Excellent Usability of the Sushi Sensor

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Yokogawa Electronic Corporation has developed the Sushi Sensor, a compact wireless sensor for plant maintenance, environmental monitoring, and energy management. Although there are various restrictions on plant premises, a large number of Sushi Sensors can be easily installed to collect data. This paper introduces the excellent usability of the Sushi Sensor, which is achieved by using smartphones, the cloud, and wireless networks.

INTRODUCTION

The efficiency of equipment maintenance, environmental monitoring, and energy management in plants can be improved with sensing technology. In contrast to plant operation and safety, however, such applications need to measure several hundred to several thousand points. Compact wireless sensors are an attractive solution for such applications because they do not require wiring in the field, but it is necessary to reduce their cost and improve durability so that these sensors can be used more widely in industry. The workload for installing sensors, collecting data, and maintaining functions and performance also needs to be reduced substantially[(1)(2)].

Figure 1 shows Yokogawa's Sushi Sensor, which has been developed by implementing functions for exploiting universal IT infrastructure such as smartphones and the cloud in the wireless sensor. Featuring a lean body without a display and a keypad, the Sushi Sensor simplifies various procedures that are necessary for installation and operation.

This paper describes its software technology for easy operation, as well as the features and impacts of the software.

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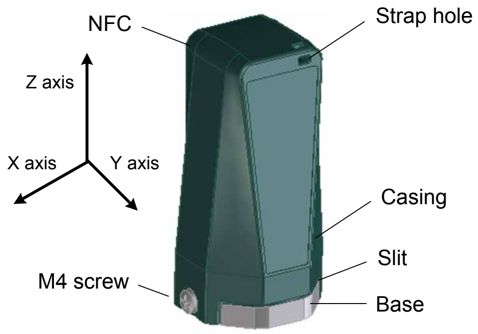

Figure 1 XS770A Sushi Sensor

INFORMATION TECHNOLOGY IN INDUSTRIAL WIRELESS SENSORS

The interface complying with the near field communication (NFC) standard is widely used for various smart IC cards such as employee ID cards and other payment settling cards, as well as smartphones and other mobile terminals. This interface offers contactless operation, minute power consumption, quick data exchange, and high security. This is a good example of information technology that makes daily life more convenient.

The Sushi Sensor is equipped with an NFC-compliant data exchange interface. Users can set up the sensor and maintain it through the Sushi Sensor App installed in smartphones. Figure 2 shows its home screen.

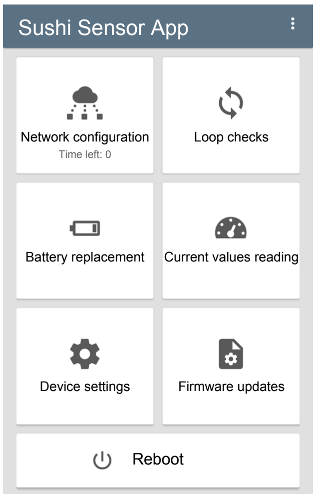

Figure 2 Home screen of Sushi Sensor App

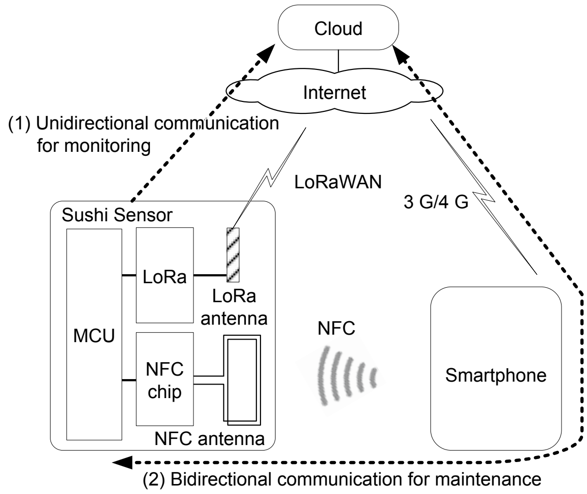

Figure 3 Sushi Sensor system

Users can also use smartphones for the central management of device setting information. This information is acquired from the cloud via the mobile phone network or the internet using the Wi-Fi connection, and then is set to a sensor via NFC.

The cloud eliminates the need for management and maintenance of servers and other information facilities, and enables multiple organizations to share and efficiently use the information. The cloud also enables computing resources to be used for analyzing huge amounts of sensor data that have been collected over a long period.

The Sushi Sensor stores sensor data in the cloud via the wireless network complying with the LoRaWAN standard(3). In Japan, the 920 MHz band is allowed for the LoRaWAN protocol. Although its communication speed is slower than that of wireless communications in the 2.4 GHz band, LoRaWAN has fewer restrictions on the communication distance and installation location. Thus, LoRaWAN is an ideal wireless protocol for sensing systems that collect data at a relatively long cycle comparable to that of conventional operator rounds. The wide area coverage of LoRaWAN makes it easy to select installation locations for wireless sensors in industrial environments as long as low communication speed is acceptable.

Figure 3 shows the system configuration of the Sushi Sensor. Bidirectional communication ((2) in Figure 3) via the 3G/4G wide area network is used for setting the Sushi Sensor and maintaining it. Unidirectional communication ((1) in Figure 3) via the wide area network based on the LoRaWAN technology is used for monitoring and collecting sensor data. Both communications make the system highly flexible in terms of installation and operation of sensors. The LoRa gateway is installed between LoRaWAN and the internet and serves as a protocol converter.

SIMPLE SECURITY SETTINGS

To cryptographically protect the LoRaWAN communication, an encryption key must be set between the Sushi Sensor and the wireless network. Figure 4 shows the flow of security settings. The encryption key is acquired from a network server in the cloud, and is set on the Sushi Sensor via NFC.

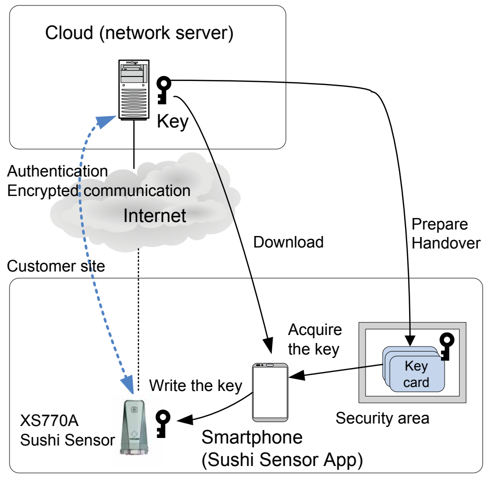

Figure 4 Flow of security settings

The Sushi Sensor App accesses the network server in the cloud via the mobile internet service provided by the public wireless network, and acquires and then sets the encryption key. The communication between the Sushi Sensor App and the network server is protected by password authentication and encryption.

If internet connection to the network server is not allowed for security reasons, the key information is first stored in an NFC card (key card), is then read by a NFC-compliant smartphone, and finally the encryption key is set in the sensor by the Sushi Sensor App. The key card is created by network engineers when the wireless infrastructure is built, and is given to the sensor user. To prevent unauthorized duplication, the key card is protected by the security mechanism specified in the NFC standard.

To reduce the risk of information leakage from lost or misplaced smartphones, the Sushi Sensor App automatically erases the key information after a preset period.

IDENTIFYING SENSOR LOCATIONS

In the case of sensors for operation and safety, their location is identified by giving a tag name (string of characters) to each sensor, and these names are displayed on a piping and instrumentation diagram (P&ID).

For equipment maintenance, environmental monitoring, and energy management, the number of sensors to be installed in a plant will increase from several hundred to several thousand. Thus, the conventional method described above is troublesome and requires a huge workload, so a radical solution is needed.

The global positioning system (GPS) is an attractive solution. However, putting a GPS device in each sensor would shorten the battery life and increase costs. The Sushi Sensor also uses GPS, but via the function on a smartphone. Combined with the NFC interface, the location of the Sushi Sensor can be identified without affecting the battery life and costs.

Figure 5 shows how to identify the sensor location by using the GPS function on a smartphone.

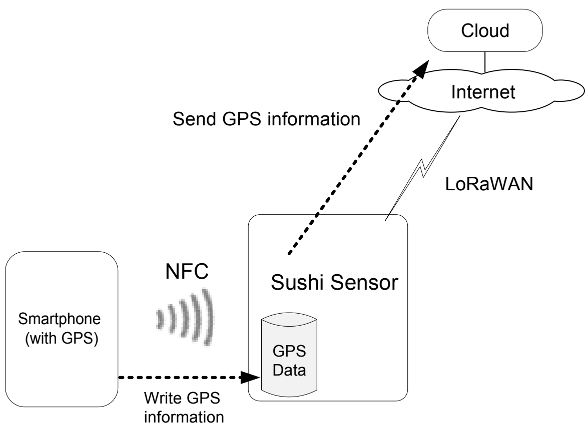

Figure 5 Management of location information

When put close to a Sushi Sensor, a GPS-enabled smartphone communicates with it via NFC. The GPS function of the smartphone calculates the location coordinates, which are sent via NFC to the Sushi Sensor, which in turn sends it to the cloud via LoRaWAN. Users can develop software that applies the coordinates to a mapping service such as Google Maps and displays the sensor locations. In this way, users can obtain information on sensor locations in the field. Since there is no need for the additional work of depicting sensor locations on the layout, this method greatly simplifies the addition or relocation of sensors.

SIMPLE SENSOR SETTINGS

Figure 6 shows how to confirm the settings and operating status of the Sushi Sensor. The settings of a Sushi Sensor are backed up in the cloud, which enables multiple workers to use the same sensor settings. Even when a Sushi Sensor fails, it can be restored quickly by using the setting information saved in the cloud.

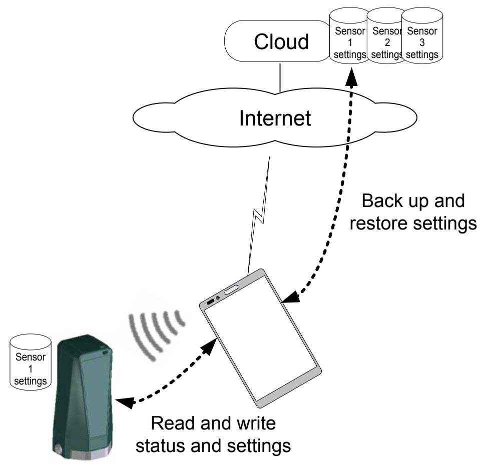

Figure 6 Confirming sensor settings and operating status

Figure 7 shows the sensor information setting screens of the Sushi Sensor App. These simple screens are suitable for touch control on smartphones.

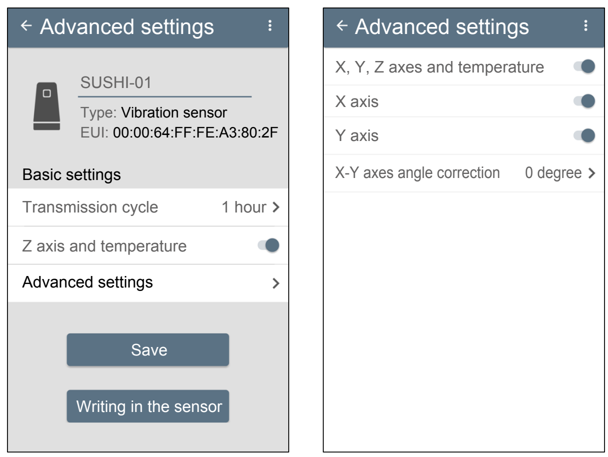

Figure 7 Sensor information setting screens

SIMPLE MAINTENANCE

It is critical to reduce maintenance workload so that several thousand wireless sensors can keep working stably over a long period in industrial environments.

The Sushi Sensor is equipped with an NFC chip. This chip is a passive device, and electromagnetic induction is used to create a current and power the chip. Active devices such as smartphones play this role. Even when the battery of a Sushi

Sensor runs flat or the internal circuit fails, this feature enables the setting information to be transferred smoothly from the Sushi Sensor to another one. Figure 8 shows how to transfer setting information. When the battery life is coming to an end, a large number of sensors need to be replaced in the field in a short period. Therefore, the Sushi Sensor is designed for easy resetting.

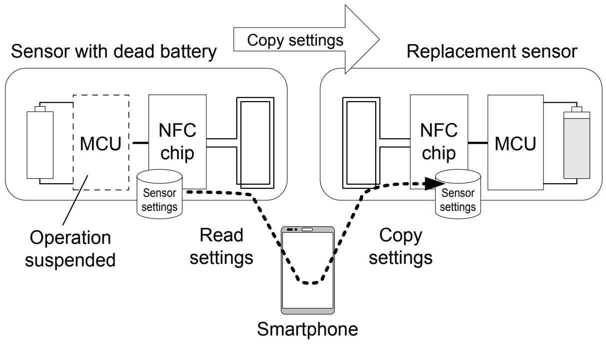

Figure 8 Transferring settings when replacing Sushi Sensors

As shown on the left of Figure 8, when the battery is exhausted, internal circuits including the micro control unit (MCU) do not work. However, since the sensor settings are stored in the nonvolatile memory of the NFC chip, the configuration data can be read and transferred to a replacement sensor in the field by using a smartphone. Previously, a sensor with a dead battery is brought to a service station to have the battery replaced, and the sensor is then returned to its original location. In the case of the Sushi Sensor, maintenance engineers can replace batteries or Sushi Sensors in the field on a single visit. This feature halves the time required for maintenance.

ESTIMATING BATTERY LIFE

There is a strong need to estimate the battery life in industrial environments because it significantly affects the running cost.

The Sushi Sensor uses the LoRa communication technology, which automatically optimizes the transmission power and data rate according to communication conditions. If communication conditions are poor, high transmission power and low data rate are selected to ensure the communication quality over a long distance. Meanwhile, low transmission power and high data rate are selected in good communication conditions to save the battery power. The adaptive data rate (ADR) function defined in the LoRaWAN standard selects the optimum data rate. Thus, the actual battery life depends not only on the sensor operation conditions such as the measurement cycle, but also on the environmental conditions of wireless communication. For estimating battery life precisely, the actual communication conditions must be taken into account. Table 1 shows the relation between the communication conditions and the battery life.

Table 1 Relation between communication conditions and battery life

Communication condition	Received signal intensity	Data rate	Battery life
Good (unobstructed)	High	High	Long
Poor (pipe jungle)	Low	Low	Short

The Sushi Sensor has a function to precisely estimate the battery life, by using the protocol standardized in the LoRaWAN standard and by taking communication conditions into account.

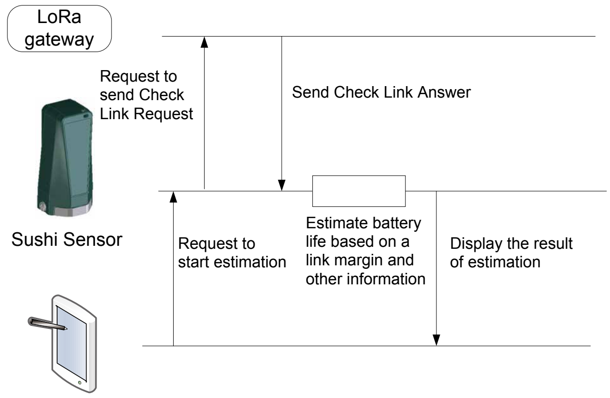

Figure 9 Estimating battery life using loop check

Figure 9 shows the procedure of estimating battery life during a loop check, in which the information on communication conditions is obtained via the LoRa WAN communication and is reflected in the estimation. First, a mobile terminal for maintenance requests the Sushi Sensor to estimate the battery life, and the Sushi Sensor sends Link Check Request the LoRa gateway. The LoRa gateway calculates a link margin, which is the difference between the radio field intensity at the moment of receiving the request and the minimum receivable field intensity, and sends it to the Sushi Sensor via Link Check Answer. Based on this value, the Sushi Sensor determines the optimum data rate for communication with the LoRa gateway. Then, the Sushi Sensor estimates the battery life taking into account the measurement cycle, transmission cycle, and the estimated current consumption in sensors and internal circuits. The estimated battery life is shown on the screen of the mobile terminal, as shown in Figure 10. The Sushi Sensor completes identifying the communication conditions and estimating the battery life in about 10 seconds.

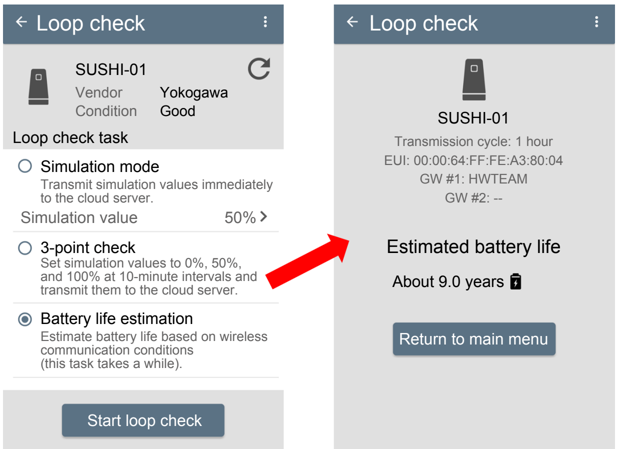

Figure 10 Battery life display screen

CONCLUSION

The Sushi Sensor is a next-generation industrial wireless sensor that leverages open IT infrastructure. The sensor uses the cloud for data collection and its own management, and the use of smartphones makes the sensor user-friendly.

Compact wireless sensors for the industrial internet of things (IIoT) enable field workers to understand the situation of plant equipment in far more detail with far less effort than before. These sensors will accelerate the revolution in equipment maintenance, environmental monitoring, and energy management. Based on the concept of the Sushi Sensor, Yokogawa will expand the lineup for measuring a wider range of objects.

REFERENCES

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(2) Masayuki Saito and Masato Yamaji, et al., "Sushi Sensor for Achieving Industrial IoT Solutions," Yokogawa Technical Report English Edition, Vol. 61, No. 1, 2018, pp. 7-10
(3) LoRa Alliance, Inc., LoRaWAN 1.1 Specification, 2017

* Sushi Sensor is to be released outside Japan soon. For details, please visit Yokogawa's website.