EIB Bus as a Key Technology for Integrating People with Disabilities. A Case Study

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Introduction

In the last few years many systems have been designed to facilitate the integration of disabled people (PWD's), particularly those with severe problems of movement, caused in many cases by brain paralysis.

The approaches that have been taken have supplied valid solutions but always at the cost of being based outside integrated, commercial and flexible systems. This has made the co-operation between the different groups of researchers specialising in this subject difficult.

Our aim in this project has been the design and development of an intelligent home control system (control of the house environment), accessible to people with different grades of disability and to those who retain all their inherent functions; the called "design for everyone". The development has been realised in collaboration with the "Tutelary Association of the Disabled" ASTUS of Cartagena.

To this end, a demonstration model of the system has been designed, which combines all the basic control functions, and which has permitted the development and debugging of the software and hardware elements necessary in our centre of investigation.

Since the demonstration model is now operative, the system will be installed in the house of a disabled user (still in development), i.e., a "real case" application.

The proposed solution takes advantage of the great flexibility that the EIB system offers, as well as the numerous tools available for the development of new applications in this area.

Disability and environmental control [1]

It is obvious that an environmental control that includes communication functions adapted to a user with motor disabilities must be structured around a computer.

Excluding users with visual disabilities, when the remaining ability of the PWD and his degree of functionality make impossible the access to the keyboard or mouse, the technology must help overcome the barrier to access to the environment control system (computer), using hardware and software tools.

There are two possible solutions to overcome this barrier to access:

1. The development of hardware (keyboard, mouse, joystick, etc.) totally compatible with current models, but adapted to the reduced abilities of the user. In this case the software that a disabled person utilises, would be identical to that used by an able-bodied person.
2. Development of specific applications for disabled users which would work by using a very reduced range of entrance signals (for example, the activation of a switch).

The current tendency in the development of this kind of solutions has been labelled "design for everyone": to find the optimum design as well as the software and the hardware which allows access to the system for people with very different degrees of disability (from serious disability to total functionality). This implies the advantage of achieving a commercially competitive system because it increases notably the amount of potential users.

The solution adopted in our system is the development of a software following the already mentioned "design for everyone". The main aim is to be able to do a wide range of different actions from a single functionality (least favourable case). To do that, we have to start from the signals that the disabled person can still produce, received by means of appropriate sensors (push buttons, capacitive sensors, EMG signals, etc.) and to realise the necessary adaptations to select the desired option. This is done by the use of special scan techniques in the design.

Scanning techniques rely on the fact that the user can see a selection of different actions, which appear on the screen. The list of actions on the menu are highlighted cyclically, so the user selects the desired one by means of the production of a signal during the period the option is highlighted. From amongst these techniques the most used is the block scan (figure 1); this involves the actions of each menu (N in total) being highlighted in groups. First of all, we go through two groups of N/2 actions. When one of them is selected, it is divided again by two (N/4 actions) and so on

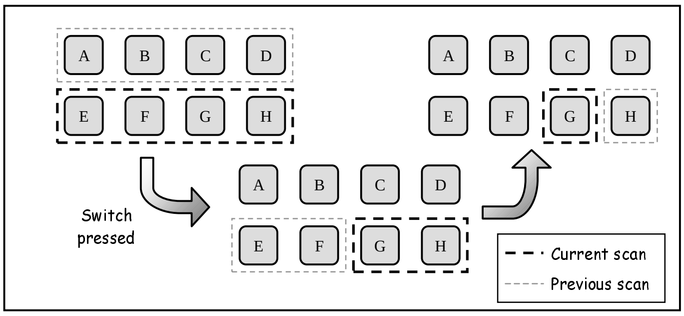


Figure 1
Block scan

until we arrive at the desired action. In this way we minimise the average time taken to access the action, as the necessary amount of selections is $\log_2 N$.

Controlled Functions

This system must allow the integration of the functions that disabled users must have access to, these are on the whole common to any conventional intelligent home installation.

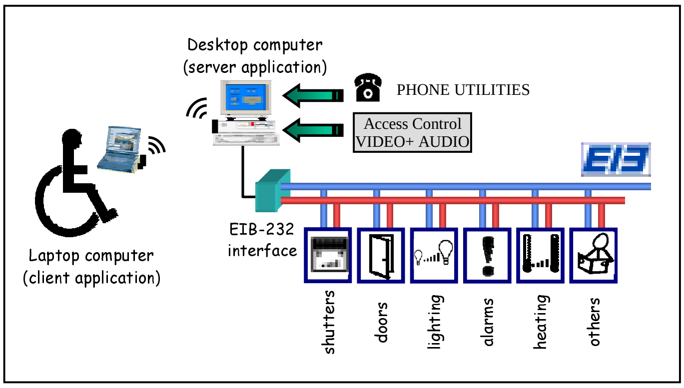
Summing up :

1. Environmental control: An essential function in the integration of the disabled person. They must be allowed to control all the elements which they would normally never have access to because of their physical impediments: lighting, heating, shutters, and access to the home (motorised door and integrated audio visual systems).
2. Security and vigilance: Alarm for the detection of intruders and safety alarms: gas, smoke detection etc.
3. Communication: Access to the telephone in order to make personal and emergency calls to pre-programmed telephone numbers with pre-recorded messages.

General Structure of the System

Figure 2 shows the different elements integrated into this system. To access the typical components of the house (sensors, press buttons, etc) a EIB bus has been used, which supplies the main characteristic for the integration: the possibility of realising the control through a personal computer which will be used as a bridge by the disabled user. This leads us to propose two possible solutions. We can implement in a single computer the interface with the PWD (using scan techniques) and at the same time implement the software for the control of the communications bus, or else, we can program the control routines of the bus elements

Figure 2
System structure



into a desk top computer, and the interface with the PWD in a laptop computer of reduced dimensions and weight.
The first option has an important disadvantage: it is necessary to design a transparent RS-232 link to provide the communication with the bus keeping at the same time the mobility required by the user, which is not possible because of the necessity of realising high speed transmissions and audio and video signals as well as those used by the bus control.
The second option fits perfectly our needs: by using wireless local area network cards (according to the regulation IEEE 802.11), and by client-server applications the transmission of the audio visual signals and control commands is made possible. This solution increases considerably the flexibility of the system in its entirety and provides a high speed link (from 2 to 11 Mbps) and total mobility for the disabled person.
For the integration of the access control functions and of the telephonic communication functions, the desk top computer is equipped with a standard voice modem, sound card and a device to capture video.

Client application
The client applications and the server have been developed in C++ (Borland C++ and Visual C++).
The first (running in the laptop computer) is an easy to use graphic interface (figure 3), suitable for any kind of user whether able-bodied or disabled. As such, this interface allows the possibility of being run using scan techniques, a conventional mouse or a tactile screen. Its functional character covers a wide range of components installed in the different rooms of the house. These

Figure 3
Client application interface

are accessible through suitable selections of the different options the program screen offers.

All the parameters of the program configuration are stored in the Windows registry (figure 4), and include:

- Network configuration: TCP/IP socket for the communication with the server.
- Scan options: type and activation, scan period, etc...
- General parameters: kind of button, etc...
- Screens: hierarchic structure of the screens with the buttons on each of them. For each button it is possible to configure: text label, image (icon), following screen or the action realised (for example, turning the lights on.).
- Especial buttons.

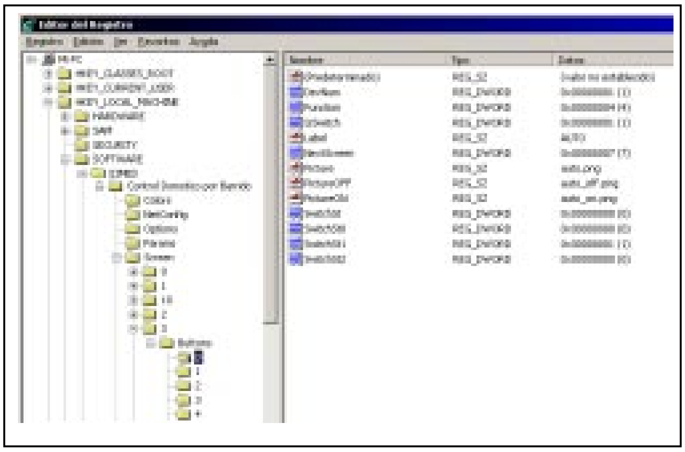


Figure 4
Client configuration (Windows Registry entries)

Server application

The second application consists of a server application (executed in the desktop computer), which exchanges data and commands with the mobile client (via TCP/IP) and with the EIB bus of the installation (via RS-232). The server realises all the control tasks in response to the clients requests, and also sends data, for example audio and video signals, when they are required.

The desktop computer therefore, will be the computer connected to the EIB bus through a RS232-EIB interface.

It is also in charge of processing the audio and video signals for the access control to the house and of managing the telephone calls: hands free telephone, automatic dialling and the transmission of pre-recorded messages, etc. The server application will normally be executed on a background level, in a transparent way for the user, who can execute other applications simultaneously. Therefore, the need for this computer does not imply additional expense, resulting in no increase in the cost of the project, because any available equipment in the house can be utilised (if any exists).

The graphic interface of the program is purely informative (figure 5) and does not permit any interaction with the user. It shows information concerning the commands exchanged during communication, current mode of control, data circulating through the bus, lighting level, temperature, etc,. All this data is very useful during the installation of the system and debugging stages.

The configuration and setting of parameters of the installation are realised through inputs in the Windows Registry (in the same way

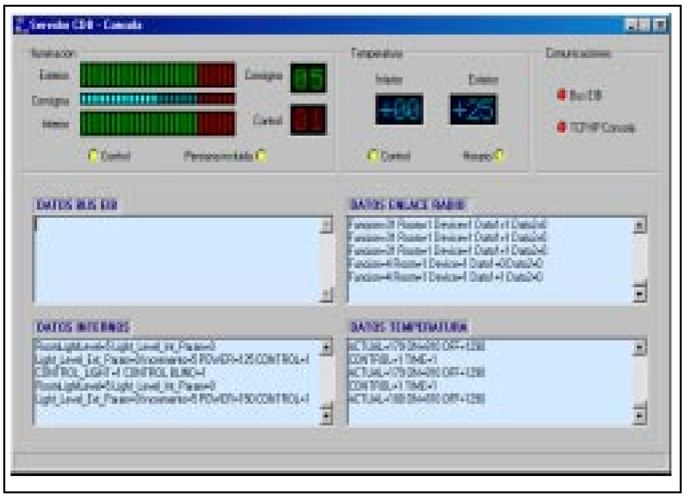


Figure 5 *Server application*

as the client), which allows us to make adaptations easily through an external application to any installation in a house. The development of an independent program which makes these configuration tasks easier is also a foreseen element of the system.
As an added advantage it is possible to have the client and server applications in the same computer, conveniently configuring the TCP/IP socket in both applications, by doing this we could dispose of a "conventional " tool for the control and monitoring of the bus; the communication between both applications would happen internally through the internally established TCP/IP connection, making network cards unnecessary.
Remote access is then also possible from any computer connected to the Internet, through communication with TCP/IP sockets.

Demonstration model

The system has been implemented in a portable demonstration model, which includes the functions of environmental control. The model is a conventional EIB installation to which the previously described elements have been added.
The basic aims of developing this demonstration model have been to: realise the design of the installation on a small scale, which allows us to fine-tune the system in our research centre, and to use it as an example of the working system to promote its installation in houses of disabled people.
The elements used are restricted to a single room (figure 6) but includes all the necessary devices needed for the control of the following functions (accessible from the client application in the laptop computer, and most of them manually as well):

- Lighting: on / off, automatic control with prefixed level and with the option of regulating the position of the shutters to take advantage of any natural light.
- Shutters: total or continuous, with automatic control.
- Heating: on / off, automatic control (transmission of the base set point from the client application) and timed control.
- Control of access to the house: motorised opening and closing of the door with a video and audio system to identify the person wishing to gain access.
- Alarms: Intruders, fire, flood, gas, etc,.
- System of emergency telephone calls.

As the demonstration model is now operational, the system is being installed in the house of a six year old disabled user with a retardation of phycomotor development due to a chronic encephalopathy, caused by a perinatal cerebral hypoxia.

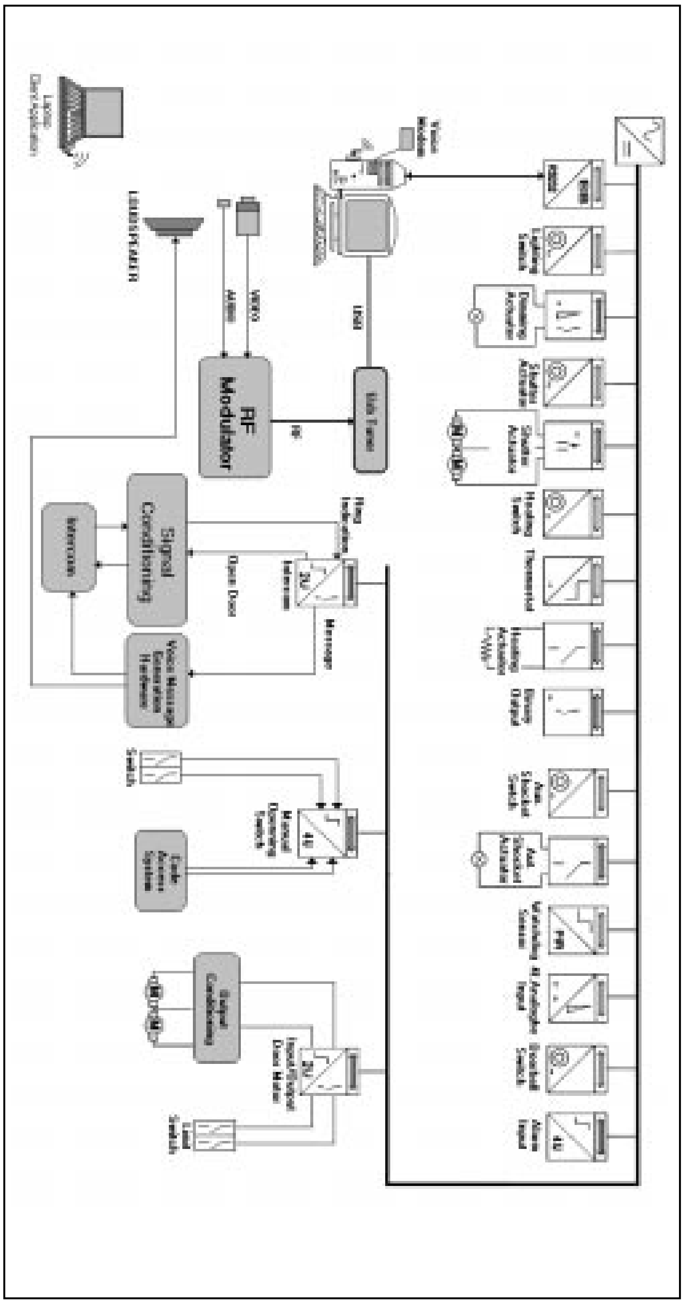


Figure 6
Demonstration model components

His pattern of movement makes the scanning techniques suitable for the easy access to the user interface of the application, using in this case a push button sensor especially adapted for the child.

The house has four bedrooms, a sitting / dinning room, two bathrooms and a kitchen, with a total floor space of 160m2. The functions that will be included are the ones which have already been described in the demonstration model: lighting, heating, shutter control of all windows, intruder and safety alarms as well as the telephonic communication and access control with audio and video transmission systems.

Once the construction and installation of the system is completed suitable studies will be undertaken to assess the degree of adaptation of the user to the system, studies will also assess the possible modifications and improvements that could be introduced in the future.

Conclusion

The installation of intelligent systems in buildings, especially in homes is destined in the next few years to occupy a distinguished place in the realm of integration and self-sufficiency of disabled people with both physical and cognitive disabilities.

The use of the EIB bus as key technology for the environmental control gives a series of qualities to the entire system that makes it different to other solutions adopted in this area. Firstly, it is a system of easy installation due to the simplicity of the bus cabling. Secondly, it is extremely flexible both in terms of possible modifications as well as possible extensions to the range of functions (qualities that have been contemplated in the control software). Lastly and perhaps the most important, it is a system which can be used simultaneously both by the disabled user as well as his family. The computer becomes the route of communication between the system and the user, at the same time people without disabilities will be able to use the push buttons and conventional EIB elements. It is important to emphasise as well, that the user interface design for the developed application takes account of its use by operators with very different degrees of disability, from people with some remaining movement, albeit extremely reduced (with disabilities such as these the only feasible option is through the use of EMG techniques.), to those users with total mobility, who can use the conventional mouse or the tactile screen.

At the same time the experience we have gained through using the demonstration model with disabled operators has been very positive and is making improvements to the system possible.

Future developments

In the future the following developments are foreseen :

- Implementation of the client application in a palm-top or PDA computer which will give to the system a greater autonomy and reduce the cost.
- Verbal control of the laptop computer application using the Via Voice SDK (IBM), taking advantage of the previous experiences of the use of these systems by the research group.
- Control of the elements by means of a infrared remote control (conventional or operated by means of scan techniques), which would eliminate the necessity of the laptop and desktop computers, making it ideally suited for applications at very low cost. Inconveniently, it would not be able to include the functions of telephonic communication or audio and video transmissions for the access control.

Literature

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