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Building Automation: An Overview of Central Control and Monitoring Systems

Please note

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Central control and monitoring systems (CCMS) are of various levels of sophistication depending on the size of the building and desired operational function. The simplest system allows an operator to check the operational status of the heating, ventilating and air conditioning (HVAC), fire and security systems, and control various equipment remotely from a central console. The most complex system ("direct digital control" DDC) has a digital computer to perform most of the work normally done by the operator, and other optimization and control functions.

This Digest presents the results of a survey of available CCMS, and outlines their main design features and areas of application. Total cost and the number of points monitored are used to develop a simple guideline for selecting a suitable system for a given large building or group of buildings.

Building Automation and Energy Conservation

Software packages designed for CCMS consist of one or more money-saving programs that contribute to energy conservation through efficient energy management. These programs interact continuously to operate as an integrated system. Consequently, the net energy saving is the sum of their contributions, making it difficult to determine the savings from each program. The following programs perform most of the functions used to save money and energy in buildings.

Start/Stop Program. -- This represents the simplest yet most effective, energy saving program. It is designed to start and stop different HVAC equipment automatically according to a pre-determined schedule.

Reset Program. -- The actual cooling load is calculated in various zones and the supply air temperature reset so that minimum cooling and reheating will occur. This action saves energy by matching the system to the actual building load during off-design conditions.

Start Time Optimization Program. -- Comfort conditions are restored in time for occupancy in buildings where the air-conditioning equipment is shut down during the silent hours.

Electric Demand Control Program. -- The controllable or discretionary portions of the building electric load are varied to compensate for load requirements elsewhere in order to present a more nearly constant total building demand to the utility company.

Enthalpy Control Program. -- This program is also known as the outdoor air quantity optimization program. When a space requires cooling, the enthalpy (total heat content) of the outdoor and return air are monitored and compared. Thus, when the enthalpy of the outdoor air is lower than that of the return air, a larger percentage of outdoor air is mixed with a smaller portion of return air. This in turn reduces the chillers load, and is therefore called "free cooling."

Chiller Load Optimization Program. -- This program is used when a group of buildings is supplied with cold water for the cooling system by a multiple chiller plant. It is designed to maximize the cooling plant efficiency during all operating conditions and ensure minimum energy consumption. The over-all cooling plant efficiency varies with the imposed cooling load, condenser water temperature, and chilled water temperature. Interactive calculations determine the most efficient operating conditions by taking into account cooling plant layout, the number of series and parallel chillers, and whether or not a heat recovery system is used.

Building Management Programs. -- Standard programs are used to provide integrated daily or monthly cooling and heating loads, kilowatt- hours, kilowatt demand, and total gas, oil and electricity consumption.

Preventive Maintenance Program. -- Totalization of machine running time enables maintenance personnel to service different equipment properly, based on total accumulated running time.

Light Control Program. -- This program is used to control lights in various zones of a building or group of buildings. A direct and profitable advantage of a light control system is the ability to reduce electric peak demand quickly when it reaches the critical range.

Fire Alarm and Life Safety Program. -- A databased computerized system for life safety, fire alarm, and smoke control operations can be designed to work in parallel with HVAC systems. Smoke control routines include control of special fans and air-handling units.

Power Demands Forecast Program. -- When the predicted electric power demand appears to exceed a preselected usage limit, the central facility is alerted and the electric demand control program is executed.

CCMS Classifications

Several types of CCMS are available. Most major control firms and other companies in this field have introduced families of building automation systems intended for a wide range of building sizes. These systems are classified as follows.

Class A Systems. -- These consist of small monitoring and control systems that can be used in buildings with floor areas up to about 20 000 m^2. The basic component is a microprocessor preprogrammed to start/stop different HVAC system components according to a preselected schedule. The systems can be designed to perform other operations such as monitoring fire alarms and smoke detectors, security checks, and load cycling.

Class B Systems. -- These systems are similar to those in Class A except that they can serve larger buildings and some building complexes. The available software packages provide functions such as: executive and operating instructions, scheduled start/stop operations, load rotation and shedding, control points resetting, optimization of start time, enthalpy optimization, and fire alarm and life-safety system monitoring.

These systems can usually monitor about 2000 addressable points, and the memory of the central processor is large enough to handle data for more than one building. When these systems are used for a group of buildings or building complexes, the central control facility is connected to remote data gathering panels by means of one or more types of data communication links. Because more than one data gathering panel is served by a central facility, each panel is allotted an equal amount of time in direct communication with the central facility.

As the number of data gathering panels increases, the time allotted each panel becomes shorter or communication between the individual panels and the central facility becomes less frequent. To overcome this inefficiency, the data gathering panels are divided into groups. Each group is supervised and served by a separate remote processing unit (RPU) that stores the software algorithms required to operate the connected control points. Each RPU is in turn connected to the central facility in order to transfer the over-all control strategies and any changes issued by the operator. This network is shown in Figure 1.

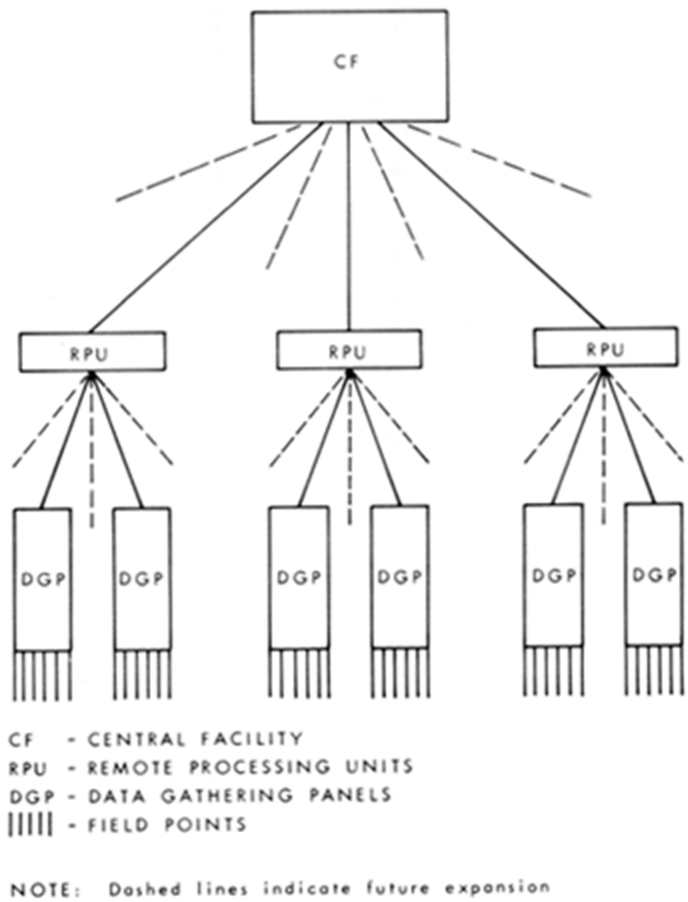

Figure 1. Block diagram for Class B systems.

Class C Systems. -- These are referred to as "direct digital control" (DDC) systems, and are the most sophisticated type of CCMS. DDC systems are used for building complexes such as educational institutes and university campuses. In addition to the basic functions described earlier, the large data storage and on-line computer make it possible to include the following programs; reset of supply air system; optimization of cooling and heating plants operation; building management; lights control; preventive maintenance; and energy auditing and efficient bookkeeping. Reference 1, on which this Digest is based, gives a detailed description of the DDC system, and compares it with the conventional pneumatic control system.

Class D Systems. -- Installation of a CCMS is neither economical nor practical for small buildings because of the relatively high initial and operating costs. The alternative is to monitor and control buildings in a wide geographical area from a single location. The benefits of a building automation centre can be obtained by purchasing the service rather than providing it independently. In this case, the manufacturers install the system in a centralized location of the area to be served. The purchased building automation service may include most of the services that could be obtained by owning a CCMS, without the burden of maintaining the system itself.

Selection of CCMS

For a particular building or building complex, the preliminary survey of the existing HVAC system and desired control functions will indicate the total number of points to be monitored. The results are used to estimate the initial cost and determine which system is most suitable.

The total number of monitored points is an important factor in selecting a CCMS. Each system has a certain number of points that it can handle efficiently, and any additional points will overload it. This results in inefficient operation and slower speed of communication between the field devices and the central facility.

To determine the total number of points, future expansion of the building and the possibility of implementing other programs or energy conservation measures should be investigated. Such expansion or new measures usually result in an additional number of points, and therefore require larger computer memory to store the pertinent information.

The procedure to select a suitable CCMS can be summarized as follows:

1. Study the existing HVAC system to determine the number of points to be monitored.
2. Determine the control and other functions required, including energy conservation measures, management, security, etc.
3. Make provision for future expansion in buildings, control strategies and operational functions.
4. Estimate the payback time or rate of return on the money invested taking into account anticipated increases in costs of labour and energy.

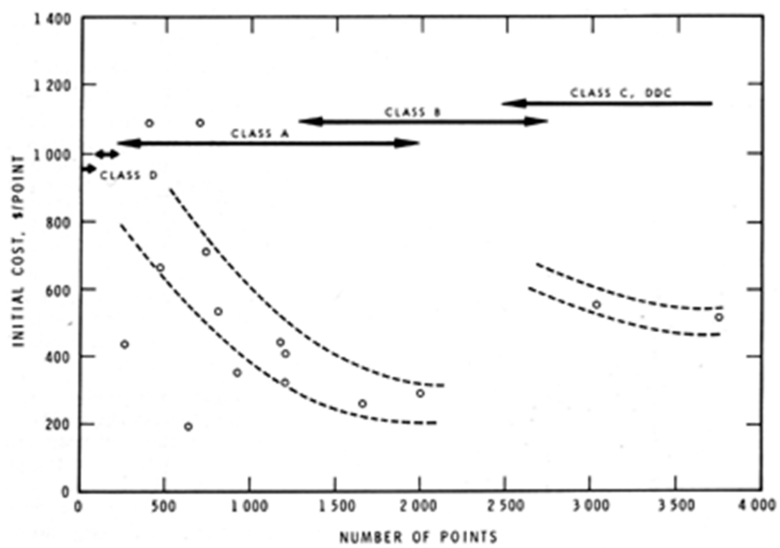

Figure 2. Correlation between the number of points and the initial cost/point of CCMS.

Figure 2 may be used to estimate the initial cost of the CCMS based on the estimated total number of points. It also gives some guidance on the class systems suitable for a particular project. For example, if the number of points is below 100, leased building services (Class D systems) are more economical than a privately owned system. If leased building services are not available, automatic time clocks (or similar electronic devices) can be used to achieve equipment scheduling.

If the number of points is between 100 and 200, then Class A systems might be used at a reasonable cost. This would probably be the case with medium and large office buildings of between 10 000 and 20 000 m². For a group of buildings where the number of monitored points is between 500 and 1500, Class B systems are believed to be suitable and more economical.

In the case of a large building complex (20 buildings or more) the number of monitored points usually exceeds 2000. In these situations, the direct digital control systems (Class C systems) may be appropriate. The cost per point for the DDC systems is usually higher than that of the other classes, but the following additional benefits are often sufficient to justify the extra cost.

1. DDC systems are expandable in terms of the number of points able to be monitored, software packages available, and operational functions.
2. They are more reliable than pneumatic control systems.
3. Failure of the central facility does not upset the individual control units because satellite processing units are programmed to stand alone in such cases.
4. Larger computer memory allows the building management to use a preventive maintenance program and perform energy audits for the different buildings.
5. Electronic components are usually available from several computer manufacturers. This has the advantage that the customer is not restricted to a particular company for equipment maintenance, and, in most cases, results in a reduction in the operation cost of the system.
6. Although the initial cost of DDC systems is relatively higher, the payback period is comparable with those of smaller systems.

Concluding Remarks

1. Building automation systems contribute to energy conservation and save money because of better control of energy consuming equipment.
2. CCMS indicate off-normal conditions before they are registered as a complaint about uncomfortable conditions in the occupied space.
3. CCMS provide maintenance personnel the convenience of checking the HVAC components without actually having to visit the system.
4. Major control companies supply, install and maintain CCMS equipment. The disadvantage is that the customer is totally dependent on the supplier for any changes, modification, or updating of the existing system.
5. Extensive engineering studies are always necessary to study the existing HVAC systems, the operational functions desired from the building automation system, and the projected expansion in both buildings and monitoring system. These are usually undertaken prior to committing a large sum of money to a specific building automation system.
6. Management personnel are often concerned about equipment obsolescence, particularly in the electronics field. This concern is justified by the rather significant changes in electronic equipment for building management systems. However, a flexible and expandable design of building automation systems minimizes the effects of obsolescence.
7. In most cases, building automation systems do not reduce manpower requirements, but a central control system can assist in making building management and maintenance personnel more efficient, particularly when implementing effective preventive maintenance programs.
8. Problems in existing HVAC systems and controls should be corrected before installation of a control centre.

References

1. Elmahdy, A. H. An overview of central control and monitoring systems for large buildings and building complexes. National Research Council of Canada, Division of Building Research, Building Research Note 159, March 1980.