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TECHNICAL MANAGEMENT FOR BUILDINGS

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Abstract

This paper is a presentation of an ‘instrument’ for the optimization of the functionality and conservation of tertiary buildings. This technique has several different names: Building Automation Systems (BAS), Central Control and Monitoring System (CCMS) in English, and *Gestion Technique du Bâtiment’* (GTB) or *Gestion Technique Centralisée (GTC)* in French.

With this technique it is possible to manage all the functions of a building, it is a modern instrument that introduces the concept of ‘automation’ in the operation of buildings using computerized procedures, earlier reserved for industrial processes. The system is structured with different automation levels with a distributed intelligence, each level characterized by a communication system (Fieldbus for the lowest and Ethernet for the highest level). In order to apply the BAS to CERN buildings it is necessary to evaluate the advantages, the CERN requirements and the integration with the several existing control and automation systems.

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1 INTRODUCTION

The technical management for buildings' is a modern instrument for the optimization of the functionality and conservation of tertiary buildings, minimizing the running costs. This kind of management is carried out by means of automation systems able to monitor and to rule all, or a part, of the functions of the buildings.

A management system for buildings has the following features:

- field devices, able to monitor and control the functions of the building;
- intelligent units, that send commands to the field devices, acquire and elaborate data;
- communication system, that allows a correct communication between the several entities;
- software running the functions of the building.

The main functions of a tertiary building controlled by a management system generally are:

- electrical distribution;
- heating, ventilation, air conditioning (HVAC);
- alarms, access control;
- lighting.

The realization costs of these management systems must be justified by the benefits obtained in the use of the building. The main benefits can be grouped in the following categories:

- energy efficiency,
- safety,
- workplace conditions,
- reducing operating costs.

But there could be other reasons to install such computerized management systems; for example, in North America in the early 1980s these management systems were installed in existing buildings in order to increase the commercial value of those buildings.

2 DEFINITIONS

The 'Technical Management for Buildings' includes different management systems that can be found on the market under different names. The differences are in strategy of management adopted and the main functions controlled. They also depend on the market of diffusion, the manufacturing firm and historical reasons. For instance, systems that have as their main task the energy management of buildings include Energy Management System (EMS), Central Control and Monitoring System (CCMS), Energy Management and Control System (EMCS). With the increasing use of computerized systems and with the evolution of the treatment of data, the type of management has changed.

In this way from Central Control Systems (in French *Gestion Technique Centralisée'*) we get more developed management systems which are defined as Building Automation Systems, Intelligent Building, and in French *(Gestion Technique du Bâtiment).*

3 COMPARISON WITH INDUSTRIAL AUTOMATION SYSTEMS

All the building management systems have been derived from the industrial automation systems with several differences. The communication system can be simpler because there is a lower complexity of the controlled process with less data to be transmitted, but it may have to cover larger distances if there are buildings placed in an extended area. After it has been set up, an industrial automation system can be considered stable. However, in tertiary systems there are often modifications and enlargements both of the controlled functions and of the controlled zone. For this reason, the building management system must have an open structure that is easily modifiable.

4 STRUCTURE OF THE SYSTEM

A technical management system for buildings is the result of the installation of physical components and software. The system in the most general form is structured in three levels, as shown in Fig.1:

- field level,
- automation level,
- management level.

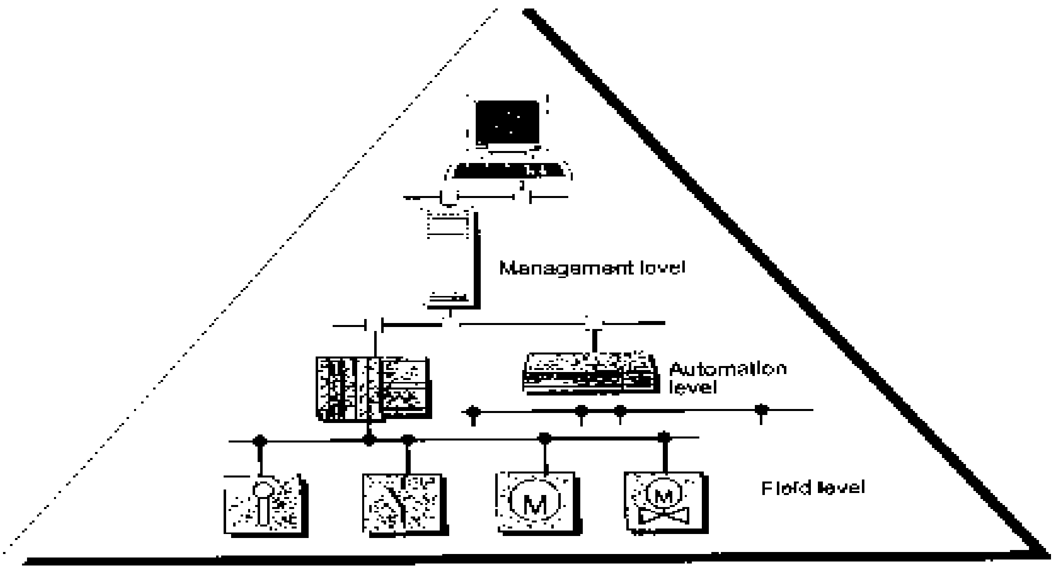

Figure 1: Three-level structure of a technical management system for buildings.

This kind of architecture does not have a single control unit, but is characterized by a decentralization of several control and automation tasks that are carried out by Programmable Logic Controllers (PLC), named Local Processing Units (LPU).

4.1 Field level

At this level, there is the interface between the management system and the controlled physical processes. By means of sensors and actuators, integrating or replacing the normal device, the system is able to acquire process data and to modify the process itself by executing the commands coming from the automation level; there is no 'intelligence' at this level. The sensors convert a measure or the registration of an event to a representative signal to be sent to the upper level; the actuators have to execute the orders coming from the automation level. All these instruments must therefore be equipped with devices able to communicate with the processing units by means of the field communication medium (fieldbus) and its communication protocol.

4.2 Automation level

This level has LPUs that may have more or less sophisticated tasks, from the simple centre of communication between the management and the field level, to completely managing a process, for example the lighting system of a floor, transmitting at the management level only the data about the process.

The most important tasks for the main LPUs are:

- to rule the process, or a part of the process, following automation programs;
- to acquire data from the field devices;
- to transmit to the management level all or part of the data coming from the field;
- to acquire from the management level the reference parameters for the automation program.

The automation level can be organized with a main LPU at the head of a zone, or at the head of a function of a zone, for example the air conditioning of a building.

4.3 Management level

The management level is formed by one or several central processing units. These are personal computers, communicating between themselves and with the automation level via one or separated communication networks. A typical configuration for structured management systems is composed of several central processing units, each one dedicated to a special function, for example HVAC, power system, access control. These central control units carry out the most sophisticated tasks by means of software elaborating the data coming from the lower levels and the data entered by the user. At the present time modular computer programs are available on the market that can be easily implemented and modified, improving the number of controlled functions or zones or the integration of the several subsystems. At this level there are the global management functions which elaborate the main data of all the single processes. The most common of these functions are:

- maintenance management, with scheduling of the interventions and evaluation of the overall costs;
- analysis of current or previous process operations;
- data exchange with other systems, e.g. administrative database;
- monitoring and displaying of operation mode and alarms;
- faults statistics;
- coordination of energy-saving operations of the different processes.

4.4 Communication systems

Several technologies and standards are used at the present time. There are a large number of technologies, protocol communications and configurations on the market. There is currently no overall standardization.

4.4.1 Connection between the local processing units and field devices

The lowest level of communication is between processing units and sensors and actuators. These connections can be made with a discrete wiring from each field sensor or actuator to the unit. Many of the management systems for buildings use a large number of I/O devices and operate over long distances. This leads to high wiring and installation costs; additional limitations are the reduced flexibility for system modification or extension and the limited availability in the case of defective control units. To reduce costs and overcome these limitations serial control systems known as *fieldbus systems* have been developed. These consist of a simple cable supporting the feeding of the device and the communication.

In a fieldbus system the processing units communicate with all the field devices connected with the bus. In this case the field instruments are equipped with a device which allows the exchange of information in digital format, RS 232, RS422 or RS485 transmission standards. A fieldbus standard is characterized by the physical medium (usually a cable with 2 or 5 conductors), the communication protocol and the communication strategy that involves the transmission speed and the complexity of the communication devices. In building management systems both industrial fieldbuses and specific building automation buses are used. These have lower communication speed and data capacity but, at the same time, the complete system has lower costs and allows easy modifications.

The choice of the fieldbus involves that all the devices forming the system must be compatible with its standards. There is also a strong dependence for future modifications, with the producer, or producers, following the specific standard.

Table 1 lists some of the most common fieldbuses present on the market and used in building management systems.

Table1

Common fieldbuses used in building management systems

Name	Main Firms	Data rate	Nodes	Bus length
Controlled Area Network (CAN)	Bosch, Allen Bradley	1 Mb/s : 50 kb/s	64 : 127	40 : 1000 m
PROFIBUS	Siemens, ABB, Landis &Gyr, Schneider Group	500 : 93.7 kb/s	32	200 : 1200 m
European Installation Bus (EIB)	Siemens, Phillips	9.6 kb/s	64	350 : 700 m
Batibus	Schneider Group, Landis & Gyr	4.8 kb/s	75	300 m
Lon Works	Echelon Corp.	1.25 : 0.078 Mb/s	64	130 : 2700 m
WordFIP	Cegelec, ABB	31.25 kb/s : 1 Mb/s	32	1900 : 750 m

4.4.2 Connection between the management and the automation level

The communication bus at this level is named 'system bus' or 'process bus' and it is required to have better performance than the bus used at the field level. At this level the priority is not the acquisition data, but the exchange of more complex information. For this reason other kinds of communication buses are used, with different technology, protocols and performances. In more extended and structured management systems, with a large number of processing units, there is a single communication network for the automation of a management level.

4.4.3 Communication at the management level

The communication network supporting this task is also called a LAN (Local Area Network). At this level there is an exchange of information between computers and PLC with a large amount of data and a continuous flux. There is the need to have a medium that allows good transmission speed, long-distance transmission, and flexibility. For smaller systems where almost all the operator stations are located in the same area, it is possible to use a bus system. But for an extended network the most common network used at this level is based on the IEEE (Institute of Electrical and Electronics Engineers) 802.3 standard and usually defined with the name Ethernet.

5 CERN SITUATION

Over the years, several systems of automation and control have been installed at CERN, for a variety of applications, and several kinds of fieldbus have been extensively used. In this way the control and monitoring systems of various functions have been set up, also in a few tertiary buildings, for example for HVAC systems, but these systems are run in an independent way. The several systems are structured with two communication levels: fieldbuses connecting all the process devices and CERN's LAN used as communication medium inside the management level and between the management and automation levels. The LAN is made up of an Ethernet network (Réseau Ethernet Service). The processing units of the several management systems of all the controlled processes are linked to this network. Each processing unit of the management level is able to communicate with its own automation level.

6 EVALUATIONS

The evaluation of the usefulness of installing such management systems for buildings at CERN has to be executed by the users, by the people that are in charge of the management of the several functions and of the management of the site, examining the possible advantages, not only the economic ones. Nevertheless the estimation of the economic convenience must take into account the cost and the payback time of the realization of the systems. This cost includes the costs of all the components: field devices, LPU, fieldbus and management units with suitable software. The problem of setting up the communication structure of the future automation systems or of coordinating the existing systems is simplified by the existence at CERN of the LAN covering almost all the site. But there are high costs, compared with a normal installation, in setting up a technical installation (electrical system, HVAC, etc.)

equipped with all the field and automation components necessary in order to be managed by an automation system. Consider the example, of a low-tension electrical switchboard of main distribution with the following characteristics: In = 800 [A], one incoming circuit breaker and ten outgoing circuit breakers. To be able to run it with such a management system, we have to install components able to execute commands or to transmit their status or measures, a communication device, a fieldbus and LPU able to carry out the communication with the Ethernet network and simple automation functions. This involves an extra cost of about 15% in comparison with a normal switchboard, without considering the cost of the software and the personal computer at the management level. The automation extra cost of automation is even higher for secondary distribution switchboards: about 80% for a switchboard with one incoming and twenty outgoing circuit breakers having In $\leq$ 63 [A]. In existing buildings, generally, it is not possible to implement the existing installations; with controlled field devices instead it is necessary to replace them with new installations at high cost.

7 CONCLUSIONS

At the present time at CERN, it is difficult to justify the cost of systematically installing global management systems for existing buildings. There is the eventuality that in the future in some tertiary buildings there will be special requirements, which will be able to justify the investments. In that case it will be possible to realize computerized technical management systems for certain functions in existing or new buildings. It will also be possible to collect and coordinate all the control and automation systems of the tertiary buildings by a single management system.

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