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SOFTWARE TOOLS FOR PLC PROGRAMMING AND INTERNET HMI IN DOMOTICS

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Abstract: Domotics is the technology for developing the automation of common installations in a house or building. Despite the high expectations due to the potential energy saving, comfort and security, there was a low increasing in the number of domotics installations. Main reasons are the diversity of existing products and the difficulties potential users perceive in their managing. Our research group has developed several software tools that simplify the design, installation and maintenance of domotics buildings. Also, they provide a friendly interface with the end user, for the local and remote supervision of the automated functions. *Copyright © 2002 IFAC*

Keywords: Automation, Communication control applications, Control panels, Decentralized systems, Human-machine interface, Programmable logic controllers, Software tools, Supervision.

1. INTRODUCTION

Domotics is the technology for developing and implementing the automation of common installations in a house or building. Safety, energy savings, comfort and communications are its main aims. There are many different domotics products and architectures (centralized, decentralized, distributed). They involve the use of technologies in the field of electronics, computation and telecommunications.

However, the increase of domotics installations since their origins is lower than expected. Some reasons for this low rate are:
- The variety of existing products.
- The difficulty end users can find in their management.
- The complexity in their design, programming and further maintenance.
- Their functionality sometimes doesn't match with that demanded by the potential users.

Several convergence criteria (Konnex, SCP, OSGI) have been formulated as solutions to the lack of standardization in most of the existing domotics systems.
The main characteristics a domotics system must have for general acceptance are:
- Simple and friendly interface with the user.
- It must be possible the remote access to the system.
- The modification of its features must not be painful.

Our research group, GENIA, from the University of Oviedo, has worked out a solution oriented to spread the implantation of domotics systems (Mateos Martín *et al*, 2000), (Mateos Martín *et al*, 2001). This solution is based on industrial programmable controllers (PLCs) and web technologies. Some software tools have been developed:
- SIMATICA (García Prado, 2000): this tool allows to configure all domotics functions and automatically generates the required information for implanting the system (architecture, components, electrical schemes, control program, manual of use, estimates, etc.).
- SIMAWEB (Valdés Fernández, 2001): this tool obtains the domotics project information from a database generated by Simatica. Next, it automatically generates web pages for the remote

handling and supervision of the domotics system. The Simaweb user can easily personalize the screens of the domotics installations.

In the following sections we present those aspects in more detail. First, we present a brief review about the current state of the art in domotics and the characteristics of the main convergency trends in this field. Then, we introduce the types of management of domotics systems we consider most appropriate, regarding the end user. It follows a summary with the basic characteristics of the software tool Simatica, and the types of supervision it currently has, both local and remote (by telephonic control) . Finally, it is presented the adaptation of Simatica that is now in progress for performing the remote control and monitorization of the domotics system via internet.

2. CURRENT STATUS OF DOMOTICS

We have to go back to the end of the 80s and beginning of the 90s, when we record the first initiatives of implementing automatic installations in houses. The initial studies on this sector, awoke very high expectations due to the potential energy saving, comfort and security. But this phase was also characterized by the following negative aspects:

- a great ignorance of domotics possibilities and uses, and a low number of companies specialized in this sector.
- A short offer of small integrated systems, difficult to install and use by the end user, and very expensive.
- The lack of trained staff in the sector.
- The unfortunate image the media gave by relating this discipline to science fiction, far from its possibilities and purposes.
- The lack of software, for the design and monitoring of the systems.

However, this discipline has experienced a low but constant evolution (Departamento de Ingeniería Eléctrica de la Universidad de Oviedo, 2000; Kranz and Gisler, 2002). A proof of this, among others, are following facts:

- New companies have been created and work exclusively in this sector.
- The market has been automatically ruled and many of the products that did not fulfilled the expectations and needs of users have disappeared.
- There have been price cuts in some of the new design products. The development of the market and the knowledge of the real user needs may allow a redesign of the products and a price reduction.
- The first constructions included several systems and applications difficult to use, the newer ones have a reduced equipment with better features and easier to manage.
- Numerous seminars have been held in fairs and forums in order to promote the domotics.

2.1 Convergence criteria

Nowadays, the lack of standardization in most of the existing domotics systems has derived in three main convergence criteria (Antón J., 2001): Konnex, SCP and OSGI.

Konnex (Weber, 2000) is a project of three European associations:

- EIBA (European Installation Bus Association)
- BCI (BatiBUS Club International)
- EHSA (European Home System Association)

Its convergence objectives are:

- Create an only standard for domotics and immotics that covers all needs and requirements of professional and residential installations in the European field.
- Increase the presence of domotics buses in areas such as air conditioning or HVAC.
- Improve the features of the physical communication media, specially in radio frequency technology.
- Introduce new working ways that allow us to apply the philosophy Plug&Play to many of the typical household devices.
- Contact service supplying companies such as telecommunication and electricity companies, in order to promote installations of technical tele-management or domotics in households.

In short, the aim is to create an only European standard from the EIB, EHS and BatiBUS, able to compete with other north American systems, such as LonWorks or CEBus, in quality, features and prices.

SCP (*Simple Control Protocol*) (HNT, 2001) is an attempt of Microsoft and General Electric of creating a control network protocol that can consolidate itself in all automation applications for buildings and households. It tries to arrange the offer in the USA for this matter (X-10., CEBus, LonWorks, others), to promote the convergence of all these towards an open protocol free of royalties and to develop a series of products that meet the requirements for automation in households. This project is officially only two years old, although there are previous works. Its development did not begun from scratch: CIC (CEBus Industry Council) joined the companies that promote the development of the UpnP (Universal Plug&Play) and work from the beginning in this convergence. UpnP is a project led by Microsoft, and aims to be a standard solution to installation and configuration problems of a network of big or small devices, making life easier for the end user. We must stress that UpnP and Jini (Sun Microsystems) have similar aims, and therefore are being developed as competitors.

OSGI (*Open Services Gateway Initiative)* association was founded in March, 1999, with the objective of providing an open software specification and free of royalties, able to design and construct compatible platforms for the deliver of multiple services for the residential market and the automobile industry.

OSGi aims to offer a complete and end-to-end architecture, that satisfy the needs of the supplier, client and of any device installed in the household. This platform is called generally "Services Gateway", but for households and small business it is called "Residential Gateway". The initial founding members were 15 companies: Sun Microsystems, IBM, Lucent Technologies, Motorola, Ericsson, Toshiba, Nortel Networks, Oracle, Philips, Sybase, among others. Now there are more than 80 member companies: hardware or PCs manufacturers, software companies, corporate management systems companies, telecommunications operators, and even some electric companies. As for now, Unión Fenosa is the only Spanish company in OSGI.

The most important work areas of OSGI are:

- SERVICES: It is hoped to create a platform able to process correctly the necessary information for communication, entertainment, tele-management and security services. Therefore, the specification OSGI must have the right interfaces in order to support this services without showing incompatibilities and allow to manage them correctly.
- ACCESS METHODS: The objective is that the OSGI gateway is able to access that outer world (data networks such as Internet), by using any of the technologies currently available. The current tendency is to devote the efforts to wide band access technologies with stand by connection to the Internet (Always-On), such as ADSL, cable modem, and wireless systems such as UMTS, LDMS.
- DATA NETWORKS AND HOUSEHOLDS CONTROL: Taken into account the variety of homes and buildings where the gateways must be installed, this project does not only choose an only connection network in multiple electrical appliances or households devices. The objective is to find a common interface for all of them. Manufactures will have to build appropriate controls for each of them. OSGI gateways will be able to use wireless connection technologies (IrDa, HomeRF, IEEE 802.11x, Bluetooth), over telephone cables (HomePNA), over low tension network (HomePlug, LonWorks, EIB/KNX, etc.) over connections such as Ethernet, USB, etc. and protocols such as HAVi, VESA, Jini, etc.

3. DOMOTICS MANAGEMENT

One of the main reasons for the low increasing in the number of domotics installations is that the potential users perceive difficulties in their managing. There has been a great advance in this aspect, but there are still some lacks :

- Interfaces difficult to manage by the user.
- Subsequent changes in the system management, complicated or difficult to make.
- Only local access to the system that manages the building or household.

To achieve a friendly interface with the final user, the domotics system must have:

- Local control panels for an easy and intuitive control and monitorization of the automated functions in the building.
- Internet connection, to allow the remote control and monitorization of the system. This remote communication must be secure and easy to use.

To allow a painless modification in the functional specifications, we must have an open and easily reconfigurable system. At this point, it is essential to take into account the manageability of the system, not only by the end user, but also by the installer.

These characteristics do not assure the success of the domotics systems, but they are essential for their wide-spreading in the next future.

The great development of the last decade in the telecommunications and computer industry allows substantial advances. One way of facilitating the interface between the domotics system and the end user is by using touch control panels instead of text panels. Those touch panels will allow the use of graphics representations. In this way, the user, at a glance, will know (and could change) the current state of all the different elements controlled in the house: lights, heating, alarms, etc. Touch panels are easy to programme. Their programming tools are usually event-oriented.

Figure 1 shows an example of a screen for the supervision of a house, using the Siemens TP070 touch panel.

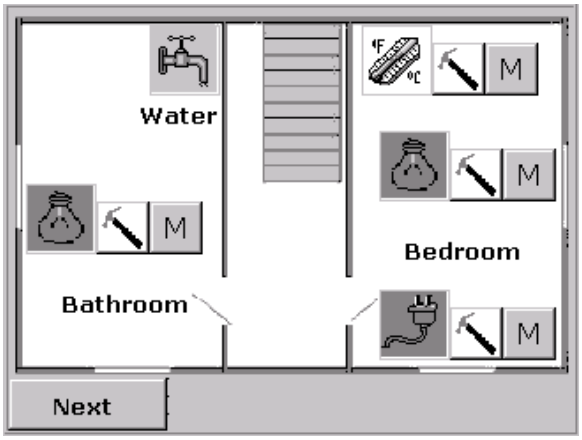

FIG.1. EXAMPLE OF A TOUCH PANEL SCREEN

So, with touch panels the end user can locally supervise the automatic building. But, why only local control? Why don´t we go a step further and consider the possibility of doing the supervision from any point in the city, or in the planet? New technologies give us this feasibility by using mobile telephones and the Internet network. The idea is to use a PC in the house that serves as a panel for local control and monitorization. Furthermore, this PC can be a server of web pages, so it will allow the remote supervision of the house.

In the next sections, we present the software tools our research group has developed, oriented to facilitate and spread the implantation of domotics systems.

4. SIMATICA

Simatica is a software tool that allows the design and development of domotics projects with, for example, light control, alarms, heating control, garden irrigation, etc. Most of these functions are in our houses, businesses and offices.

Simatica v2.1 has been developed by the GENIA group and it is property of SIEMENS.

Simatica automatically generates the control program for a CPU from the S7-200 PLC family of SIEMENS. The management of the whole system, once installed, is made with a text control panel TD-200, that has two lines of characters.

4.1 *Addressing*

With this program, the domotics installer first selects the functions to be controlled in the house, as shown in Figure 2. The installer will select the most appropriate architecture (centralized, decentralized or hybrid) and the input/output addresses (an automatic addressing system is also possible). In few minutes, it is possible to obtain the control program needed for controlling the house and for generating the messages that will appear in the panel, without writing a single line.

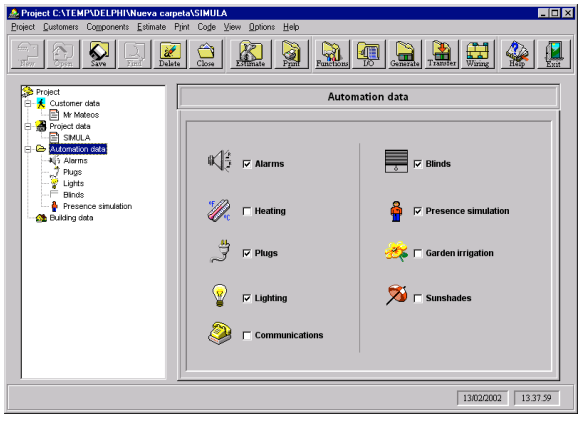

FIG. 2. CONTROL FUNCTIONS IN SIMATICA

4.2 Control program

Simatica will automatically generate the control program for the selected CPU. You can choose among these CPUs: 214, 215, 216, 222, 224 and 226, that belong to the S7-200 PLC family of SIEMENS.

4.3 Architecture

Simatica allows centralized architecture (inputs and outputs connected to PLC inputs/outputs or to extended modules), decentralized (inputs/outputs connected to AS-i modules) and hybrid (mixture of centralized and decentralized). For decentralized and hybrid architectures, the software will use AS-i bus and the SIEMENS components needed.

4.4 Electrical schemes

Simatica generates the electrical schemes to carry out the installation of the domotics system. These schemes are available both on screen and on paper (there is an option for printing schemes). Figure 3 represents a screen with an electrical scheme.

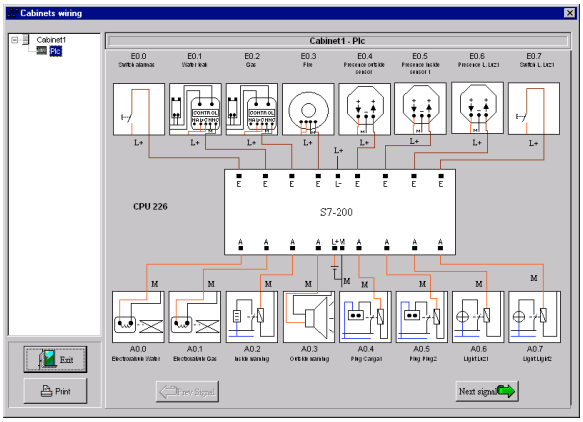

Fig. 3. ELECTRICAL SCHEMA IN SIMATICA

4.5 Data base management

This application allows the management of a data base of domotics components and distributors, and the automatic generation of estimates. The installer can create, modify and delete components of the data base. For every domotics project the application will automatically create the estimate in Simatica and EXCEL formats. Figure 4 illustrates an estimate in EXCEL format.

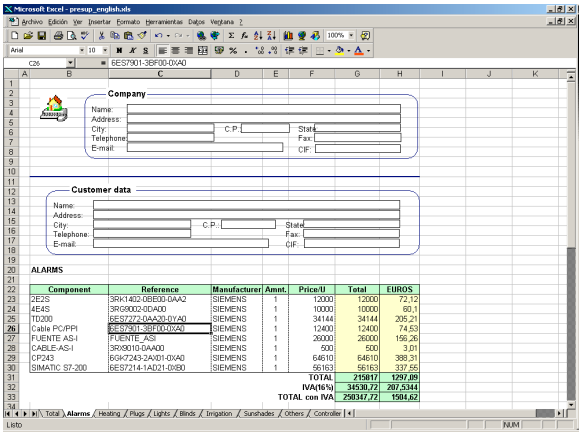

FIG. 4. PROJECT ESTIMATE IN EXCEL FORMAT

4.6 *Communications*

Simatica also allows the connection/disconnection of different elements by phone.

Moreover, in case of alarm the system will make a telephone call to the configured user numbers. It works in this way:
The user can phone at home to control the system. If nobody takes the phone, the PLC will answer. Then, the PLC will emit 3 short tones to say "hello". Next, the system will be waiting for 29 seconds for the correct password. It the password is ok and there are no alarms in the house, the PLC will emit 3 short tones again. If the password is not ok, or there are alarms in the house, the PLC will emit long tones to indicate what is the problem. The user also can connect and disconnect elements in the house using the phone keys on the form shown it table 1:

Table 1. Phone control keys

Key	Action
0 (1)	It connects (disconnects) the alarms of water, fire, gas and intruders
2 (3)	It connects (disconnects) a plug
4 (5)	It connects (disconnects) a light
6 (7)	It connects (disconnects) the heating
8 (9)	It connects (disconnects) the presence simulation
#	It disconnects the produced alarm and checks if there are more alarms without confirmation
*	Exit, finish communications

If there were any alarms, the PLC will emit a sequence of long tones as table 2 shows.

Table 2. Alarm tones

Tones	Alarm
1 long tone	Fire Alarm
2 long tones	Water leak alarm
3 long tones	Gas leak alarm
4 long tones	Intruder alarm

5. SIMAWEB

Simaweb is a software tool that generates web pages for Simatica domotics projects. These web pages allow the remote supervision and control of the house using internet network.

With Simaweb, the domotics installer first creates a new project from data generated by Simatica. Then, on each page of the project, the installer will insert and configure a graphic representation of the elements to be supervised and controlled by the end user. Finally, Simaweb will generate the asp code for each page.

The end user (client) will enter the application web page (http://corresponding_path/name_fich.asp), which is protected with a security code. The main page is divided in two frames. On the left, the client will select a piece or room of the house. On the right it will appear all the elements that can be controlled in it. For each element, the client can visualize its current state and can make changes in its configuration. Figure 5 shows, as an example, the screens for configuring the light of the living room. With a click on 'Automatic', the client can select the use of the presence and/or daylight detectors, and two time intervals for switching on/off that light. With a click on 'Manual', the light will be switched on/off by using the conventional wall device.

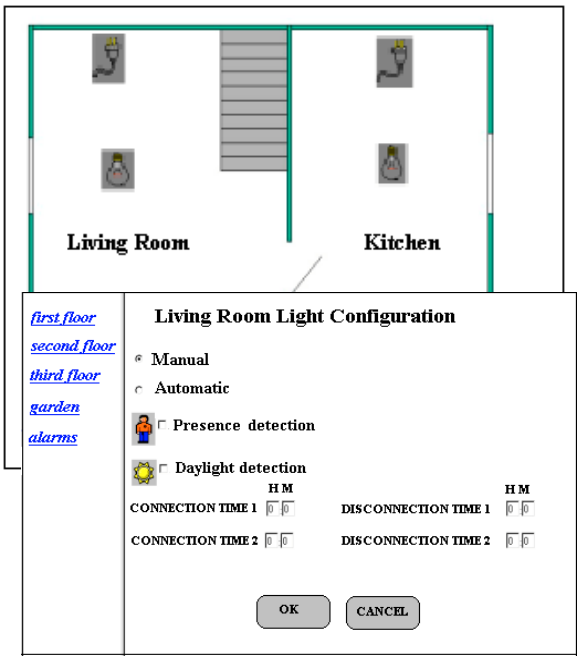

FIG. 5. SIMAWEB INTERFACE

Simaweb imports the database generated by Simatica and creates a Microsoft Access database, that is completed by means of the Simaweb interface. The Access database must be updated with the PLC data. With this purpose, GENIA has developed a software architecture that obtains the PLC data and updates the database.

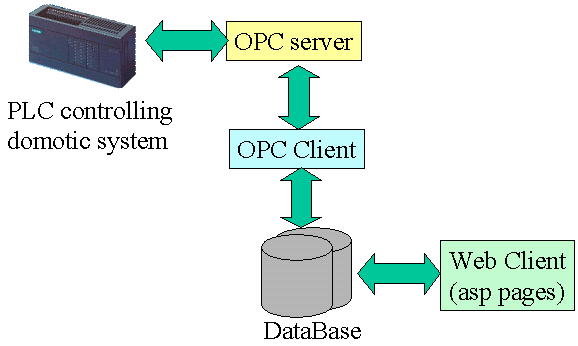

FIG. 6. PLC – WEB CLIENT COMMUNICATIONS

The main elements of this architecture are:
- PLC: it controls the process.
- OPC Server: software that obtains the signal values from the PLC and sends them to the OPC

Client. This software also receives data from the OPC Client and updates the PLC signals.
- OPC Client: software that reads signal values of the OPC Server and updates the database. This software also sends data to the OPC Server when those data are changed from the web.
- Database: it contains the house configuration data for web pages.
- Web Client (asp pages): web interface that shows the state of the different elements in the house and allows the user to configure them.

If the PLC is replaced, the only change in this architecture would be in the OPC server.

5.1 WAP

Additionally, this architecture could be used to supervise and control the house using WAP technology. The PC in the can work as a WAP Server. Figure 7 illustrates this feature.

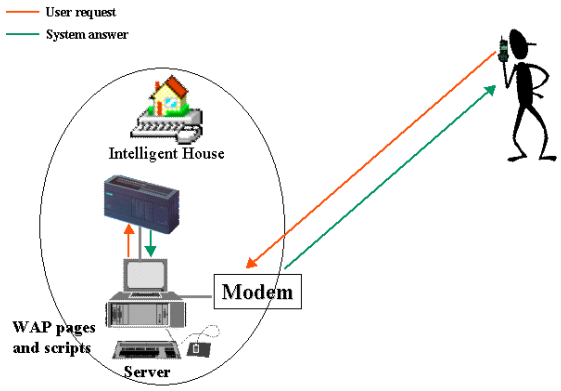

FIG. 7. WAP SUPERVISION

WAP technology has a problem: the low speed. In a near future, perhaps the house could be controlled using the WAP successor: UMTS technology.

6. CONCLUSIONS

Our solution is based on simplicity of system handling and a robust controller. The selected controller, PLC, is sufficiently robust for controlling a house. The user can configure and control his/her house by different means: by a local panel, by WEB or by phone.

This solution also fulfills the main characteristics a domotics system must have:
- Simple and friendly interface with the user.
- It must be possible the remote access to the system.
- The modification of its features must not be painful.

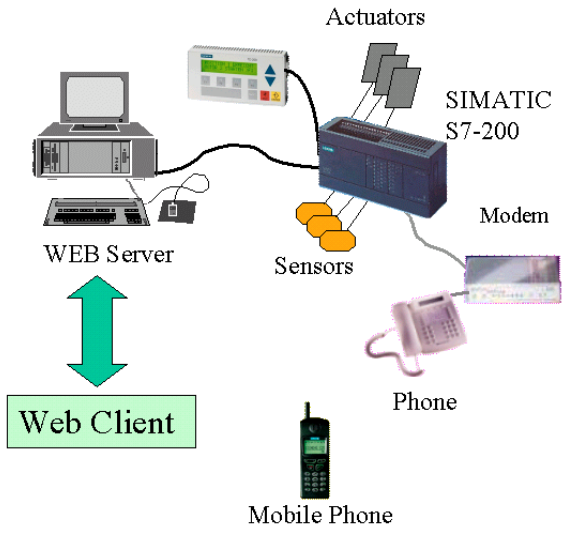

FIG. 8. PROPOSED ARCHITECTURE

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