A New Engineering Tool that Contributes to Enhancing the Operational Efficiency of a Building Automation System

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The PC Engineering Tool is designed for quick configuration of the newly developed savic-net™ G5 building automation system and for more efficient adjustment. To improve the existing level of usability and development efficiency, we defined the basic user interface (UI) and commonly used functions as a platform and implemented various engineering functions as applications of this tool.

1. Introduction

We developed, manufactured, and marketed the building automation systems (hereinafter, BASs) shown in figure 1 beginning in around 1980. Early BASs used only their built-in loader functions to perform operational work. Since 1996, we have developed engineering tools separately from products in the form of software that operates on PCs. Since then, we have developed engineering tools to upgrade products and add functions to them. Those tools have been released separately as individual tools and have increased in number. As a result, multiple tools are difficult to use and complex procedures have been required for engineering work, leading to reduced efficiency of operation. In addition, over 20 years have passed since the full-scale spread of PCs in offices and homes began, and users now have a better knowledge of GUIs. It is often difficult to satisfy these users with our existing engineering tools, which have unique screen layouts an operational constraints.

Against this backdrop, after beginning the development of a new system, savic-net G5, we are now in the process of developing a PC Engineering Tool for this product.

This paper describes the background and purpose of the development of the PC Engineering Tool for savic-net G5, the platform that we developed, an example of its application, and our expectations for the future.

1980–1996 Microcomputer BA System **SAVIC**	• Loader
1987–2002 Distributed Microcomputer BA System **savic-net**	• Loader • File generator • H-MMI
1996–2013 Personal Computer BA System **savic-net EV**	• BESS (File generator) • BACnet engineering tool • PC-MMI • Instrumentation engineering tool • DDC panel editor • H-MMI
Since 2004 Web-type BA System **savic-net FX**	• Engineering tool for savic-net FX (BESS, BACnet engineering tool, instrumentation engineering tool, PC-MMI, R4FX2, BACnet Configuration Tool) • Adjustment support tool • DDC panel editor • Summary graph generator • H-MMI
Since 2016 Web-type BA System **savic-net G5**	PC Engineering Tool for savic-net G5

Fig. 1. Past and present systems and engineering tools

2. Overview of the PC Engineering Tool for savic-net G5

The PC Engineering Tool for savic-net G5 has the following functions.

(1) Main window / common functions

Setting functions common to the whole savic-net G5 system

(2) BH-1 engineering functions

Engineering functions and graphic creation functions related to the central monitoring unit (hereinafter, BH-1)

(3) WJ-11 engineering functions

Engineering functions and control program setting functions related to the BACnet controller (hereinafter, WJ-11)

Figure 2 illustrates the configuration of the savic-net G5 system and the functional scope of the PC Engineering Tool for savic-net G5.
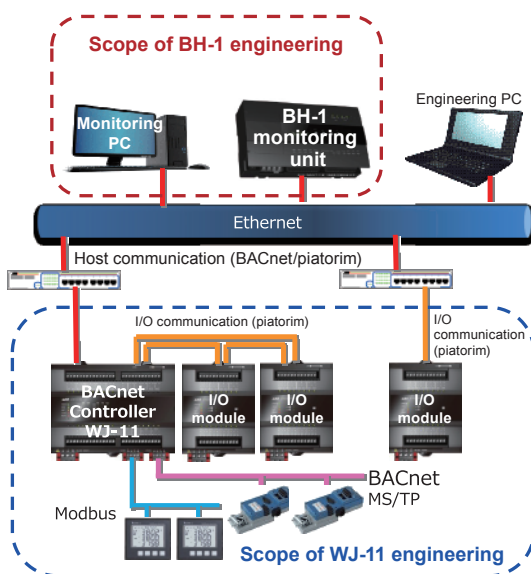

Fig. 2. System configuration and functional scope

3. Development Concepts and Objectives

The PC Engineering Tool for savic-net G5 is designed to provide new functions for configuring and adjusting the savic-net G5 system, and to replace the conventional engineering tools used for savic-net™ FX. Improvement in operational efficiency is a requirement of development.

The concepts and objectives that were of primary importance in the development of the PC Engineering Tool for savic-net G5 are described below.

3.1 Unification of the UI, improvement of operability, and building of a platform

"Unification of the UI and improvement of operability" were not realized in our conventional tools. To achieve unification and improvement, we defined basic window specifications as a UI common to all windows of the PC Engineering Tool for savic-net G5 and thereby unified the layout and operation methods of the entire tool. In addition, we developed a platform (described below) of common functions for "improving input efficiency", achieving improvement in the operational efficiency and development efficiency of the entire tool.

The basic window is described in section 4.

3.2 All-in-one tool

For the previous savic-net FX system, different engineering tools needed to be used depending on the target product and purpose of the work. Users were required to manage data files in order to ensure data synchronization among tools. In addition, the versions of the tools needed to be matched with one another. For the PC Engineering Tool for savic-net G5, all of the functions necessary for operation are integrated into one package (an all-in-one tool). This integration unifies operational methods, enables data files to be managed collectively, and eliminates version management, thereby improving operational efficiency (fig. 3).
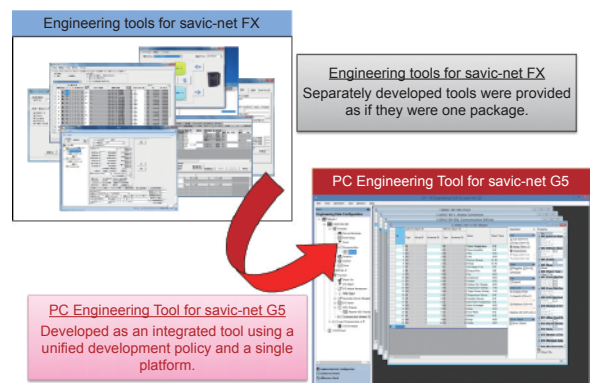

Fig. 3. All-in-one tool

3.3 Online engineering

In previous systems, operation of the equipment had to be stopped and then restarted whenever new engineering data was written. In contrast, the savic-net G5 system does not require restarting when new engineering data, except for some settings, is updated. The PC Engineering Tool for savic-net G5 allows changes to be made while the system is running, thereby shortening the time required to perform operations and minimizing the time that the system is in an unmonitored or uncontrolled state.

4. PC Engineering Tool Platform

Considering the above-described concepts and objectives of development, in order to create the PC Engineering tool we defined the software configuration described below (see too fig. 4 and table 1).

- **Application functions** : implement functions for the configuration and adjustment of the savic-net G5 system
- **Platform** : consists of the framework and services, including all of the parts of the UI and the functional parts repeatedly used in combination to implement the application functions
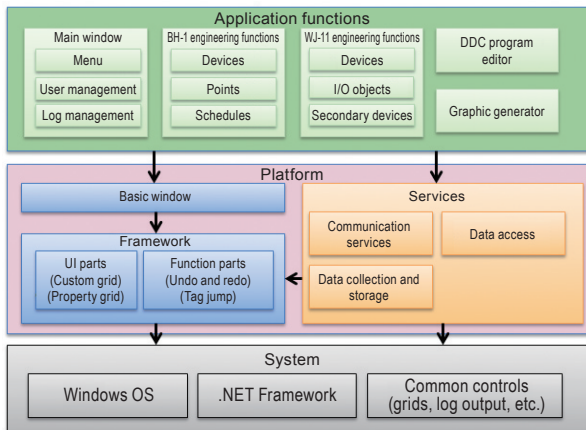- **System** : consists of an OS, an execution environment, and common controls

Fig. 4. Software configuration

Table 1. Description of the software configuration

Classification		Description
Application functions		The main window, BH-1 engineering functions, WJ-11 engineering functions, etc.
Platform		The basic window and the following functions.
	Framework	UI components and functional parts repeatedly used in combination, such as the data grid and the property grid.
	Services	Data access, communication services, etc.
System		The OS, .NET Framework, common controls, etc.

The next section describes the basic window of the platform.

4.1 Structure of the basic window

To prevent users from being confused during operation, we defined a basic window layout. As shown in figure 5, the basic window consists of a main window, an application window, and an output window. We adopted a multi-document interface (hereinafter, MDI), which simultaneously displays multiple windows, to allow users to easily switch between windows.
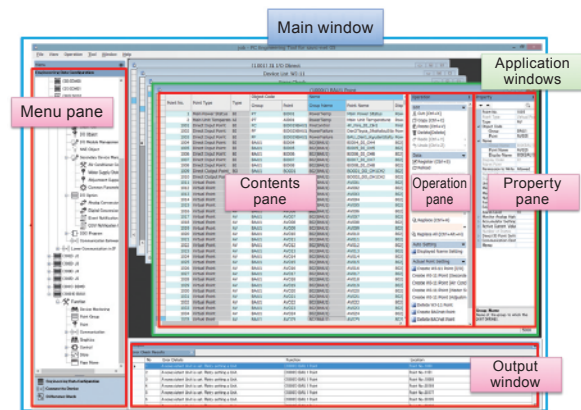

Fig. 5. Component elements of the basic window

4.1.1 Main window

The window that is displayed upon starting the PC Engineering Tool for savic-net G5 is called the main window. The main window acts as the parent window of the MDI. Through this window, users can invoke the main controls (e.g., start or close a tool) of the PC Engineering Tool for savic-net G5, the controls for display of the child windows (application windows), and the necessary application functions in the menu pane.

4.1.2 Application window

An application window consists of a contents pane, operation pane, and property pane. The contents pane uses a table (data grid) similar to Microsoft Excel files, which is familiar to many users, to list operation items and data. The contents pane can be resized depending on the screen size of the PC. However, if it contains too many items to display at once, horizontal scrolling would be required. To avoid this, we enabled the property pane to vertically list all the setting items.

4.1.3 Output window

The output window is displayed in the lower area of the main window. It can indicate any processing results, such as the result of an error check.

4.2 Convenient functions of the basic window

The PC Engineering Tool is used for various purposes, such as the creation of initial data in an office, product configuration on site, and changes in the settings of a product after its configuration. To support the various types of needs in each situation, we provided the following convenient functions common to all of the windows to enable users to build work environments flexibly depending on their needs.

4.2.1 Data editing operations and a function for identifying modified locations

We provide basic data editing operations (copy and paste, undo and redo) and data output processing (file output in xlsx format).

There is also a function that changes the background color of cells where data has been modified. This function allows users to easily identify modified locations (fig. 6).

Fig. 6. Change in the background color of modified cells

4.2.2 Change of displayed settings depending on the task or user preference of user

In the savic-net G5 system, different settings for BH-1 and WJ-11 are used in different situations. For example, when settings for device data sharing are being checked, there is no need to display the settings for alarms. Since the number of settings that can be simultaneously displayed in the contents pane is limited due to constraints on window size, we made it possible to change the items that are displayed in the window by changing a setting (fig. 7).

Also, to avoid the need for scrolling, we made it possible to anchor the display of important settings in a particular column, and to change the location where a column is displayed (fig. 8).

Fig. 7. Selection of items to display

Drag the column header to the target location.

Fig. 8. Moving a column

4.2.3 Changes to the window display layout

We adopted an MDI to allow users to display and edit multiple windows simultaneously based on their work needs (fig. 9).
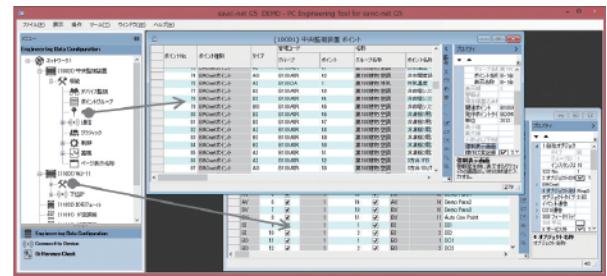

Fig. 9. MDI on the screen

Users can select the display mode they need from the following choices: (1) cascade, (2) horizontally tiled, (3) vertically tiled, (4) tabbed, and (5) separate from parent window / merged with parent window.

Figure 10 shows an example of a screen displayed with tabbed windows.

Fig. 10. Screen when tabbed display is selected

In some cases, the user needs to compare the settings of multiple devices, or to refer to the settings of multiple related functions simultaneously. We therefore made it possible to display multiple child windows (application windows) as tiles (fig. 11).
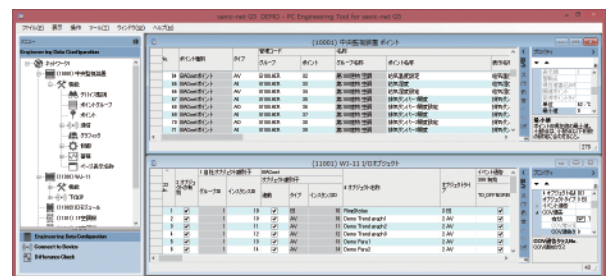

Fig. 11. Windows displayed as tiles

In some cases, the tool is used in a dual monitor environment. We therefore made it possible to separate child windows (fig. 12).
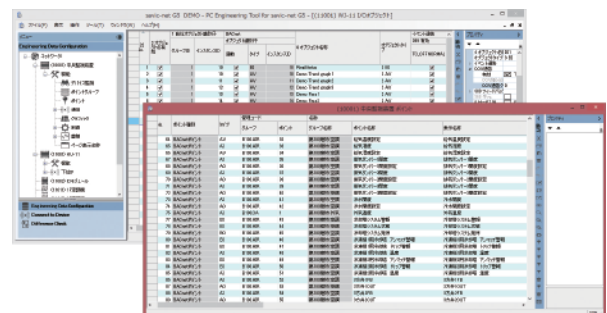

Fig. 12. Separated child window

5. Application Functions

Table 2 lists the primary application functions provided by the PC Engineering Tool for savic-net G5.

Table 2. Primary application functions

Main window	
	Menu management
	User management (license management)
	Log management
	Unit settings
BH-1 engineering functions	
	Device settings
	Point settings
	Writing of engineering data
	Creation of graphics
WJ-11 engineering functions	
	Device settings
	I/O object settings
	Secondary device management
	Device data sharing
	DDC program editing

The DDC (direct digital controller) program editor was previously a separate tool but has now been developed as an application integrated with the PC Engineering Tool for savic-net G5. This section describes the characteristics of the newly developed DDC program editor, improvements that have been made, and design ideas for its development.

5.1 DDC program editor

5.1.1 Characteristics and operation modes

The DDC program, a control program for controllers, was created by combining DDC program blocks for control calculation to formulate the control logic and then setting various control-target objects as input and output sources. The DDC program editor allows users to create a control program by drawing a logic diagram and arranging and connecting the control components of that control program. This process is achieved not by using the UI of the basic window described above but by using an easily-readable logic diagram as a unique UI. This approach improves the quality of the created control logic in comparison to the previous approach through a UI that uses configuration files to define connection relationships.

The DDC program editor is equipped with an engineering configured, debug mode, and connection mode. Ordinary control settings are configured in engineering mode. The control operation of the actual system is verified in debug mode. Modifications to parameters of the actual system and operational checking of the system are performed in connection mode. These modes can be switched on the same logic diagram at any time, allowing the efficient design and testing of control programs. The operability of the DDC program editor is thus enhanced.

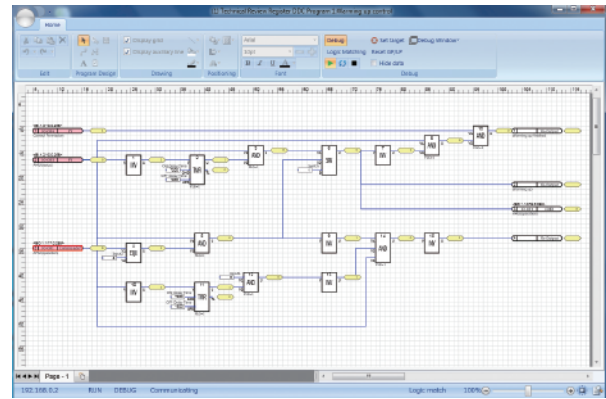Figure 13 shows an example of the display in debug mode.

Fig. 13. Debug mode

5.1.2 Master/instance data structure

The efficiency of air-conditioning system design for a building is ensured by using the same configuration and instrumentation for air-conditioning facilities on all office floors. For a building, accordingly, there are many DDC programs that describe the same instrumentation. Collective management of logic diagrams is effective for efficiently creating the same DDC program logic. With collective management, users need to create the relevant logic only once. In addition, since only one piece of diagram information needs to be edited in order to modify the shared logic, users need only to edit the relevant information once to modify the DDC program logic for a number of related sections. However, the parameters of the DDC program blocks composing a DDC program need to be adjusted separately for each floor, and therefore, parameter values need to be retained separately.

As the data structure of the DDC program logic, we adopted the master/instance data structure illustrated in figure 14. This structure retains common settings in the master and differences from the master in the instances, thereby ensuring work efficiency and enhancing processing performance by reducing the amount of data.
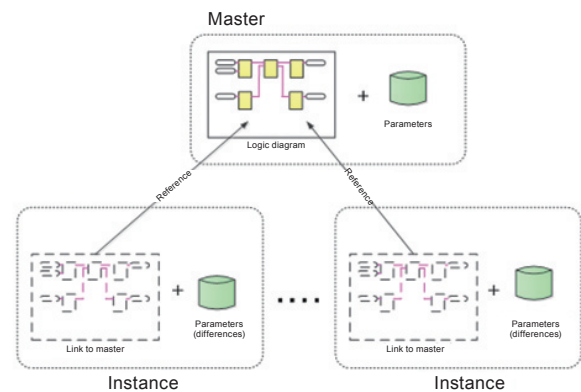

Fig. 14. Master/instance data structure

6. Expected Effects of Platform Use

This section describes the expected effects of using the engineering tool platform from the perspective of development efficiency and usability.

6.1 Development efficiency

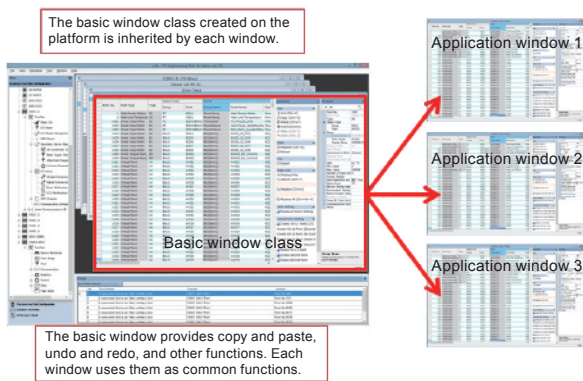As illustrated in figure 15, windows based on the basic window can be developed by inheritance from the basic window.

The basic window class created on the platform is inherited by each window.

Basic window class

Application window 1

Application window 2

Application window 3

The basic window provides copy and paste, undo and redo, and other functions. Each window uses them as common functions.

Fig. 15. Basic window class and inheritance

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The platform also provides functions for data editing operations (copy and paste, undo and redo) and data output processing (file output in xlsx format). Accordingly, the development of basic simple windows takes only a small amount of time.

This platform, designed to be optimal for the engineering tool, will contribute to the efficient expansion of the PC Engineering Tool through future savic-net G5 upgrades, expansion, and function additions.

6.2 Usability

If the specifications and operability of windows differ depending on the function, users need to learn how to operate them separately. The UI of the PC Engineering Tool for savic-net G5 was released was made similar to that of Excel, allowing users to intuitively understand how to operate it. When the PC Engineering Tool for savic-net G5, we interviewed people in charge of jobs using the tool and users being training participants. According to their evaluations, the efficiency of data input work with the PC Engineering Tool for savic-net G5 was improved in comparison with work with previous engineering tools.

7. Future Plans

This paper has provided an overview of the PC Engineering Tool for savic-net G5 and the functions of the engineering tool platform. As savic-net G5 itself is expanded, we plan to make formats other than the table format also available in the tool's basic window, so that various user requirements can be supported. We also plan to enhance the functions of the platform by adding various support functions to improve engineering efficiency.

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