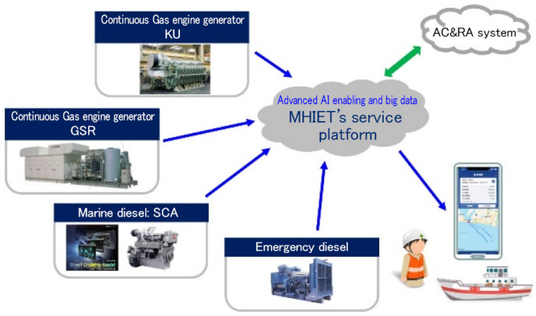
Approach and Perspective for Remote Monitoring/Control and IoT Applications in Engine & Energy Division



YOSHIMI OKAZAKI[*1] OSAMU NAKAKITA[*2]
MASAKI TAGUCHI[*3] HIROYUKI SUZUKI[*4]
TOMOHIRO OHNO[*5]

In 2018, in addition to our well-established remote monitoring services for private power generation facilities using the internet via VPN, Mitsubishi Heavy Industries Engine & Turbocharger, Ltd. (MHIET) started new services for marine engines including ship-to-shore communications using cellular telecommunications and ship-to-ship communications in the sub-GHz band. We have thus promoted the use of IoT applications. With this background, we are currently developing a simple, low-cost monitoring system that can provide various services through cloud servers for customers of marine engines, customers that we were unable to reach out to until now. Also under development is an automatic remote control system for customers of private power generation facilities in response to electricity system reform.

1. Introduction

In recent years, widely-available cloud services, global use of cellular communications and reduced prices have made the use of data communications ubiquitous. A wide variety of products are now IoT-enabled. Along with this trend, cellular communication menus for IoT and network services called “low-power wide-area (LPWA)” have also become available. While high-speed large-capacity 5G is often the center of attention, building an environment that enables low-price wireless communications for minimized amounts of data is under way. In order for IoT to be applied at a low cost, it is necessary to minimize the amount of data by allowing the edge devices to perform processing such as computation. Our challenge therefore is how to upload the necessary information to servers while minimizing the amount of data.

When it comes to the situation surrounding private power generation facilities in Japan, the supply and demand balancing market and the capacity market will be successively introduced from 2021, as part of electricity system reform promoted by the Ministry of Economy, Trade and Industry. This necessitates connecting power transmission and distribution system operators with resources (such as generators, batteries, private power generators and power demand facilities) to enable power demand to be remotely controlled according to requests. **Figure 1** presents the business operators expected to take part in the supply and demand balancing market[(1)]. The aim of this market is to reduce the electricity cost in Japan by creating a mechanism to maintain the balance between supply and demand through coordinated utilization of many resources. Ensuring both security and a low cost is the key, especially in terms of successful tertiary balancing power operations for which a simple online system via the internet without dedicated lines is used.

This report presents our approach to the aforementioned issues, including how to reduce costs by employing LPWA networks and improving edge computing processing for data

*1 Chief Staff Manager, Engine Technology Development Department, Engine & Energy Division, Mitsubishi Heavy Industries Engine & Turbocharger, Ltd.
*2 Deputy Director, Engine Technology Development Department, Engine & Energy Division, Mitsubishi Heavy Industries Engine & Turbocharger, Ltd.
*3 Engine Engineering Department, Engine & Energy Division, Mitsubishi Heavy Industries Engine & Turbocharger, Ltd.
*4 Engine Technology Development Department, Engine & Energy Division, Mitsubishi Heavy Industries Engine & Turbocharger, Ltd.
*5 Chief Staff Manager, Engine Service Department, Engine & Energy Division, Mitsubishi Heavy Industries Engine & Turbocharger, Ltd.

minimization, as well as ensuring security using a closed network connection.

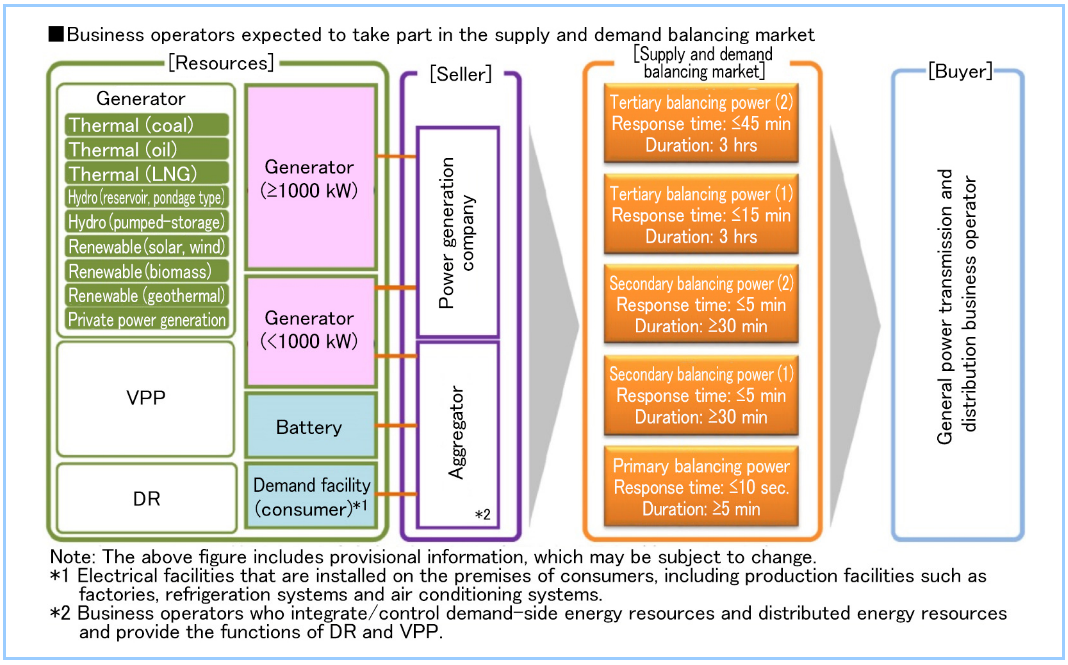


Figure 1 Business operators expected to take part in the supply and demand balancing market

2. Remote monitoring systems

2.1 For continuous power diesel/gas engine generators

MHIET started providing services using remote monitoring technology in the late 1990s, after developing a remote monitoring system to help customers with their operations by collecting data on the operating conditions of continuous power diesel engine generators via telephone lines. The Remote Monitoring Center was then opened within the premises of our factory in Sagamihara City, Japan. The internet-based remote monitoring system (i.e., GEMS: the global engine monitoring system or KU remote monitoring system) was launched in the market, and currently remotely monitors more than 450 generator engines. In the GEMS, KU remote monitoring system, a variety of data regarding operating conditions are regularly sent to servers from the control panel on the engine generator. For some types of engines, real-time monitoring is also possible. We are also working on predictive diagnostics by making use of the obtained data. In the event of an emergency, cause analysis is performed using these technologies, allowing us to promptly take necessary measures and help customers to quickly recover their facilities. Other ongoing projects include data analysis-based prediction of abnormalities and the prevention of their occurrence.

2.2 For marine engines

(1) Energy-saving operation promotion system “Smart Cruising Assist”(2)

For marine engines, MHIET released in 2015 “Smart Cruising Assist” (SCA), which can mainly (1) realize energy-saving ship operation, (2) manage ship operating conditions, (3) indicate when to inspect for maintenance and (4) estimate fuel consumption, and we later succeeded in making SCA IoT-enabled. The products “SCA.net” and “SCA.920” were released in 2019 after practical trial use.

Figure 2 illustrates how the “SCA.net” system works. In “SCA.net,” cellular communications are used and data can be viewed through the internet via cloud servers. As a future plan, data will be aggregated on MHIET’s service platform through cooperation between servers.

In recent years, the sub-GHz band is being widely used for various services and purposes. “SCA.920” is a system using frequencies in this band for short-range wireless communications and the available functions include: (1) remote monitoring of the engine’s operating conditions from a distant area within the ship, (2) sending of instructions at sea to a fleet of ships several hundred meters away and (3) the mother ship’s management of the locations of its accompanying ships. It therefore becomes possible to transmit data through wireless communications even beyond the range of cellular communications, thus improving customer usability (**Figure 3**).

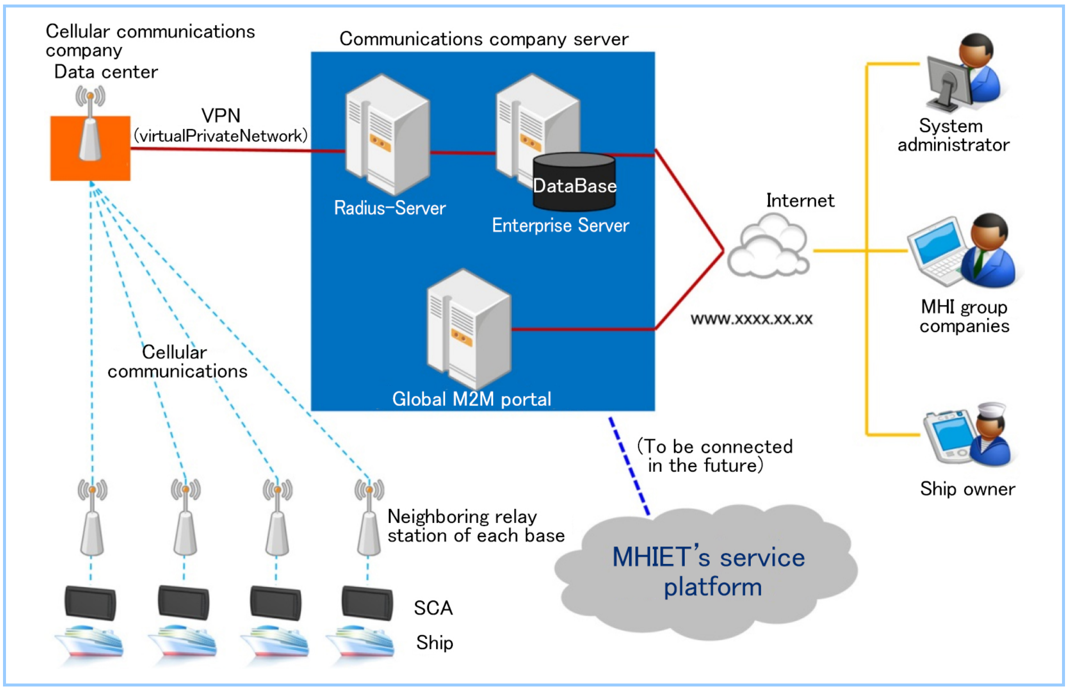


Figure 2 SCA.net system diagram

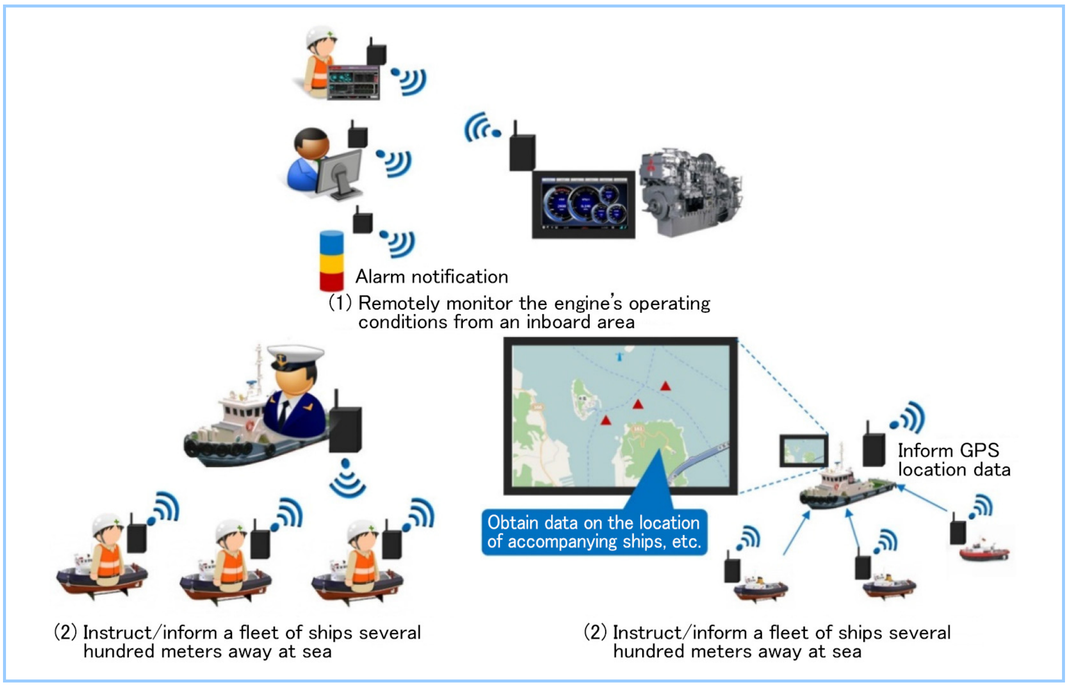


Figure 3 SCA.920 application examples

(2) Simple, low-cost remote monitoring system

For applications that do not require as advanced functionality as that offered by SCA, we are developing a simple, low-cost remote monitoring system using an LPWA network. The aim of this system is to improve customer usability by providing various services that are enabled by connecting a customer's smartphone with our engine via MHIET's service platform at a low cost. **Figure 4** presents the overall concept of the system. The controller installed near the engine collects data such as GPS location information and engine speeds and performs a variety of computing processing tasks, before sending indexed data to servers where the data are collated with a variety of measurement data stored therein and the relevant indicators are calculated. In this manner, the amount of data transmitted from the engine-side equipment to the servers can be reduced significantly. This system can provide the following information/services at a low cost: (1) total travel distance based on GPS data, (2) estimated fuel consumption, (3) estimated period until maintenance, (4) engine status check and (5) online management of information such as pre-operation inspection records. We can thus help reduce the workload of customers in terms of ship/engine management.

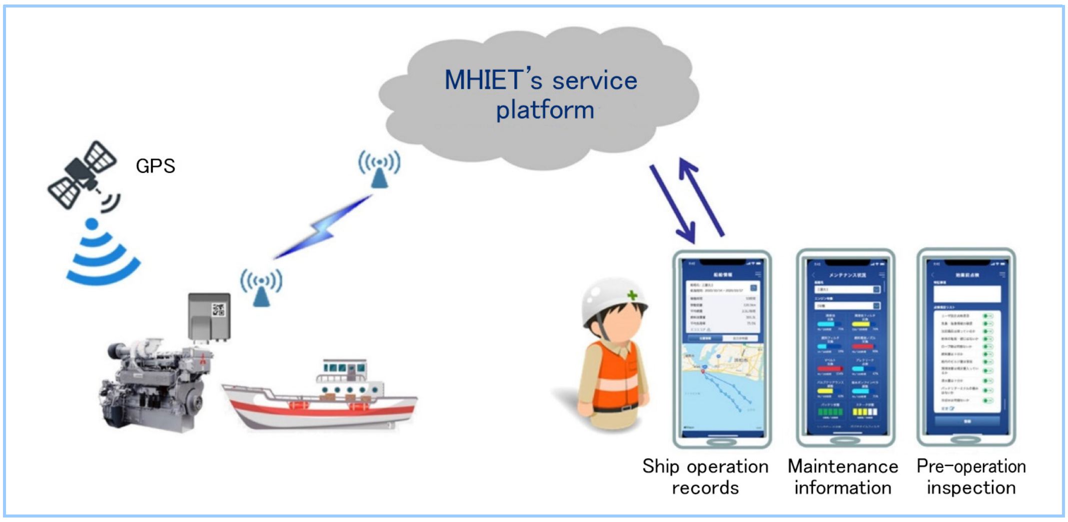


Figure 4 A conceptual diagram of the simple, low-cost remote monitoring system

3. Remote control systems

Lastly described is the IoT application for Japanese supply-and-demand balancing markets, which we have been taking on since 2016. The recent promotion of the adoption of renewable energy, especially by means of solar photovoltaic power generation, has been increasing the importance of balancing power. Against this backdrop, a supply and demand balancing market will commence in 2021 for tertiary balancing power (2) operation. In 2019, in order to take on the challenges of electricity system reform, MHIET participated in the demonstration project for the construction of a virtual power plant (VPP) that utilizes demand-side energy resources, thus proceeding with the demonstration of viable tertiary balancing power operation. In this supply and demand balancing market, balancing power (ΔkW) from the selected resources (such as generators and power demand facilities) of the seller called the aggregator is offered to the market and is provided to general transmission system operators (TSO), that is, the buyers. The actual flow of commands from TSO through the aggregator to the resources is connected by a simple online system and power demand is balanced by automatic remote control.

On the other hand, our products supplied to each customer, which serve as the resources in this context, may vary depending on the site or each engine, in terms of their different specifications for communications to receive commands and operational restrictions. As a result, each installation requires a different system to be built and the cost inevitably increases as a result. To convert/control such differences and enable the reception of commands from TSO, we are developing a resource control server (**Figure 5**). With this system, the resource control server can handle different specifications, thereby making it relatively easy for customers to register their facilities in the supply and demand balancing market and offer balancing power. Automatic remote control of this system necessitates ensuring a high level of security. For this purpose, we have adopted communications via a closed wireless network and security software with whitelist-based access control. The established server is compliant with the "Cybersecurity Guidelines for ERAB"[*1]. **Figure 6** shows the configuration of the cloud-based DR control system.

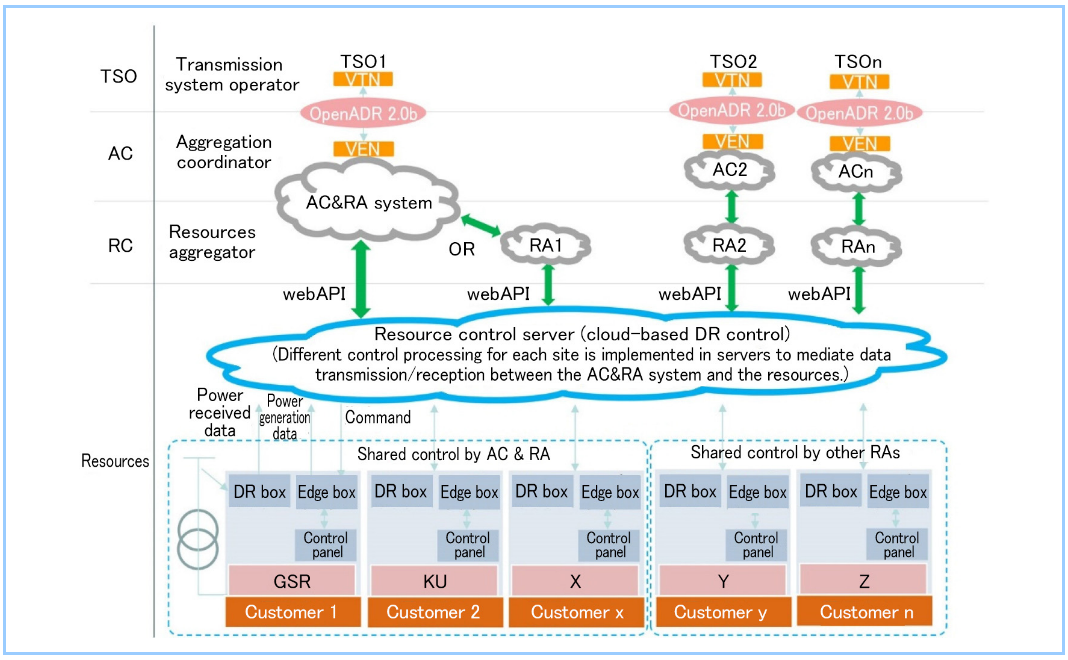


Figure 5　Resource control server

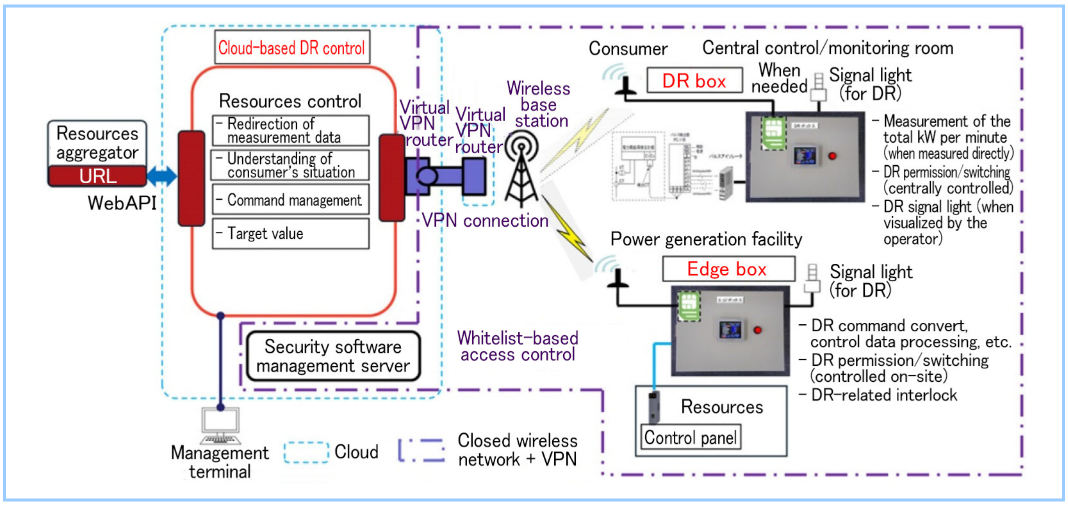


Figure 6　Configuration of cloud-based DR control system

4. Conclusion

We have been engaged in the development of remote monitoring technology for about 30 years. By making use of the recent widely-available cloud servers and wireless communications suitable for IoT applications, we have enhanced the added value of continuous power diesel/gas engines and marine engines. In addition to the simple monitoring system using the new IoT technologies, this report presents our remote control system for the supply and demand balancing market and the capacity market. We will proceed with the development of edge sensors that collect/analyze data regarding various conditions of continuous power diesel/gas engine generators and marine engines and the construction of digital twin technologies. By further improving the energy-saving operation of our products and reducing the downtime through predictive analysis, we will continue to dedicate ourselves to maximizing the value that we can offer to our customers.

*1　Guidelines of cybersecurity measures that should be taken by any business operators participating in the energy resource aggregation business (ERAB(*2))

*2　ERAB (energy resource aggregation business): a business in which virtual power plants and demand response are used to offer customers (such as electricity transmission/distribution system operators, electricity retailers, consumers and renewable power generation operators) a variety of services including the prevention of imbalances in balancing power, electricity price reduction and the prevention of output suppression.

References

(1) Ministry of Economy, Trade and Industry, #43 Advisory Committee for Natural Resources and Energy, Electricity and Gas Industry Committee, Subcommittee on Basic Electricity and Gas Policies, WG for Reviewing System Document 4-1
https://www.meti.go.jp/shingikai/enecho/denryoku_gas/denryoku_gas/seido_kento/pdf/043_04_01.pdf
(2) Smart Cruising Assist Contributes to Fuel-Efficient Operation for Ships, Mitsubishi Heavy Industries Technical Review Vol.56 No.2 (2019)