MANAGEMENT AND CONTROL OF ENERGY FLOWS IN BUILDING

F. Garzia, G. Veca, IEEE Sr Member

Dipartimento di Ingegneria Elettrica
Università degli Studi di Roma "La Sapienza"
Via Eudossiana, 18
00184 Roma, Italy
Tel.+39-6-44585804, Fax +39-6-4883235

ABSTRACT
A general scheme of a system to control the energy flows in a building is illustrated. We will show that it is possible to provide a high quality system characterized by a plenty of useful secondary services if a distributed smart system is used. Thanks to the flexibility of this kind of system it is possible to develop different applications and sophisticated functions. A very interesting employment of this system was made in the Cathedral of Saints John and Paul in Rome, which has been equipped with artistic light control, heater control, anti-thieves system, presence control and guided visit arrangement.

1. INTRODUCTION

The rapid decreasing of the price of electronic components has increased the number of the possible applications of microprocessors in a lot of interest fields of every day life.

In particular, referring to the home or to the office, a series of applications has grown whose features was only thinkable but not practically realizable.

The words "office automation", "domotics" and so on, are nowadays very common, but their exact meaning strictly depends on the contest where they are used.

A lot of electric components (i.e. switches, etc.) building companies call "smart building" a structure where are present some devices that are able to be controlled by means of computers through a bus.

According to the authors, the word "smart" ought to be exclusively reserved to a system that is capable of acquiring informations from the environs and of actuating an operative strategy, by means of an expert system running on computer. The actual technique of the most of the systems commercially available is in reality limited to series of sensors that read the value of a parameter (such as temperature, light and so on) and generate an on/off signal that is properly actuated.

A smart system, on the contrary, acquires the values of the controlled parameters (light intensity in a room, temperature, presence, etc.) by means of a supervision computer that stores data in its memory and controls the different installations according to a well defined procedure such as:

a) call the security service if there is a presence in a not allowed room,

b) call the maintenance if any equipment does not work properly,

c) turns on or off a fan-coil,

d) turns on or off or trims a light, and so on.

The target of our paper is to illustrate a technique through which can be performed a real smart control of a building.

Actually the components building companies are trying to impose on the commercial scenario advanced devices but first of all they are trying to impose their own technical standard to draw the economical advantage that unavoidably derives from affirming an universal referring standard.

In our paper will be examined first of all the architecture of an automatic system to control the energy flows in the office or in the house. Then it will be illustrated in details a real installation that realizes this kind of control without any commercial reference, only referring to its functional property. In fact, due to the high developing velocity of microelectronic, it is possible to realize any advanced controlling devices without the need of a prestigious trade mark.

On the other side it is very usual that building companies, even the most famous, buy pre-assembled devices in Est Asia, to reduce the costs, and that they terminate the assembling process in Europe or in USA.

2. THE SMART SYSTEM TO CONTROL THE ENERGY FLOWS

Nowadays a lot of different system architectures can be used to manage and control the energy flows inside a building. Their differences lies on the features and performance and obviously on the cost necessary to install them.

The scope of the controller system is obviously to acquire the environmental informations through proper read points and act on the building installations through proper action points. In the following we briefly call them points.

The controller systems can be divided into two main groups: central smart system and distributed smart system. Both of them show positive and negative features, depending on the point of view of the analysis.

The central smart systems are characterized by a main controller system that is connected to the single point by means of a dedicated connection wire. The advantage of these kind of systems is that a great computation power is available to execute a high number of operations. Further it is also available a great amount of memory resources to record all the necessary informations. The disadvantage of them is represented by the need of transmitting each informations from the peripheral point to the main system and viceversa. In fact these operations unavoidably slow down the operative velocity of the hole system and expose the building to the danger of total lost of control. In fact, since each operative decision is made by the central system, an eventual stop of it implies a total arrest of the functionality of the installations. Moreover, due to the need of connection of each points with the main system, two inconveniences are present. The first is that the data to be transmitted or received are subjected to corruption, due to the long distance it could be necessary cross to reach the final destination. This is not a problem if data are transmitted in a digital way because of the capability of error detection and correction of this kind of method, increasing anyway the cost of the system, but could represent a great operative problem if the transmission is made in an analogic way. The second inconvenience is the high cost of installation of the system since each connection wire must be installed from the center to the peripheral point by means of a manual job, and therefore the cost greatly increases with the distance and the complexity of the system. This last inconvenience make the cost of the centralized system dependent on the hourly cost of the work force, and therefore on the place where it is installed.

The distributed smart system are characterized by a variable number of low cost microcontrollers, connected between them according to different configurations, where each unity controls a certain number of points. The advantage of these kind of scheme is that the smartness of the system is distributed all over the system and an eventual bad working of a controller does not imply a lost of control of the installation but eventually only the misworking of the controlled zone. This inconvenience, because of the low cost of the controller, can be avoided using a reserve device, that is activated when the main device fails its task. Further the transmitted data are less subjected to corruption due to external disturbs, because the distance they have to cross to reach the destination is greatly reduced. In this kind of system the operative procedures are recorded inside the single device, that takes care of the elaboration of the informations. This allows higher operative velocity, because each task is rapidly satisfied locally, without the need of reaching the central system (being exposed to transmission mistakes), without elaboration and back transmission. The installation cost is reduced too, because the points are locally connected to the controller through a relative short connection. The only long connection is the communication network that allows the data exchange between the devices.

3. THE SUPERVISION AND CONTROLLER DEVICES

We want now to describe the architecture of the used system. Since we use a distributed smart system, our one is composed by a certain number of micro computerized modules (MCM) connected each other by means of a communication network. We first analyze the typical structure of the MCM, the communication network and finally the acquiring sensors. The MCM is a micro computerized module properly reduced and boarded, equipped with a microprocessor, a random access memory (RAM) and a read only memory (ROM). The MCM is built using low energy consumption CMOS technology. This feature allows the module to work even in absence of the main electrical power source, using an auxiliary battery. The typical power consumption is of about 2 watts. Further, to avoid misfunctioning or lost of memory due to electrical disturbs or spikes, that would unavoidably compromise the data stored in the RAM, this component of the system is provided with a back up on board battery that ensures the memory to be always stable supply, even in absence of the main energy supply. Further the MCM is equipped with a serial electrical erasable serial programmable read only memory (EEPROM) that is a particular kind of memory that shows the interesting features of being written in a random way, such as RAM memory, and of storing the data indefinitely, such as ROM memory. In this kind of memory can be stored important informations as, for example, the calibration constants of the sensors, that cannot risk to be corrupted and do not need to be changed continuously. In fact this kind of memory is quite expensive and therefore has a limited size (few hundred of bytes), and due to its operative features, the writing cycle is slower respect to the other memories. But the most powerful features of the MCM is its capabilities of self writing in its EEPROM the main program. This features drastically reduces the start up work, since the program, once transferred on board, can rapidly tested and eventually changed directed by the MCM and eventually changed directly by the MCM that definitively store it in its EEPROM when it is completed. The traditional procedure, on the contrary, needs the program to be tested on a simulator computer, without a direct correspondence with input-output real situation, to be stored in an EPROM chip, by means of a rather expensive memory programmer.

Finally it is necessary to transfer manually the programmed chip on the MCM board exposing it to the risk of mechanical damage, due to bad pin insertion, or to electrical damage, due to electrostatic voltage.

Therefore the MCM can be summarized as a low energy consumption composed by a 16 bit high computation power microprocessor, a ROM memory, where it is stored the operative system, a EEPROM memory, where it is stored the main program to be executed, a RAM memory, where it is stored all the running time data and a serial EEPROM where it is stored not frequently changed data. Further there are digital and analogic input-output, communication port and keyboard and display interface.

The digital and analogic inputs-outputs are all opto-insulated through proper opto-modules. This features allows the MCM to be totally separated from the electrical power that could damage it. For this pourpose the opto-modules are installed on a separate board that is connected to the MCM by means of a flat cable. In this way it is avoided any connection error that unavoidably can verifies during the installation of the system. Its flexibility is due to the fact that the ports can be configured both as inputs or outputs, allowing the system to be reconfigured in each moment of its operative life. The writing-reading cycle takes about 100 nsec for digital port and 0.5 msec for analogic port.

The MCM is equipped with some buffered communication ports that allow a variety of network configuration. The buffer features of the port allows the microprocessor to be totally free from the task of controlling the communication since this work is made by a dedicated chip that:

- receives data from microprocessor,
- prepares them to be transmitted according to the desired protocol to the network as soon as it is available,
- decodes network data storing them in its internal buffer memory,
- advises the microprocessor that there are available data in the buffer.

The MCM is further equipped with keyboard and display interface that allows any kind of desired input-output user operation.

Due to the high computation capability and to the configuration flexibility of the fundamental element of the smart distributed system, constituted by the MCM above described, it is possible to realize a high level management and control of energy flows that can be extended, without any economic surcharge, to the other equipments such as anti-thief system, anti-fire system, presence control system and so on.

A typical operative scheme of the controlling system is shown in fig.1.

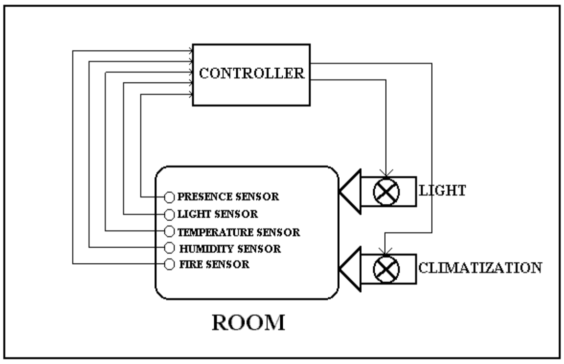

Fig.1 Scheme of the considered control system

The first controlled energy flows is the light system. We first describe the acquiring sensor discussing the reasons that lead to choose a particular light sensor respect to the other one.

The two main low cost light sensor commercially available are the photoresistor and the photodiode. The first one is a particular sensor composed by two electrodes separated by a photo-sensible component such as ZnS. This material has the property of varying its resistivity according to the intensity of the light that is received. The resistance variation range is for a typical commercial device very wide since it varies from few tens of ohm at some thousands of lux to few mega ohms in total obscurity. The variation law is non linear: in particular, we have measured this law in the range of interest, that is between one thousand of lux and one hundred of lux. The obtained results shows that it decays according to a quasi-exponential curve, as shown in fig.2.

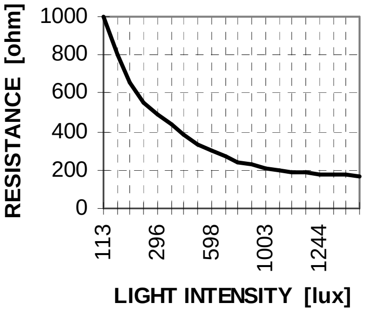

Fig.2 Resistance of the sensor as a function of the light intensity.

It is interesting to note that in the most common light intensity range (200÷600) the sensor shows a fast variation of its resistance, and therefore a good sensibility.

To transform these resistance variations into a voltage variations, that can be read by the MCM, it is necessary to use a resistance partitor, where the photoresistor can be mounted both as superior element or inferior element and the output voltage can be read both on the sensor or on the other resistance of the partitor. The choice of one configuration respect to the other depends only on a personal project choice since there are not advantages of one scheme respect to the other.

Particular care must be taken in the dimensioning of the other resistance of the partitor to limit the maximum current that flows though the photo resistance at values of the order of few milliamperes, to avoid of damaging it.

The other element considered here is the photo diode. This sensor, if properly supplied, gives a current whose value depends on the incoming light. It is not a very useful component for this kind of application because of the little value of the output current, of the order of microamperes, that are very difficult to be discriminated and read in noisy environment as could the one considered here. Further, since there could be a long distance to be crossed by the sensor current before reaching the MCM, it is necessary to insert a local current amplifier, or a current-voltage converter, very close to the sensor, that must obviously be supplied, increasing unavoidably the energy consumption and the installation cost due to the need to provide a separate cable to give voltage to this auxiliary circuit. The photoresistor, on the contrary, needs only two wires and no other circuit, providing a good low-cost solution. Thanks to the high computation capability of the MCM it is possible to give to the module a few calibration points, and let it calculates, through a proper interpolating algorithm, the right values of light intensity.

We want now to describe the light controller device. Different circuits are available to trim the light intensity of a lamp, that shows different features and obviously different costs. Since the light sources considered here are only incandescent, fluorescent and dicroic lamps, whose intensity strictly depends on the applied voltage, it is possible to control them accurately controlling the voltage applied to them, with some exceptions and precautions whose we will talk later. The most common low-cost technique used to control the voltage of an alternate source is the phase control. It consists, given a sinusoidal voltage, in controlling exactly the phase delay, through a proper switching mechanism, to supply the desired electrical charge. It is evident that the medium square value of the voltage is totally applied to the charge if the phase delay is equal to zero, and decreases with the phase-delay φ according to the following law:

$$\bar{V}^2(\varphi) = V\sqrt{\frac{1}{2\pi}\int_{\varphi}^{2\pi}\left(sin(t)\right)^2 dt} = V\sqrt{\frac{1}{2} - \frac{\varphi}{4\pi} + \frac{sin(2\varphi)}{8\pi}},$$

where V is the amplitude of the voltage and φ the phase-delay.

This technique can be used without any inconvenient in light source that can tolerate sudden voltage transition such as the one that takes place when the switch changes its state from off to on. This is not a problem for the three considered kind of lamps. The only secondary effect presented by the incandescent and dicroic lamps is the change of the spectral emission towards the red zone of the visible spectrum due to the lesser temperature of the filament of the bulb depending of the lower controlled voltage.

Another inconvenient is represented by the switch-off risk of fluorescent lamp if the phase-delay is too long. In fact it is well known that to activate the conduction in this kind of lamp it is necessary to apply an over-voltage generated by the couple starter-reactor. This conduction is kept on only if the applied voltage does not lie under the minimum threshold for a long time. For this reason the phase-control device must be equipped with an auxiliary circuit that keeps the lamp on during the switch-off period. This can be done rather easily acting on the heater filaments of the lamps.

The phase-control technique, due to already mentioned rapid switch-on and off, generates a high number of harmonics that could create electromagnetic compatibility problems if they are not properly shielded. Even if the trimmer is well shielded it would be recommendable to position the device as close as possible to the lamps to be controlled, so that eventual residual disturbs, do not irradiates thanks to the antenna effect shown by the long connection wires. In this way there could be some problems due to the fact that, the more the connection between the trimmer and the lamps is short the more the connection between the MCM and the trimmer is long, exposing the MCM to the risk of damage. This inconvenient is not present in the considered MCM thanks to the opto-insulated inputs and outputs.

The control of the trimmer circuit is made through a digital output of the MCM by means of a frequency-voltage converter that ensures a high robustness to the external disturbs unvoidably present in this kind of application.

We want now to tell something about the stability of the controlling mechanism. In fact, due to the presence of a feedback loop constituted by the chain “sensor → controller → actuator”, it is necessary to ensure that a certain desired value of the controlled parameter is kept even in the presence of external disturbs. The stability theory of this kind of system would be too long to be studied in this paper. We only briefly mention a practical criterion that guarantees the well-staying of the users of the controlled zone, based on the velocity of variation of the desired parameter. In fact it is well known that the more a parameter varies slowly the more an environmental is comfortable. See for example the situation where a room has reached a too high temperature that is out of the well-staying interval: in this situation a sudden decrease of degrees, aimed at ensuring the correct temperature, is felt as a disease, even if the final situation is the correct one. This is equal to say that each environmental parameter such as light, temperature, humidity and so on, has its own optimal variation velocity that cannot be exceeded without generating a disease sensation.

In our case, the velocity of the loop “energy flows → effect → sensor → controller → actuator” strictly depends on the physical features of the considered phenomenon that is the binomial “energy flows → effect”, since the remaining part of the loop is characterized by electronic velocity excepted the actuator . In fact while in the case of light the velocity of the binomial “energy flows → effect” is very fast since any variation of the intensity is immediately read by the sensor, in the case of the climatization this velocity is very slower due the intrinsic features of the phenomenon.

In the light case it is demonstrated that a variation velocity of 10 lux/sec is the maximum tolerable variation that does not provoke disease. The delay time of the loop in this case can be ensured both by the controller or by the actuator, depending on the project choice. It is anyway preferable to let the MCM to control the delay time using an actuator whose velocity is as fast as possible, so that it is possible to vary, without any restriction, the variation velocity at any time.

We want now to describe the sensor and the actuator used to control the other important energy flow that is the climatization. The considered acquiring sensor are the thermoresistances, the thermocouples and the integrated sensors. The thermoresistances are properly built resistances whose values can increase (PTC or positive temperature coefficient) or decrease (NTC or negative temperature coefficient) with temperature. The variation law is typically non linear. The same considerations we made about the photoresistances are valid for thermoresistances. The other important sensors are the thermocouple that generates an output voltage whose value is proportional to the temperature. These kinds of sensor are rather precise and linear. Unfortunately the voltage gradient generated with temperature is very little (microvolts) making them unsuitable since in this kind of application there could be a long wires path to cross before reaching the reading point, exposing the voltage data to corruption due to voltage disturb or fall across the line. This problem can be avoided thanks to be help of a voltage amplifier, that increases the cost and the complexity of the installation. The third and very useful kind of sensor considered here is the temperature sensor. These devices are particular integrated components that generate a voltage proportional to the temperature. They have three pins: one is the positive voltage, one is the output and one is the common ground. The temperature gradient is generally equal to 10 mV/°C. Considering a sensor built to work in the range 0÷100 °C, we have an output voltage of 0 V at 0 °C and an output voltage of 1 V at 100 °C. Wider ranged sensor shows generally different temperature gradients so that it is possible to measure all the temperatures obtaining reasonable output voltage. These sensors, thanks to their robustness and to their optimal output voltage are very interesting to be used in these kind of applications.

The actuator devices used depends on the kind of devices to control. If a traditional heater is present, it is necessary to use an electro-valve that opens or closes the hot water flow inside it. If a fan coil is present there are two controlling possibilities: step control or continuous control. The step control uses a discrete number of velocities of the fan while the continuous control varies the fan velocities in a continuous range according to the needs. This last control is generally more expensive respect to the other one since it is necessary to use a proper controller device of the velocity of the fan. The step control, on the contrary, just exchanges the velocity of the fan using the switch already present in the fan coil, representing a valid compromise between the efficient and the cost. In fact, due to the relevant inertia of heather phenomenon, it is not necessary to use a precise and fast control of the heater source.

Due to the low velocity of heather processes, it is not generally necessary to introduce a delay time in the MCM to slow down the operative velocity of the loop, to avoid instability. It is anyway convenient to introduce more refined control mechanism respect to the simple on-off, as for example a simple hysteresis.

The other equipments such as anti-fire system, anti-thefts system just need digital sensor and actuator and can be read and piloted from the MCM without any particular problem. For this reason we do not discuss further about them.

At this point it is evident that, thanks to the high computation capabilities of the system considered, it is possible to realize a very useful energy flows controlling system that ensures a high energy saving and an elevated comfort of the building where it is installed.

In fact the system can be programmed to satisfy any exigencies and needs. It is possible for example to turn light off after a certain time that a room is left empty. Since the MCM is equipped with a clock on board, it can memorize the time and the frequency of these situations and calibrate its turn off action according to these. It can further trim exactly the light intensity according to the light entering from the window, so that the medium intensity is constant. In this way it is avoided any intensity gradient that would disturb the occupants and it is avoided an energy waste. Since the intensity of the light entering from the window decreases with distance, as shown for example in figure 3, if the system is equipped with different actuator, can decrease the intensity of the lamps situated closer to the window and can increase the intensity of the light that is positioned more distant from the window, generating a constant intensity distribution.

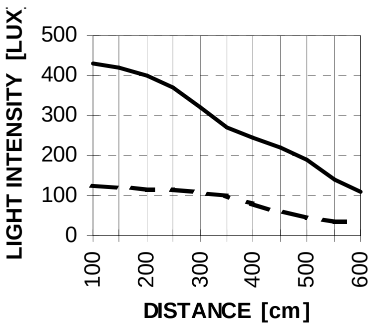

Fig.3 Intensity distribution of the light as a function of the distance from the window: with lights on (continuous line); with lights off (dotted line).

The system can shift the turning-on time of the climatization according to the daily environmental conditions. It changes the same turn on and off time according to the memorized and refreshed occupation time of each single room. In this way each room can have its exact level of temperature and humidity.

The system controls the smoke sensor and in case of fire, that is confirmed for example by means of the temperature sensor, activates the alarm and turns-off the climatization to avoid the feeding of the fire due to the fresh air.

A plenty of ideas and procedures can be realized using this system and we could say that the only limits is fantasy!

In the following we are showing an interesting application of a smart system that has been realized in the cathedral of Saints John and Paul in Rome.

4. AN APPLICATION: THE CATHEDRAL OF SAINTS JOHN AND PAUL IN ROME

The cathedral of Saints John and Paul in Rome is one of the most important Basilica of Rome. It was built on a christian catacomb of the fourth century A.D., still present under the ground level of the church. The building, due to its long history, is therefore composed by different stratified structures until reaching its final state in 19^{th} century. The plant of the cathedral is shown in fig.4. A very important and impressive particularity of the cathedral is the massive presence of lights, as can be partially viewed in fig.5, whose turning-on greatly change the architectonic aspect of the church, giving it a unique atmosphere but increases dramatically the energy consumption exposing, as a secondary effect, the important pictures that are present inside the church to a premature olden due to the fact that they are exposed to light even if no visitors are present inside.

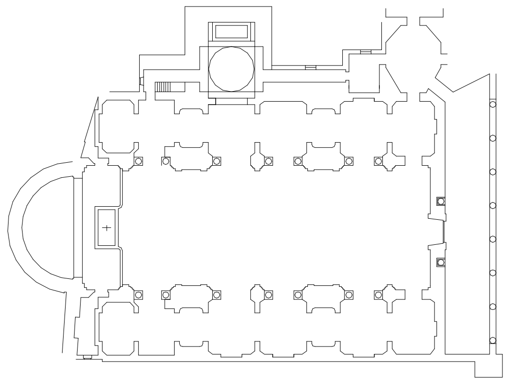

Fig.4 Plant of the cathedral of Saints John and Paul.

All this problems have been solved by a smart distributed system, whose realization we participate together with the other members of the “Ufficio Speciale del Genio Civile per le OO.EE. della Capitale, Provveditorato dei Lavori Pubblici per il Lazio” of the Ministry of Pubblic Works of Italy. The use of a automatic system in a church is, to our knowledge, the first application of this kind. In fact this class of equipment is generally reserved to different sort of buildings. This realization demonstrated the great importance and flexibility of smart distributed systems. In fact, due to the prestigious artistic environmental, it is impossible to install a centralized system because of the great number of wires necessary to connect the central unity with each controlled point. Using a distributed system, it is just necessary to install the main cable to bring energy to the MCM that controls and distributes energy to the devices according to well-defined procedures.

Further the use of distributed system greatly simplifies the use of the installations of the church, since it is possible to activate any control procedures, even the most complex, pressing only a key of the keyboard available in each MCM . Since the MCMs are distributed all-over the building, it is clear that the system allows any kind of light mixing of the sources that are present inside, and it ensures suggestive effects that recreate different atmospheres according to different operative exigencies. These procedures are obviously impossible to be generated by means of a traditional installation.

The assemblage has revealed to be a continuously growing system, since the users discover day by day new exigencies and needs that are rapidly and immediately integrated in it, allowing a high and unknown degree of freedom, absolutely new in this kind of building.

We first rapidly describe the system and then the operative procedures that have been implemented until now.

The old electrical installation was composed by the candle-lamps, visible in fig.5, some alogene lamps, to enlighten the ceiling of the church, a few casual lamps to enlighten the lateral sides and the chapel of Saint Paul that is situated in the upper-left side of fig.4. The switches of the various lights were situated all over the church in a casual way so that the control of the building was totally uncoordinated and unesthetic because of the massive presence of switches very close to paintings, decorations, statues and so on.

The new light equipment is divided into a trimable part and a non trimable part. The non trimable part is reserved to the ceiling, the altar, the paintings of the altar, the ceiling of the chapel of Saint Paul. All the other light sources such as the suggestive lamps of the central part of the church, the lateral sides, the lateral paintings, the chorus and the paintings of the altar and the altar of the chapel of Saint Paul are trimable . The presence sensors are properly hidden and distributed all over the church. Since there were already in the church some catalytic gas heaters disposed on the upper part of the central zone that can be only turned on and off all together, generating probable diseases to the people inside because of temperature gradients unavoidably present this kind of situation. To avoid these problems we have inserted some temperature sensors properly disposed who capillary control the temperature inside the church. Each heater element is singularly controlled by the system always ensuring the optimal climate conditions for both the occupants and the precious paintings inside the church.

The acoustic diffusion system has also been connected to the system that can now emit talked messages and sounds in each separate zone of the church. The message is generated by the main computer on request of the single controller who takes care of activating the amplifier and switching on the local loudspeaker.

Due to the presence of pieces of artistic importance, it was necessary to install some reduced CCD cameras inside the cathedral, whose image is properly controlled and recorded by the system according to the procedures we are describing later.

The system is composed by the MCM distributed in the church matching the need of reducing as soon as possible the amount of wires and at the same time the need of reducing as soon as possible the number of modules. It has not to be forgotten that because of the artistic environmental we operated, it was necessary to find a proper installation position for each module.

The central part of the church is separately controlled by two MCM for the left and right side. The same division was made for the lateral side of the church. The altar and the chapel of Saint Paul are controlled each by a MCM .

All the MCMs are connected by a single couple wires, generating a network connected to the main computer, that is positioned in the office of the church, situated in the right-upper side of the plant of fig.4. Other computer are present in other zone of the building near the cathedral to allow a remote control of the hole cathedral.

Each MCM is equipped with keyboard and display so that it is possible, if enabled by means of a security code, to activate any procedures and control.

The system controls all the light sources generating different miscellaneous according to the kind of celebration that is taking place and according to the moment of the celebration, generating particular atmosphere of great effect. Any operation is highly simplified and guided by means of the display. It can be made pressing just one key.

The system also control the temperature and the heater ensuring the best condition at the fixed time.

It works as an anti-thieves system, controlling automatically the presence inside the church. If someone results to be present out of a certain time interval, it means that is unauthorized and the system activate the CCD camera, recording each event is happening in the alarmed zone.

The system also works as a perfectly automatic and complimentary guardian and guide, since it controls if any visitors is present inside the church. In case of presence it activates the proper light in the visited zone and emits the relative message of artistic and historical notices about that part of the cathedral, without disturbing the people that is visiting the remaining parts. In this way it is possible to ensure a low consumption of energy and the best quality of the visit of the church.

Fig.5 Picture of the main altar of the cathedral.

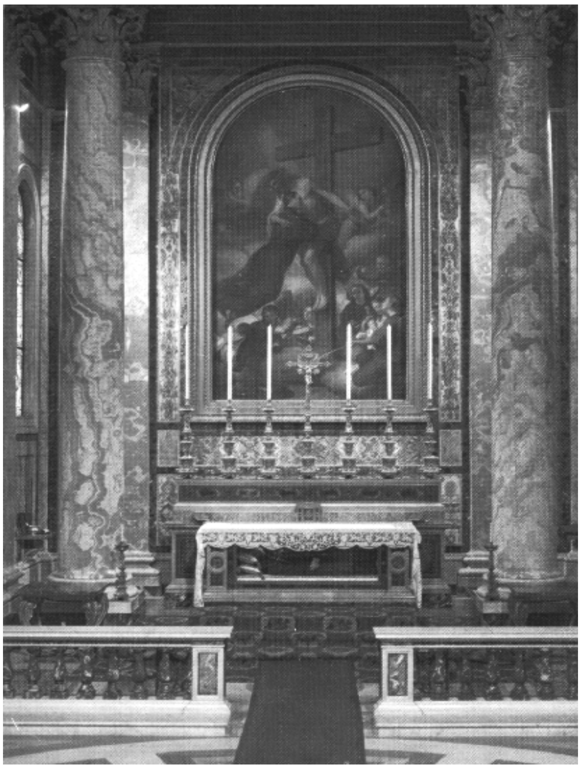

Fig.6 Picture of the altar of the Chapel of Saint Paul situated inside the cathedral of Saints John and Paul.

5. CONCLUSIONS

We have illustrated a scheme of a system to control the energy flows in a building. We have demonstrated that a high quality of the control can performed if a distributed smart system is used. Thanks to its peculiar features it is possible to provide other important services such as anti-thieves system, anti-fire system, presence control and so on.

We have shown a very interesting application of this system to the Cathedral of Saint John and Paul in Rome, which has been equipped with artistic light control, heater control, anti-thieves system, presence control and guided and talked visit system.

6. ACKNOWLEDGE

This work was made thanks to the precious collaboration of **Ing. Aldo Mancurti** (Chief of the Office), **Ing. Fabio Riva** (Chief of the Section), and **Geom. Alfonso Marcucci** (Collaborator of the Chief of the Section) of the "**Ufficio Speciale del Genio Civile per le OO.EE. della Capitale, Provveditorato alle Opere Pubbliche per il Lazio**" of "**Ministero dei Lavori Pubblici**". A particular thanks for allowing us to participate to the realization of the distributed smart system of the Cathedral of Saints John and Paul in Rome and for giving us all the permissions and all the documentation necessary to insert the mentioned work in the present paper.

We even want to thank **Padre Augusto Matrullo** (Rector of the Cathedral of Saints John and Paul) who gave us his full collaboration to realize the smart distributed system. He also gave us historical documentation and important recommendations about the operative needs of the church that we implemented in the system.

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