

Integrated Energy Management System Platform

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ABSTRACT

Fuji Electric has developed an integrated energy management system (EMS) platform that can visualize energy consumption and integrate energy-saving controls in various fields such as iron and steel production, general industries, retail distribution, water treatment, regional communities and so on to provide energy management functions expeditiously and at low cost. The platform is compatible with models of various energy types such as electric power, gas, water and heat energies and can realize optimal energy-saving control even with renewable energies. Various web screens support local languages, and systems ranging in size from a small single-server system to a system consisting of several tens of servers can be developed easily using the same engineering tools.

1. Introduction

The Japanese government's setting of medium-term targets for cutting greenhouse gas emissions (cutting emissions by 25% from 1990 levels by 2020), revision of the "Law concerning the rational use of energy" (energy saving law), the international standard (ISO 50001) concerning energy management to be issued this year, and the like are measures that address the urgent need to prevent global warming. Additionally, many smart communities, aiming to realize a global sustainable society, are proceeding with efforts to use new forms of energy and to conserve energy. To attain these goals, the entire supply and demand of energy must be integrally managed and operated, and for this purpose, energy management systems (EMS) will have a greater role than ever before.

Fuji Electric has developed various EMS focused on the energy supply chain in the fields of power, iron and steel, water, industry, retail distribution, etc. The functions of a cluster EMS (CEMS), factory EMS (FEMS), building EMS (BEMS), and retail EMS (REMS) have been integrated into a single platform to develop an integrated EMS platform for providing EMS functions that meet various onsite needs, rapidly and at low cost.

2. Configuration and Functions

2.1 Development concepts

The integrated EMS platform is important middleware that forms the core in the construction of an EMS. The development concepts of the EMS platform are listed below.

- (a) For various types of energy (electric, gas, water,

heat, etc.) facilities, the EMS platform shall have ability to optimize each type of energy and to selectively implement optimization and control functions according to goals regardless of the industrial field

- (b) In accordance with the size of a user's energy facility, systems ranging in size from small-scale systems with a single server to large-scale distributed systems with multiple servers, shall be constructible quickly and easily with the same engineering operations
- (c) Even during online operation, it shall be possible to conduct system enhancement and evaluations with simulation when adding or renewing energy equipment.

2.2 Software configuration

Figure 1 shows the integrated EMS platform and its peripheral software configuration. The software configuration is the same as that of a typical EMS, and consists of software for various Web screens, performance data management, optimization/control program groups, and driver management that controls communications with field sensors and control equipment and the like. The most prominent features of this platform are the "Fuji Service Bus" high-speed program linking service that can associate various functions, the "Field Connector" high-speed data sharing service and the integrated energy network model that unifies various control targets. As needed, an EMS ranging in size from a small-scale single-server system to a system consisting of multiple large-scale distributed servers can be constructed on the same platform, with the same engineering operations and within a short time.

Functions of the core integrated EMS platform as well as its peripheral functions are described below.

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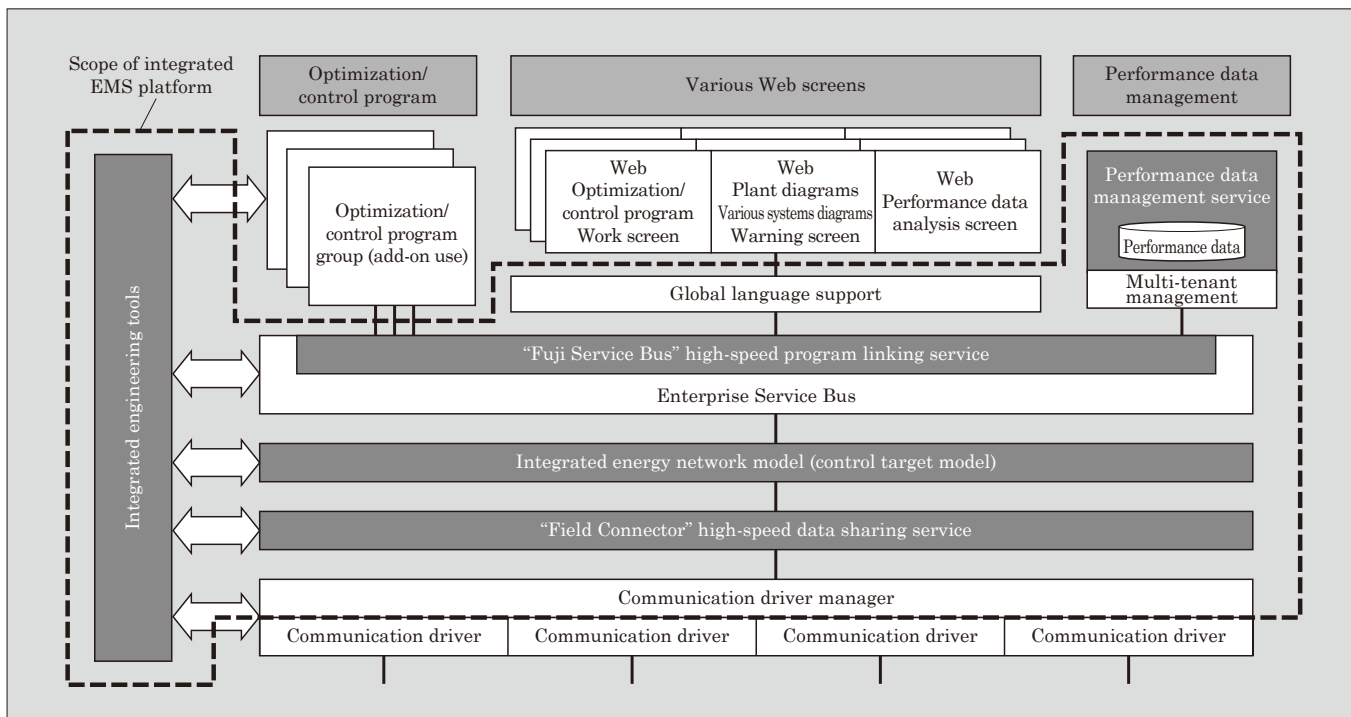


Fig.1 Integrated EMS platform and its peripheral software configuration

2.3 “Fuji Service Bus” high-speed program linking service

According to the size of the control target, the number of required software functions, the monitoring and control cycle, and required server redundancy, an EMS may be constructed as a system ranging in size from a single-server configuration to a large-scale distributed configuration consisting of several tens of servers in a CEMS or the like.

The “Fuji Service Bus” is a mechanism for linking, without awareness of these types of differences in server configurations, the processing among optimization/control programs distributed in each server, and among Web screens and optimization/control programs.

Traditionally, program calls in a distributed environment were implemented as a “program X residing on server Y”, with the server allocation information for each program having been defined in advance. For this reason, when adding servers or changing the server configuration due to an increased number of control targets, a system engineer would have to shut down the system, and redefine the server allocation information for each program.

With the Fuji Service Bus, however, rather than requiring server allocation information definitions in advance for programs, the relevant program residing on any server can be called using only the service name (program function name). This is because the Fuji Bus Service exchanges information dynamically and in real-time with the service name list residing in each server.

As a result, with easy operation of integrated en-

gineering tools (to be described later) by the user, the Fuji Service Bus instantaneously acquires the server allocation information for program even when optimization/control programs are newly added or existing optimization/control programs are transferred between servers in accordance with CPU load conditions. Consequently, work tasks can be performed while the system continues to operate.

Moreover, because the optimization/control program groups previously developed for various industrial fields used various different languages (C, C++ and Java), they could not be made to interact easily with each other. The Fuji Service Bus, however, enables mutual interaction regardless of the development language. As a result, Fuji Electric’s EMS software assets can be provided seamlessly.

In the future, by linking the Fuji Service Bus with a general Enterprise Service Bus, standard linking with global-standard core software will be realized.

2.4 “Field Connector” high-speed data sharing service

With the Fuji Service Bus, each program is able to interact mutually, regardless of the server on which it is allocated. However, in order for each program to perform actual operations and control, an environment in which each program, regardless of the server on which it is located, is able to reference online data and issue control instructions is necessary. This capability is realized with a mechanism known as the “Field Connector.”

The Field Connector manages online data with TAG management (data management method using a TAG name such as “TAG0001” and a corresponding

TAG value). In contrast to a typical TAG value that only accommodates a single integer or floating-point value, the Field Connector TAG value is a string of variable length. As a result, TAG values can be stored by handling 30-minute power generation planning values and other continuous numeric data as comma-separated character string data. For example, TAG management can also be used effectively for linking data (24-hour continuous data in units of 30-minute intervals) among programs in the sequence shown below.

- Power demand forecasting program
- Optimal power generation planning program for each generator according to the power demand forecast value
- Generator control program conforming to optimal generated plan

Additionally, because Field Connectors on all servers are mutually linked and the Field Connector on each server performs TAG value management for all the servers, programs that reference and update TAG values can run without problem regardless of the server on which they reside.

In addition to use for data linking among programs, Field Connectors also are provided with a function for connecting to field devices via a communication driver manager. The online data obtained through communications with field sensors and control devices is managed as TAG values, and TAG values set by control programs can also be output directly to the field devices.

Thus, with a Field Connector, data can be shared among various programs from any server, online data of the entire system can be referenced, control signals can be output, and a system that meets various needs can be configured and built easily.

A Field Connector is able to manage 500,000 TAG values system-wide.

2.5 Integrated energy network model

An energy network model defines how electricity, gas, water, heat and other forms of energy are converted and transmitted by each device.

To optimize energy and control the balance between supply and demand, the various optimization/control program groups must be commonly aware of the energy transmission of the control target. Previously, with optimization/control programs in various fields, different types of model representation methods were applied in order to process calculations with the highest efficiency. As a result, models had to be defined with engineering tools that differed for each optimization/control program that was applied⁽¹⁾.

On the other hand, to simplify the engineering work to be performed by users, the representation method and data structures were prescribed so that an intuitive easy-to-understand common integrated energy network model, which does not depend on the optimization/control program to be applied, could be

realized. As a result, energy network model definitions can be made with the same engineering operations, regardless of the type of optimization control program to be applied.

Fig. 2 shows an example representation of an integrated energy network model.

With this model representation scheme, equipment is placed at nodes, and connections between equipment are represented with a node-branch model that connects branches to the nodes. Additionally, definitions of energy conversion characteristics (efficiency, etc.), maximum output power, TAG names for obtaining the real-time status of field equipment, TAG names for control output destinations, and the like are defined as properties in the nodes. Integrated management is performed in advance to control which types of properties are required for each of the various node devices. The model definitions are output as xml data, and prior to use, are converted into the model representation format used by the optimization/control programs in each field.

For the creation of power system models, a function that converts between the common information model (CIM) of IEC 61968 and IEC 61970 and an integrated energy model network model is being developed to facilitate the incorporation of existing power system equipment data.

2.6 Performance data management service

The performance data management service is a feature that periodically extracts TAG values from the Field Connector, accumulating and managing those values as performance data. Through the use of an energy analysis function, provided as a standard feature, the energy usage status can be analyzed in an easy to understand manner.

With the performance data management service, performance data is linked in advance to an equipment hierarchy consisting of, for example, business office and plant, building, line and device levels, so that energy across an entire company or at an arbitrary hierarchical layer can be tallied instantaneously. As

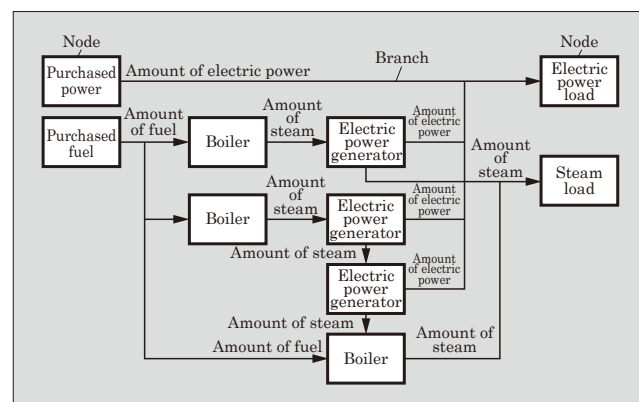


Fig.2 Example representation of integrated energy network model

a display method, a configuration graph of energy type (gas, heavy oil, coal, electric power, etc.) and a configuration graph of energy application (power, air conditioning, lighting, etc.) can be indicated with equivalent amounts of t-CO₂ (carbon dioxide equivalent tons) or crude oil. Moreover, arbitrary measurement data can be combined and displayed graphically, or may be output to spreadsheet software for the user to perform their own analyses.

In actual energy analysis, the production quantity, operating time and the like are important considerations. The performance data management service is able to associate and manage a variety of data in addition to energy data in the equipment hierarchy, and energy analyses can be performed horizontally across the hierarchical equipment locations (see Fig. 3).

The performance data management service also has a multi-tenant management function. This function, if incorporated into a software as a service (SaaS) environment, allows even a single server to provide the performance data management service to multiple companies (tenants) simultaneously.

This service is provided in order to visualize energy data acquired from the various homes, buildings and companies in a smart community, and is an effective means for raising awareness of energy conservation.

2.7 Integrated engineering tool

The integrated engineering tool was developed so that users could construct a system easily, and by positioning user screens and work functions as in Windows Explorer, screen programs and optimization/control programs are positioned automatically for each server. Figure 4 shows an example screenshot of the integrated engineering tool.

First, the network energy models and various work functions (sets of programs combining optimization/control programs and their work screen programs) which are operated for the model as needed are positioned in the function hierarchy column on the left-side of the screen. Then, on the right-side of the screen, function settings are made for the various work func-

tions, and the servers at which the optimization/control programs should be positioned are specified. This completes the engineering work.

The integrated engineering tool automatically positions the screen programs and the optimization/control programs in each server according to the content of the function settings.

2.8 Simulation environment

In the screenshot of Fig. 4, the model and various work functions are positioned under “ONLINE,” but simply by pasting the models and the various work functions under “SIMULATION,” operation can be verified under a simulated environment that differs from the ONLINE environment.

The purpose of the simulation verification is to evaluate the effect of adding a new energy facility to the model, or to evaluate the validity of energy saving control output based upon a change in the control parameters, or the like.

So that simulations can be realized, the Fuji Service Bus, Field Connector and performance data management service are each provided with two different environments, online and simulation. As a result, various verification tests can be performed while online operation continues.

Especially with the simulation environment of the Field Connector, the control output to TAG management is limited to the TAG value setting, without being linked to the actual control devices, and is recorded as control performance data in the simulation environment and displayed graphically so that the validity of control commands can be verified.

3. Application to Community Energy Management Systems

An example system configuration when this EMS is applied to a cluster energy management system (CEMS) is shown in Fig. 5.

The servers in a CEMS all use a redundant con-

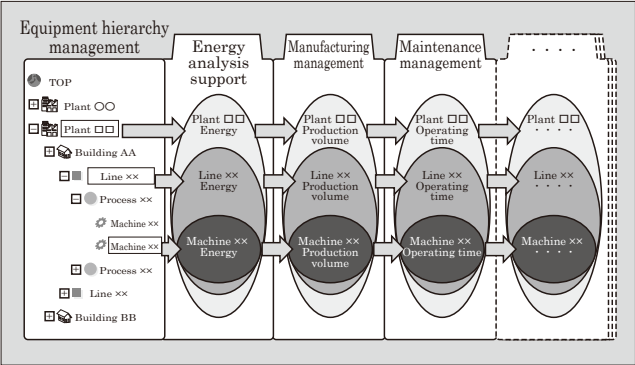


Fig.3 Energy management centered on equipment hierarchy management

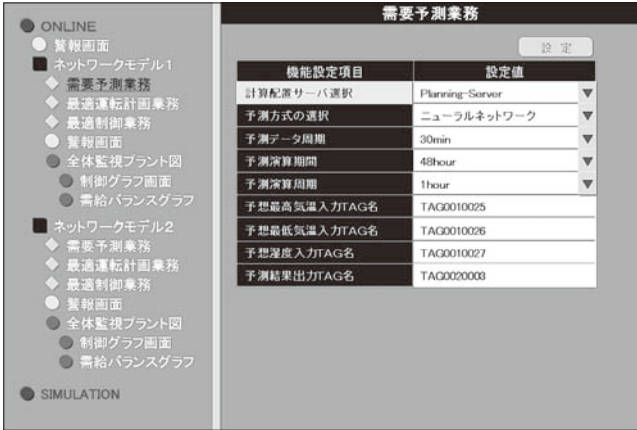


Fig.4 Integrated engineering tool screen example

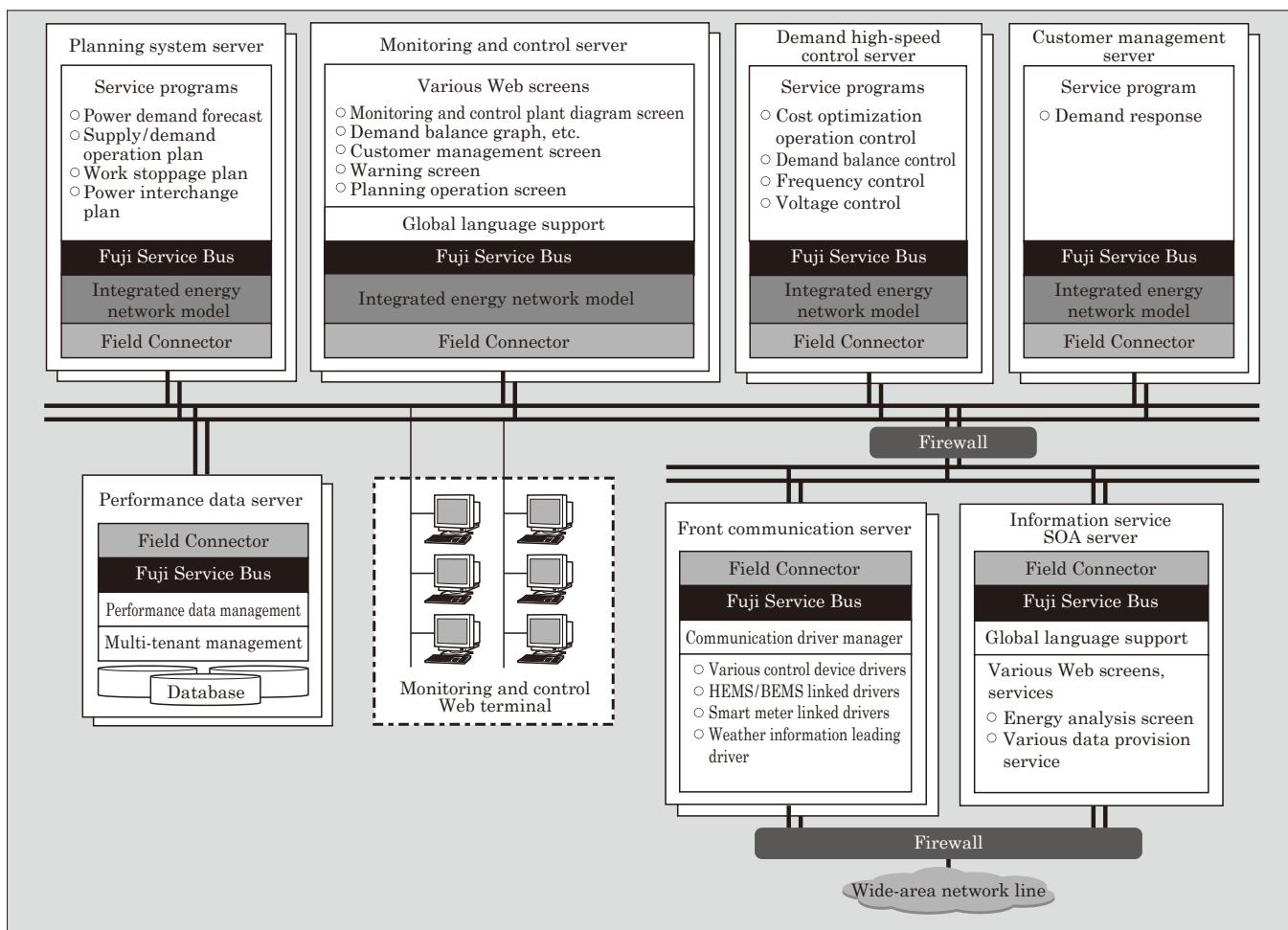


Fig.5 Example CEMS configuration with integrated EMS platform

figuration in order to improve reliability. The monitoring and control servers are provided with server functions for all Web screens, and the performance data server manages the database. Various other servers are configured as independent servers in order to distribute the CPU load. In the future, front communication servers that communicate with the field and information provision SOA servers that provide energy visualization services to homes and building managers can be added according to the number of connected communication targets and the increase in number of concurrent accesses.

By mounting a Field Connector in each server, the on-site TAG values received by the front communication server can be referenced by each server. Moreover, by writing data to the field TAG, the monitoring and control server, demand/supply and high-speed control server, and the end-user management server can implement control via the communication driver in the front communication server. Additionally, the optimal generator operation planning value calculated with a planning server is sent to the demand/supply and high-speed control server as a TAG value, and is used as the balance control target value.

The various optimization/control programs are

distributed to each server for the purpose of load distribution. These programs can be called from any server via the Fuji Service Bus, and their locations can be changed according to the system operating load.

Thus, with the powerful distribution-supportive platform of the Field Connector and Fuji Service Bus, a large-scale EMS can be constructed easily and quickly.

The newly developed EMS platform is slated for evaluation as part of the “Next Generation Energy System and Public System Demonstration” being promoted by the Japanese Ministry of Economy, Trade and Industry in Kitakyushu City and elsewhere.

4. Postscript

This paper has introduced Fuji Electric’s integrated energy management system (EMS) platform. The EMS is evolving from discrete optimization to total optimization. This EMS platform, with which the overall EMS status can be acquired and controlled from any server, is effective in realizing more advanced total operation. Fuji Electric intends to continue to enhance engineering tools further, to provide EMSs that are easy to use and have an impact in terms of their performance and pricing, and to contribute towards the

realization of sustainable society.

erational planning system for energy plants in steel-works”, Proc. of IFAC World Congress, 2008-7.

References

- (1) Fukuyama, Y., et al. “Development of an optimal op-





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