The savic-net G5 Supervisory Controller for Advanced Energy Management and Comfortable Indoor Spaces

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To prevent global warming and ensure a stable energy supply, sustainable and advanced energy utilization management is required in buildings. In addition, offices require a comfortable space to promote intellectual productivity. Since these requirements may be contradictory, it is impossible to satisfy both using only individual controls for various types of equipment. In order to satisfy both requirements, it is necessary to understand the state of the entire building and to exert integrated, optimal control of multiple types of equipment. We have developed a supervisory controller with various advanced functions for savic-net™ G5 as a foundation for providing integrated control applications.

1. Introduction

The importance of reducing greenhouse gas emissions is reflected in measures such as the Paris Agreement, an international framework to combat global warming that was adopted at the 21st Conference of the Parties to the Climate Change Framework Convention (COP 21). In the building industry in Japan as well, reporting CO_2 emissions and taking energy-saving measures are required by laws like the Act on the Rational Use of Energy (the Energy Conservation Act) and the Tokyo Metropolitan Environmental Security Ordinance. In addition, the country's July 2018 fifth basic energy plan clearly states that the use of renewable energy as a main power source, the implementation of virtual power plants (VPP), and demand response (DR) are being promoted. Not only energy conservation, but also advanced energy management has become more important. In fact, due to recent record-breaking hot weather, the implementation of DR has become necessary in order to manage the tighter supply and demand situation for power.

On the other hand, in recent years there has been an increased interest in the comfort of the indoor environment in office buildings, with a view to improving intellectual productivity and reducing stress. In addition, many companies are promoting "work-style reform," which requires comfortable spaces that allow flexible ways of working.

Since these requirements for conservation and for comfort may be contradictory, both cannot be satisfied using only individual controls for various types of equipment. To satisfy both requirements, it is necessary to understand the state of the entire building and to exert integrated, optimal control of multiple types of equipment. Integrated control by a building energy management system (BEMS) is mentioned as an important technology in the Ministry of Economy, Trade and Industry's 2016 energy-conservation technology strategy.

The Supervisory Controller, which is part of the new savic-net G5 building automation system, was developed to meet the need for integrated control. In order for the Supervisory Controller to implement integrated control, it must be able to obtain data from connected controllers, regardless of the vendor, and it must be fast and reliable. Also, engineering work should be easy, even if the number of control target devices increases. Accordingly, the Supervisory Controller was developed with multi-vendor support, high-speed scanning and value/state change recording, data sharing among Supervisory Controllers, Supervisory Controller redundancy, and the ability to continuously take on a variety of new applications.

This paper explains the platform functions which we developed to implement integrated control (sections 3, 4, 5, and 6), outlines the handling of power demand as a sample application (section 7), and reports on the effectiveness of the platform functions.

2. System Configuration

The system configuration of savic-net G5 is shown in figure 1. In a general building system, subsystems for air conditioning, lighting, electricity, etc., are constructed for each facility or floor. A Supervisory Controller is installed for each subsystem in order to monitor the multiple controllers in that subsystem. The client PC collects the data from the Supervisory Controllers to provide a user interface for the entire system.

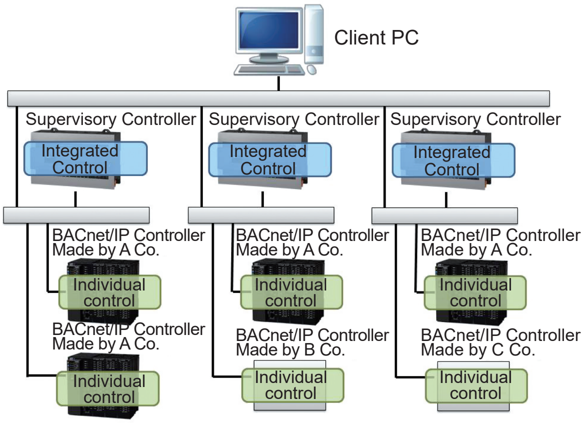


Figure 1. System configuration

3. Multi-Vendor Support

The facilities monitored by the building system include air conditioning, lighting, electricity, etc. In the case of a large-scale system, it is usual for different vendors to monitor different equipment. In order to carry out integrated control of the whole system, the various vendors' equipment must be connected and controlled in the same way.

One problem for connecting vendors' controllers is that they may use different communication protocols. Also, since there are functional differences among the vendors' controllers, a method of absorbing the differences and providing similar functions is necessary.

This section gives an overview of the method we developed for connecting the various vendors' controllers in order to implement integrated control.

3.1 Multiple Communication Protocols

The configuration used to support multiple communication protocols is shown in figure 2. The data (states/values) from devices and sensors to be monitored are controlled using the concept of the point. An application can obtain data from the devices to be monitored and control them by accessing the points. The application and communication layers are separated by the function of the point, so an application can execute control without being aware of differences in the communication protocols.

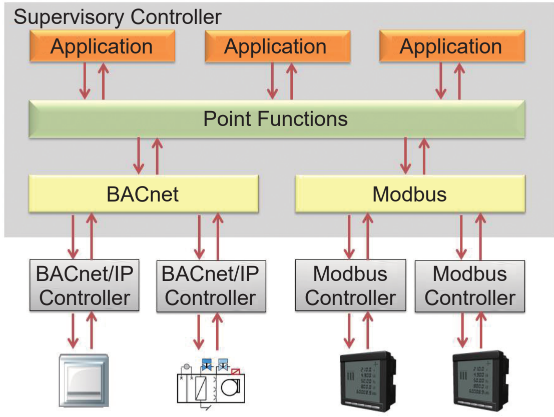


Figure 2. Support for multiple communication protocols

3.2 Function Substitution

Depending on the communication protocol used and the types of vendors' controllers, there may be differences in the provided functions. For example, priority management is available for operating BACnet point objects, but Modbus™ does not have such a function. If there is a functional difference in the input and output points of the application, there will be a difference in what can be achieved by control.

In such a case, the Supervisory Controller provides the function that is not supported by the connected controller. Since applications can treat all points as having the same functions, they can execute control regardless of any functional differences between the controllers.

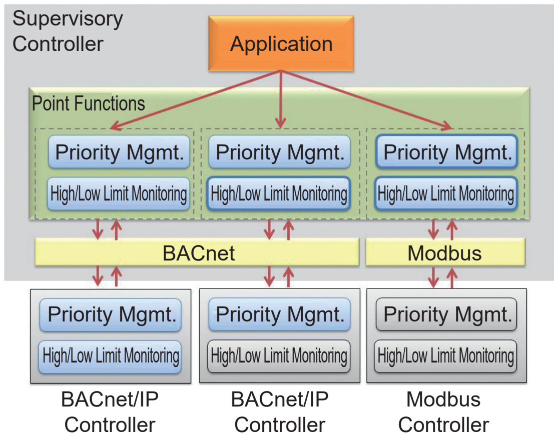


Figure 3. Provision of substitute functions

4. High-Speed Scanning and Value/State Change Recording

In order for the Supervisory Controller to execute control correctly, it must have accurate data (states/values) on the monitored devices and sensors. For parameters that do not change frequently, such as indoor temperature, it is sufficient to monitor the value every minute or so. But for parameters that change very frequently, such as power consumption, it is necessary to monitor on a faster cycle. This section gives an overview of the method used to accurately manage the monitored state and value data.

Figure 4 shows the data scanning mechanism. The Supervisory Controller learns the situation of the monitored controllers by scanning their data. The communication functions of BACnet, Modbus, etc., allow the data from the various controllers to be scanned in parallel. The scanned data is stored in the point function queue. A point function sequentially applies the queued data to the state of the point. By separating the point's functions and the communication functions in this manner, high-speed scanning can be accomplished without disturbance on account of the load of the point functions (high/low limit monitoring for measured values, priority management, etc.). The Supervisory Controller can scan data on a one-second cycle at the fastest, so it can accurately monitor rapidly changing data.

In addition, when updating the state of a point, if the state has changed, the changed state and time-of-detection timestamp are stored together, so all changes are accurately recorded.

The scan cycle and the number of changes stored can be specified for each point as appropriate for the monitored object.

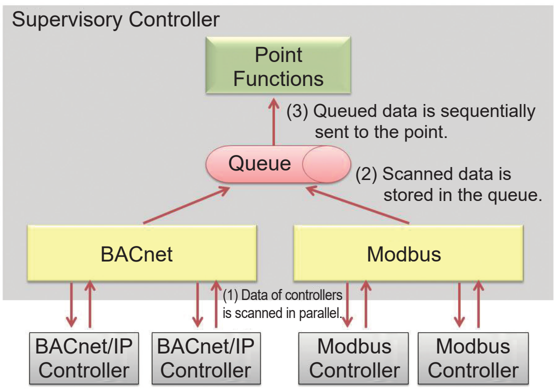


Figure 4. Data scanning

5. Data Sharing Among Supervisory Controllers

In order for Supervisory Controllers to implement integrated control of an entire system across all subsystems, it is necessary for them to share data.

In a conventional system environment, the data to be shared would be copied to each Supervisory Controller, and if copying needed to be done in offline mode, system monitoring would stop because of this engineering work. In addition, if there was a large amount of data to be shared, the cost of the engineering work would increase.

The method we developed for sharing data among the Supervisory Controllers in order to solve these problems is surveyed in this section.

5.1 Hiding of Physical Configuration

All applications in the Supervisory Controller exchange data via the platform functions. The physical configuration information—which controller has which points—is managed by the platform functions. They send/receive data with an awareness of the physical configuration, so applications can access any point in the system without consideration of the physical configuration.

Furthermore, when the state or value of a point changes, an application can learn of the change immediately through the platform functions, allowing enhanced responsiveness of control. Since applications are not restricted by the physical configuration, it is easy to construct a system.

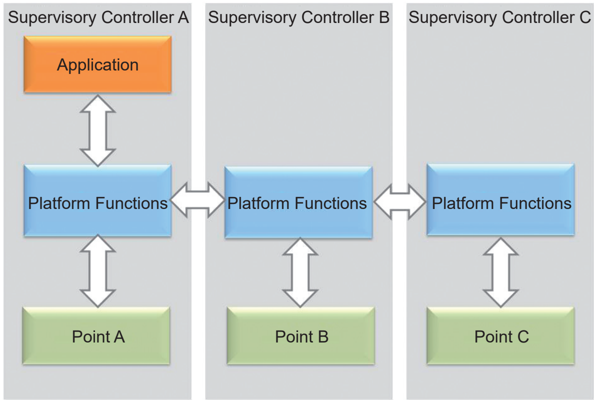


Figure 5. Data exchange between application and points

5.2 Management of Configuration Information

Figure 6 shows how the configuration information is managed. As part of its platform functions, the Supervisory Controller stores the point data from the controllers that it monitors. When an inquiry is received from an application about a point that is not managed by the Supervisory Controller, it queries other Supervisory Controllers. The response from the Supervisory Controller that has the required point information is stored as configuration information. This information is accessed if there is an inquiry about the point in the future. By storing this information, queries to other Supervisory Controllers can be avoided, helping to maintain high-speed communication. This method enables information sharing among the Supervisory Controllers without engineering work.

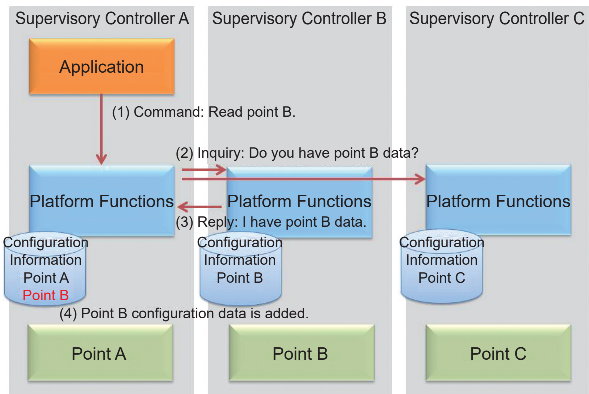


Figure 6. Management of configuration information

6. Supervisory Controller Redundancy

When integrated control is implemented for a district heating and cooling (DHC) system, etc., high reliability is required from the Supervisory Controller. It is common idea to duplicate controllers in order to improve reliability. However, if controllers are simply duplexed, the connection of other devices must take the system redundancy into consideration. This section gives an overview of our method for connecting other devices without considering system redundancy.

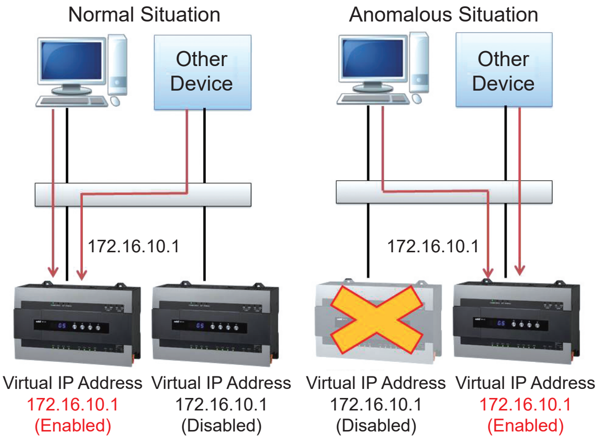


Figure 7. Supervisory Controller redundancy concept

Figure 7 shows a redundant system. Two Supervisory Controllers have a common virtual IP address so that they can be regarded as a single controller. The IP address is valid only for one controller, and is invalid for the other. If the controller with the valid IP address becomes faulty, the other switches its address from invalid to valid and continues operation. This technique allows two Supervisory Controllers to use a common IP address. Other devices can be connected without considering system redundancy because the two controllers can be regarded as a single controller.

7. Power Demand Control

As an example of an integrated control application, this section gives an overview of the power demand control that was developed for savic-net G5. It also discusses the effectiveness of the platform functions.

7.1 Overview of Power Demand Control

The power companies measure the amount of power consumption using watt-hour meters. These meters measure the amount of power consumed during a 30-minute demand period and calculate the average power consumption. This average power consumption is referred to as the demand, and if the demand exceeds the amount of contracted power, you may be requested to charge a surcharge or raise the amount of contracted power.

The power demand control predicts the amount of demand at the end of the demand period. On the basis of the prediction, it stops or starts the air conditioning, adjusts the setpoint of the air supply temperature, and sends warnings to users so that the amount of power use falls below the target amount. By setting a value that is equal to or less than the contracted amount as the target power, it is possible to operate the facility within a range that does not exceed the contracted amount of power. Furthermore, peak power use can be reduced by controlling the amount of use so as not to exceed the target amount of power, contributing to the stability of the power supply.

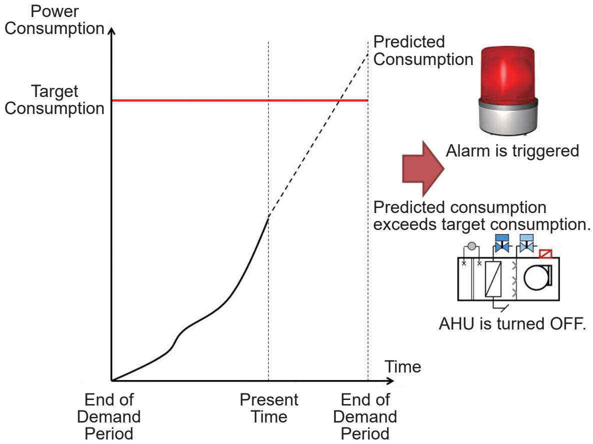


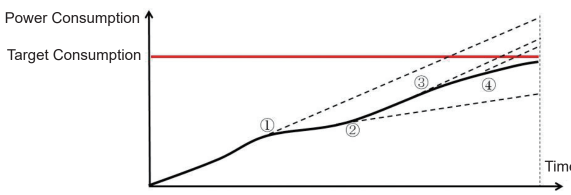
Figure 8. Power demand management concept

7.2 Power Demand Control Without Sacrificing Comfort

If the air conditioning is stopped or the air supply temperature setpoint is adjusted by the power demand control, there is a possibility that comfort will be sacrificed. This can be avoided for the most part, while still reducing power consumption, by allowing priorities to be specified for the targets of control. In addition, by rotating targets that have the same priority for control, it is possible to prevent repeated lowering of comfort in a particular area.

The devices that are targets for control can be classified into as many as 15 groups, and priorities can be assigned for each group. When the predicted power exceeds the target power, power consumption control is gradually applied to low-priority groups. If the same priority is assigned to multiple groups, groups with the same priority are rotated when power-consumption control is applied.

An example of power demand control operation is shown in figure 9. Since the predicted power use exceeds the target power use at point 1, power consumption in the public area and in office area A is restricted, in keeping with the assigned priorities. Since the predicted power use is lower than the target consumption at point 2, the restriction on power use in office area A is lifted. At point 3, the predicted power consumption again exceeds the target amount. Since office areas A and B have the same priority, this time power consumption in office area B is restricted. Since the predicted power consumption still exceeds the target amount at point 4, power consumption is also restricted in office area A and in the reception area.



	①	②	③	④
Reception Area (high priority)	Temp.: 24 °C	Temp.: 24 °C	Temp.: 24 °C	Temp.: 24 °C	Temp.: 26 °C
Office Area B (medium priority)	AHU: ON	AHU: ON	AHU: ON	AHU: OFF	AHU: OFF
Office Area A (medium priority)	AHU: ON	AHU: OFF	AHU: ON	AHU: ON	AHU: OFF
Public Area (low priority)	AHU: ON	AHU: OFF	AHU: OFF	AHU: OFF	AHU: OFF

Figure 9. Example of the operation of power demand control

7.3 Integrated Control

The configuration of devices and controllers handled by the power demand control is shown in figure 10. Since the devices subject to power demand control are distributed across multiple controllers, device priority throughout the entire system cannot be controlled by these individual controllers.

Instead, Supervisory Controllers share information between them without the need for any special engineering work, so that power demand applications can control multiple devices across the subsystems. Also, owing to multi-vendor support, devices monitored by third-party controllers can be controlled as well.

Since one Supervisory Controller can provide integrated control for the whole system, control operations that observe the priority of devices can be carried out across different facilities such as air conditioning and lighting.

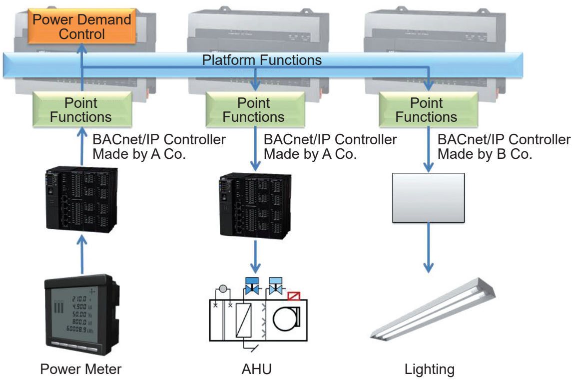


Figure 10. Integrated control of power demand

7.4 Power Consumption Prediction

Figure 11 shows the method of the power consumption prediction. Power consumption is predicted based on records of power consumption by the monitored equipment. Records up to the present time within the sampling period are used for prediction. The power demand at the end of the demand period is predicted by linear approximation, applying the least squares method to the data records.

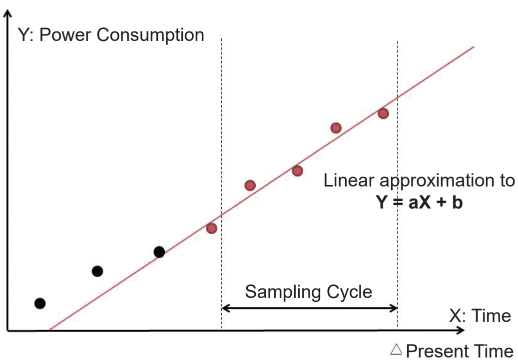


Figure 11. Power consumption prediction

In an average building system, records are collected on approximately a one minute cycle. Since the sampling time is usually 1 or 2 minutes, prediction accuracy would be low if records were collected every minute or so. The Supervisory Controller can accurately record data on power consumption of the monitored equipment using high-speed scanning and storing of data changes. Furthermore, since the scan cycle can be separately specified for each point, real-time responsiveness can be improved by setting the scan cycle short, and prediction accuracy can be improved by increasing the number of data records used.

8. Conclusions

The savic-net G5 system's Supervisory Controller was developed to execute integrated control. It facilitates the efficient development of applications by providing multi-vendor support, high-speed scanning and value/state change recording, data sharing among Supervisory Controllers, and Supervisory Controller redundancy. We look forward to continuing expansion of our applications for energy efficiency and environmental comfort using integrated control.

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