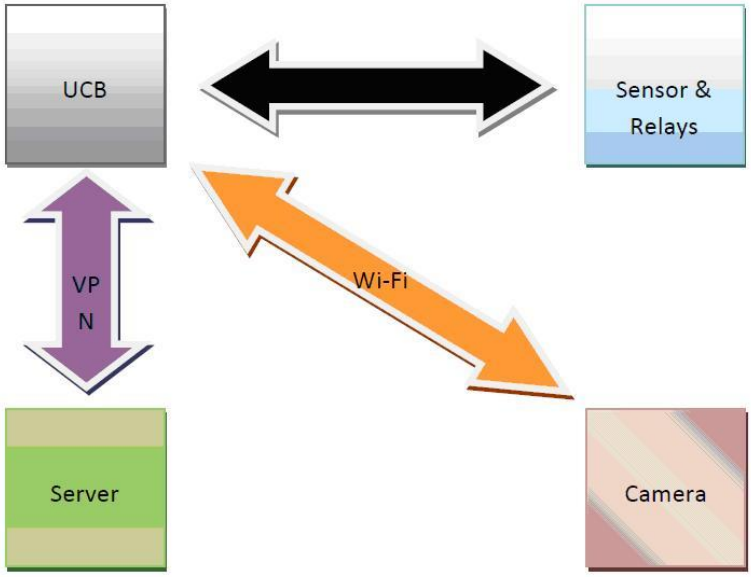

Figure 4: Communication Architecture

The UCB, where the System Engine is installed, is the central node of our system. The connections to other nodes are bidirectional and different in medium and technology as different needs require different solutions.

It should be obvious by now that ZigBee is probably the optimal choice, for networking with the sensors, with orientation to healthcare. One of its great advantages and great help for out project, apart from being wireless is the long battery life and responsiveness. A critical system as one involve in healthcare should be greatly responsive.

The WI-FI connection with IP cameras is really the standard with wireless cameras. It is easy to setup, uses normal mains power, and very secure in contract to RF cameras where the signal is available for every one to receive and watch without any encryption. In environments with network infrastructure normal Ethernet connection is used.

Sensors used

For gathering all the environmental conditions inside the patient's house Zigbee technology was chosen because of its convenient for such purposes properties e.g. low battery consumption, eligibility, extensibility and coverage area. The sensors used in the project are:

(a) ZigBee Coordinator:

This device is just a USB dongle that plugged to a PC and acts as the coordinator of the ZigBee Wireless Sensor Network (WSN) that the HOPE system uses to gather the information in the assisted ambient living, and manages all the messages and devices of the devices joined to this network.

According to this, the coordinator is the main device of the WSN, which allows the rest of the devices to be connected to it and receive all their information. The network creation is made automatically, and when the coordinator is present the rest of devices start to send their messages to it, giving information about the all measured parameters: temperature, movement, door states, etc...

(b) Door state sensor:

This sensor (ZDoor) gives information about the state of the door e.g open/close.

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(c) Temperature sensor:
(d) Movement sensor:
(e) Gas leak sensor:
(f) Plug sensor: This function is performed by the ZPlug device sensor, which consists on a pluggable device which can measure the power consumption of other device plugged on it or even disconnect it when an order for doing it is received.
(g) Care sensor: This function is performed by the ZCare device sensor, which consists on a wrist which has to be worn by the elderly in order to monitor their pulse heart rate constants and detect emergency situations like falls.

For gathering all data into the local computer Hope Local Logging Service was developed. This application, using the serial port COM reader component as a class library, just has to receive the messages waiting on the serial port through the use of the facilities implemented by the COM component, and then save it into the local database. This service processes all information arriving from devices, in other words, it receives any message which comes from every device, after that, specific action for updating a device's related information will be called, like status or data flows. Also, the service could change status of Zigbee devices, e.g switch on/off a Zplug.

Hope Conference Application

Hope Conference is software that allows a video call between the user Patient and the user Doctor, using two PCs connected to the Internet. It is essential that the two PCs be equipped with headphones, microphones and webcam.

Minimum System Requirements

(1) Windows Seven 32 bit, **(2)** Framework .Net 3.5 or upper, **(3)** 32 bit (x86) 1 GHz Processor or upper, **(4)** 1 GB di RAM (32 bit), **(5)** 3 MB free space hard disk, **(6)** Graphic card DirectX 9 with driver WDDM 1.0 or upper, **(7)** Headphone, **(8)** Microphone, **(9)** Webcam

Figure 5: HOPEConference Application

Audio Messages Application

The Audio Messages Application is installed in the client's PC. Its main functionality is to notify the patient in a case of emergency to take action, by sending an audio message to him. In order for the audio message to be broadcasted in all rooms, wireless speakers were mounted on the walls in several places inside the house.

The audio message is then sent to all wireless speakers in the home, in a broadcast way, to advise the patient about the action to be performed.

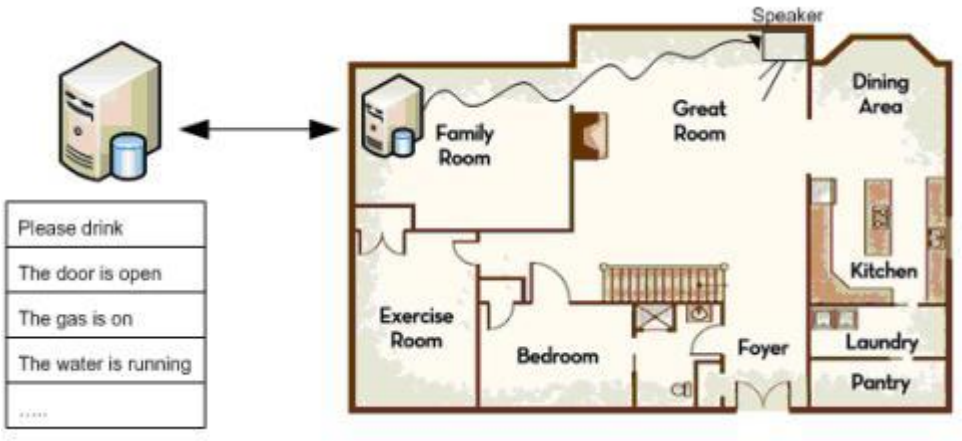

Figure 6: The Audio Messages Application

The speaker hardware is implemented in order to achieve a reliable wireless audio communication of the pre-recorded audio samples, in analogue broadcast all over the house, using RF modules at 433 MHz. The following RF modules, produced by Aurel Hybrid Microelectronics, would be used for the speakers' implementation:

-TX-FM Audio 8110 433 Mhz
-RX-FM Audio 8110 433 Mhz

The TX modules present the following technical specifications:

-Bandwidth LF between 20 Hz and 30 kHz
-carrier frequency deviation of ± 75 kHz
-With a supply voltage of 12 volts the RF transmitter produces an output of 10 mW at 50 Ohms with a consumption of 15 mA
-To improve the S / N it could be used a network of pre-emphasis
-The sensitivity at low frequency is about 100 mVpp
-Dimensions: 40.6 x 3.5 x 1 mm.

The RX modules present the following technical specifications:

-the output bandwidth BF from 20 Hz to 20 kHz with a typical signal of 90mV RMS
-RF sensitivity -100 dBm
-input impedance 50 ohms
-Squelch control output and the possibility to use a de-emphasis circuit
-3 Volt supply voltage
-Dimensions 50.8 x 20 x 4 mm
-Both modules comply with CE ETS 330 220
-To the receiver modules is coupled an amplifier BF and a speaker.
-For the amplifier BF has chosen to adopt a module based on the integrate TDA7241 SGS-Thomson.

The BF amplifier presents the following technical specifications:

-The heart of the circuit is the TDA7240, a low frequency amplifier encapsulated in a container Heptawatt with seven feet.
-This chip is capable of delivering up to 20W RMS on a load impedance of 4 ohms because internally configured as a bridge providing a high
gain, thermal protection and short circuit protection on the load.
-Compared with traditional monolithic amplifier the TDA7240 has the lowest harmonic distortion and lower noise, and then it is the best choice to the realization of audio amplifiers including in HI-FI.
-The entire system is boxed in a suitable plastic container and all is powered by an external power supply.

Multi Criteria Decision Making Module
The User Scenarios Based Application comprises the Intelligent Scheduling Tool of the Hope Project, which enables the whole system to act only when necessary. Its logic is based on simple scenarios that express the user's needs, and reassure their safety and welfare.

In order for the system to always be informed about the situation into the client's house, there is a service called "RetrieveState" that runs on the central Hope server every 1 minute and combines all the data into an encrypted string. This string afterwards gets decrypted by the Multi Criteria Decision Making (MCDM) service, that checks whether the predefined scenarios have occurred or not. In case that a scenario occurs, the MCDM service forces the appropriate applications (e.g. Audio Messages Application, SMS Module) to run, in order to urge the patient himself or his relatives and doctors to act, according to the predefined scenarios.

SMS Application

The service developed within the HOPE system, achieved via the use of SMS, will allow relatives or caregivers to be informed about the current status of the patient, especially about the latest messages sent by the system to him.

Hope web application

HOPE Server is responsible of the main functionalities provided by the HOPE system. To accomplish this there are information and plenty of settings on the server. For the data input, supervision, easy remote access of the information we have developed a web application.

The data can be viewed in various ways.

- Directly from the table they are presented
- By requesting a report.
- By requesting a statistic.

Example given, one of the most common tasks the user needs to accomplish via our system is examine the values on the devices installed in the remote locations.

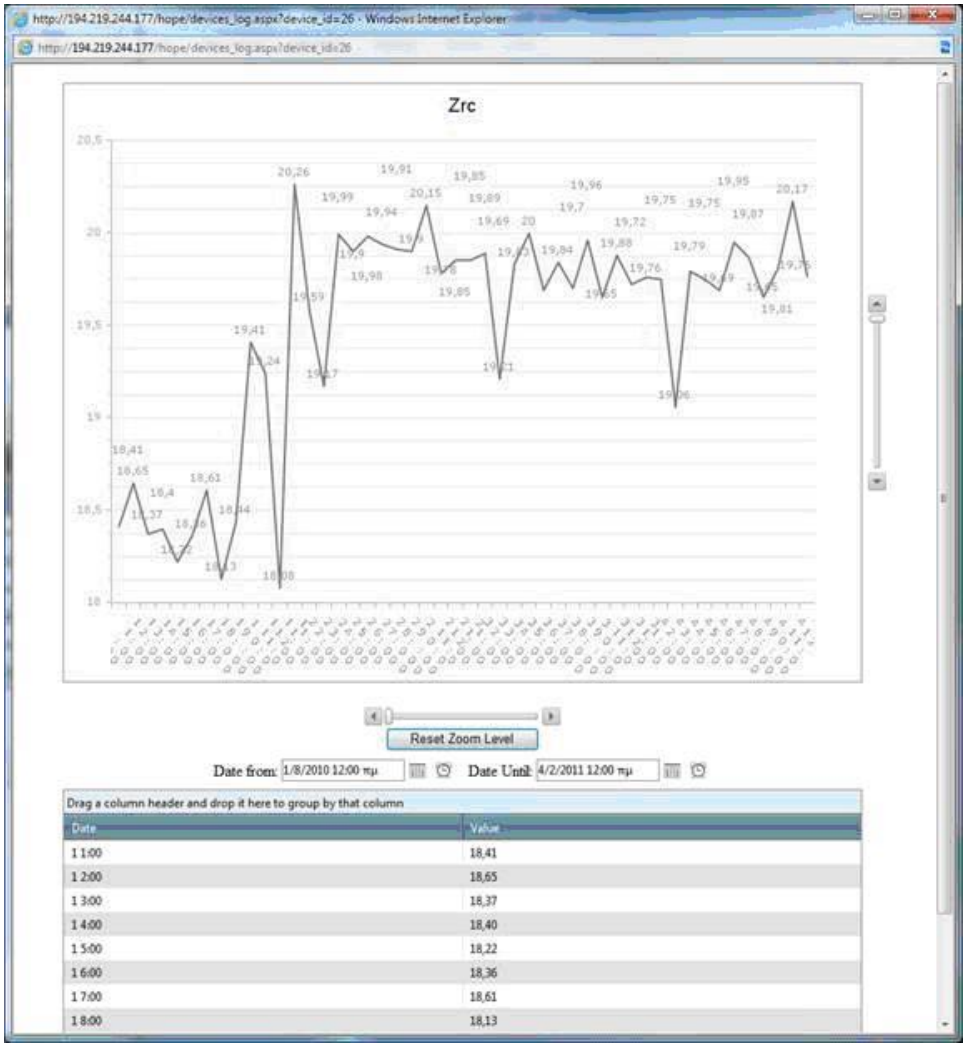

Figure 7: Getting a report