Featured Articles

Facility Monitoring Services for More Efficient Maintenance of Social Infrastructure

Masaki Ogihara
Masafumi Uematsu
Daisuke Shibata
Sachio Minami

OVERVIEW: Japan's social infrastructure underwent rapid development during the period when the economy was growing strongly. The aging of this infrastructure has now become an issue, with a need to reduce the lifecycle costs of facilities while still delivering safe and secure services to users. Facility monitoring services include condition monitoring, which uses M2M technology to collect data from sensors and other sources, and predictive diagnosis, which uses data mining techniques to analyze this collected data. The benefits of these services include the early detection of anomalies at facilities that use these services and preventive maintenance for aging facilities. They also facilitate management of the lifecycle of social infrastructure to extend its life and reduce total costs.

INTRODUCTION

THE construction of roads and bridges, public buildings, and various other forms of infrastructure proceeded at a rapid pace throughout Japan during the period starting about 50 years ago in the 1960s when Japanese economy was growing strongly. Since then, although this infrastructure has undergone earthquake-strengthening and other measures to make it more resilient to disasters, what to do about the widespread aging of social infrastructure remains an important issue. However, given the difficulty of financing the construction of replacement infrastructure, there is a need to ensure that users are kept safe and secure from threats such as disasters or accidents happening at existing facilities.

The operation and maintenance of social infrastructure is generally based on corrective maintenance, which means performing periodic inspections that are primarily conducted visually, and then following these up with more detailed investigations or repairs if any problems are found. However, in addition to supplying safe and secure services to their users, infrastructure operators also face the challenge of how to reduce the lifecycle cost of facilities. To overcome this challenge, it will be important for future facility management to implement preventive maintenance, which differs from the corrective maintenance of the past in that it performs repairs after obtaining an accurate understanding of the condition of the facility.

An essential requirement for implementing preventive maintenance will be the effective combination of technologies and know-how comprising information and communication technology (ICT), data analysis, and engineering to perform inspections more efficiently and to obtain more accurate assessments of the condition of facilities. There is also growing demand for one-stop services provided in the form of systems (see Fig. 1).

In response, Hitachi has launched a new business offering cloud-based, one-stop facility monitoring services that provide machine-to-machine (M2M)*1 technologies for data collection using sensors and radio-frequency identification (RFID), big data technologies for analyzing the collected data,

*1 Systems in which machines exchange information directly via a network, without human intervention.

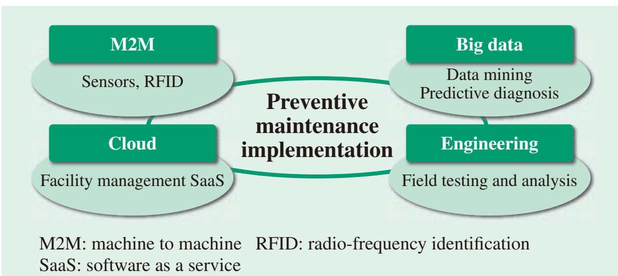

Fig. 1—Technologies Used to Implement Preventive Maintenance.
There is growing demand for one-stop services that provide the technologies and know-how required to implement preventive maintenance.

and engineering know-how built up through past experience.

This article gives an overview of Hitachi's facility monitoring services, and describes their features, example applications, and future developments.

OVERVIEW OF FACILITY MONITORING SERVICES

Hitachi launched its facility monitoring services in October 2013. Targeted primarily at roads, railways, water supply and sewage systems, and dams, they are provided through Intelligent Operations for Facilities, one of a range of services provided by Hitachi's smart information business.

The two services being offered are a condition monitoring service that uses M2M technology for the efficient collection of sensor data and provides realtime access to information on status changes at facilities, and a predictive diagnosis service that uses data mining technology to analyze the collected data.

FEATURES OF FACILITY MONITORING SERVICES

The facility monitoring services have the following four features (see Fig. 2).

(1) Use of a variety of sensors to detect status changes at facilities

Sensors for measuring parameters such as characteristic frequency or angle of tilt are selected to suit the specific requirements of the social infrastructure being monitored. They are then installed at the facility to measure and assess its soundness in various different ways.

(2) Use of wireless devices (RFID) for data collection

RFID can be used to receive measurement data from sensors remotely or when moving at high speed. The data can also be forwarded to a server in realtime via devices such as smartphones or tablets.

(3) Use of data mining for predictive diagnosis

Hitachi uses data mining techniques it has developed itself to supply a predictive diagnosis service that uses collected sensor data as a basis for learning what constitutes normal conditions and for identifying correlations with abnormal events. By analyzing changes at a facility, the service can diagnose symptoms of aging or other anomalies.

(4) Provision as a cloud-based preventive maintenance service

This is a condition monitoring service that manages collected data based on facility records to provide functions such as the archiving of monitoring data and alarm generation when a change occurs. This can provide early identification of risks to a facility by the realtime detection of changes at the facility when a disaster or accident occurs (such as a rockfall or landslide).

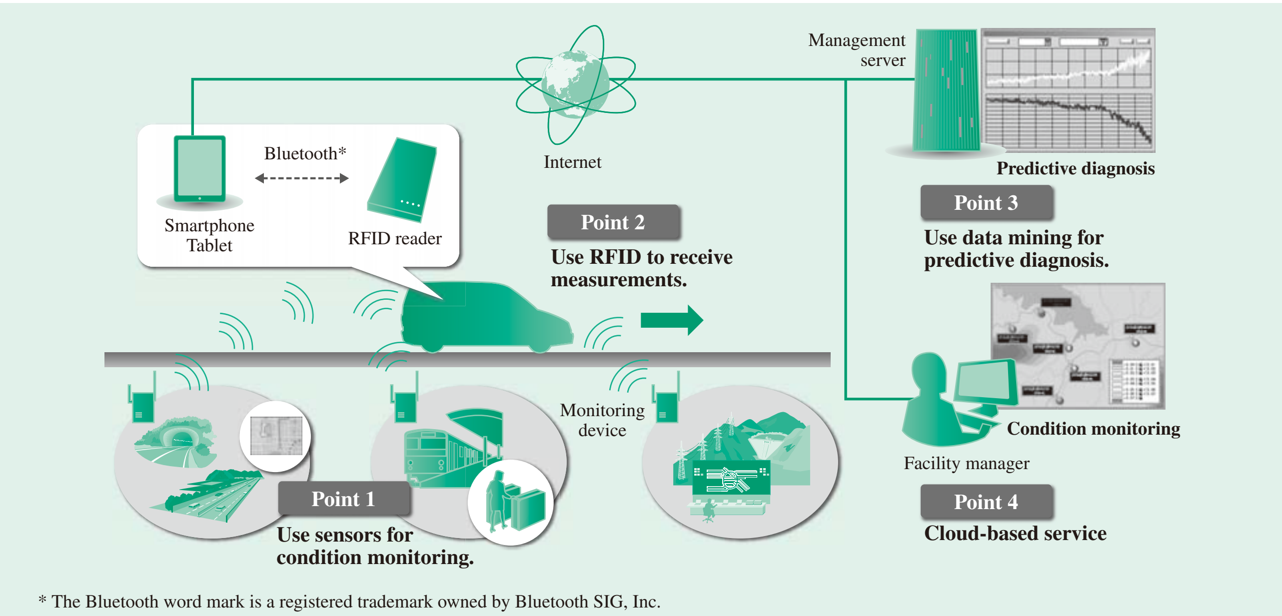

Fig. 2—Features of Facility Monitoring Services.
Hitachi cloud services utilize sensors, RFIDs, and other M2M technologies to monitor equipment and other facilities and assess their condition.

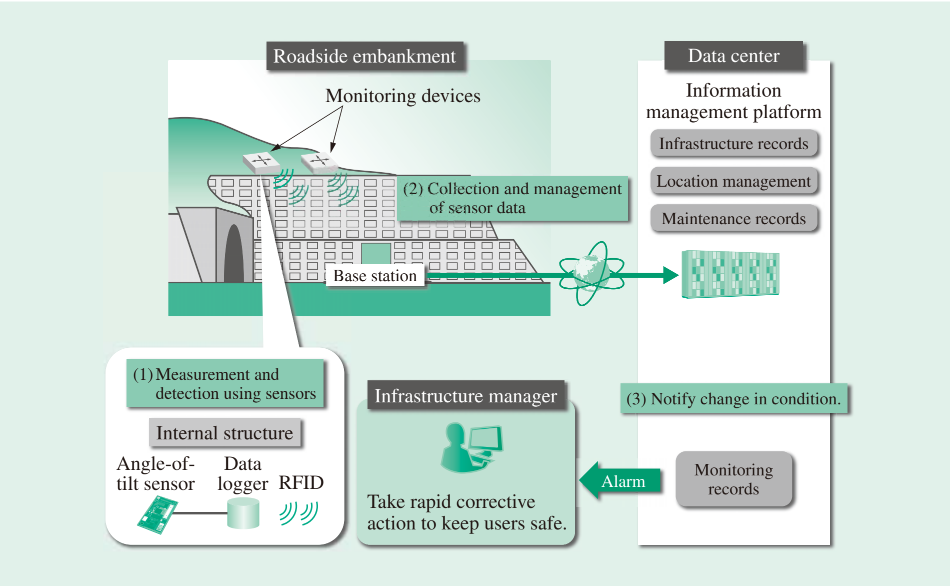

Fig. 3—Example of Condition Monitoring Service.
This example is for a roadside embankment. The condition monitoring service monitors for situations such as landslides and issues realtime alarms.

EXAMPLES OF FACILITY MONITORING SERVICES

As noted above, the facility monitoring services include condition monitoring and predictive diagnosis. The following sections describe examples of each of these taken from the highway management sector.

Example Condition Monitoring Service

Utilizing sensors, RFIDs, and other M2M technologies for the efficient collection of data, the condition monitoring service facilitates a rapid response to rarely occurring accidents or disasters, such as rockfalls or landslides, by monitoring the condition of social infrastructure and providing early detection of events such as these.

The example below describes how the service is used for an embankment built as part of road construction (see Fig. 3).

As shown in Fig. 3, angle-of-tilt sensors are installed at various points on the embankment to make periodic measurements of any changes in its shape. At locations where the installation of fixed-wire sensors would be impractical, or where road rules or other regulations would result in increased costs, RFID is used to transmit measurements to a base station. The data is then kept on a server to which it is forwarded in realtime via an existing fixed-wire network. If the server detects that a measurement has exceeded a predefined threshold, an alarm is sent to the person responsible via e-mail or some other method. This gives the person a chance to take prompt corrective action to prevent a rockfall or landslide.

Example Predictive Diagnosis Service

The predictive diagnosis service supports more sophisticated lifecycle management of social infrastructure to help extend its life and reduce total costs. It analyzes data collected by a variety of different methods, including the condition monitoring service, to provide the information required to assess the soundness of social infrastructure or other equipment and to detect any anomalies.

One example is the potential for detecting signs of problems on jet fans (which are used in highway infrastructure) by fitting them with characteristic frequency sensors and analyzing the collected data to determine their condition.

The system uses characteristic frequency sensors to measure the condition of blades (or bearings), ceiling mountings, and other components on jet fans that are installed inside tunnels to provide ventilation. This data is then collected via an RFID reader and smartphone in an inspection vehicle that makes routine visits to the site. The data is sent via the telephone network to a server for storage. At the server, data mining techniques are used to compare the measurements with data from normal operating conditions collected when the service first commenced and detect signs of problems from anomalous data or event intervals. Based on the results of this comparison, the idea is to take steps to counteract the aging of the jet fans and reduce lifecycle costs by making repairs or taking other remedial measures before parts deteriorate with age or problems arise due to fittings coming loose (see Fig. 4).

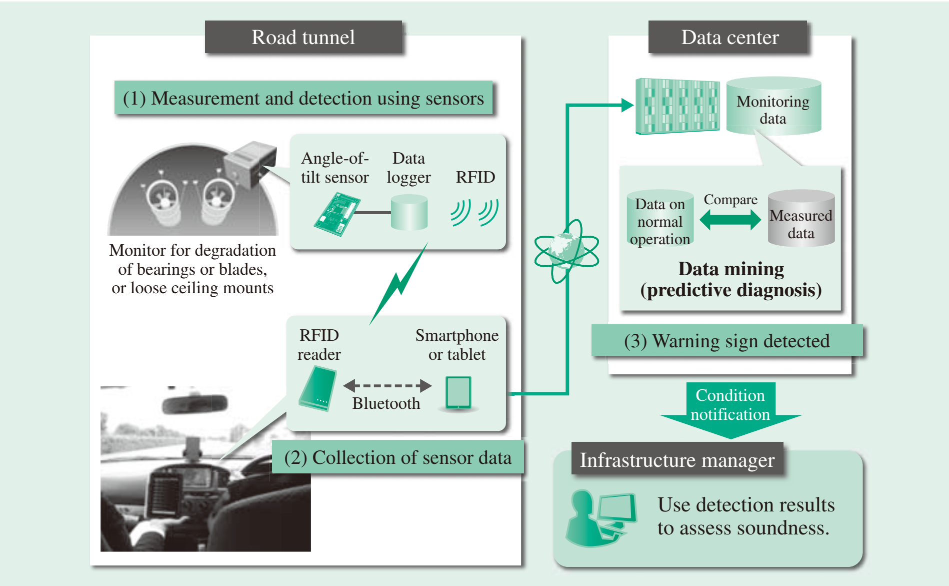

Fig. 4—Example of Predictive Diagnosis Service.
In this example, a vehicle makes routine visits to collect sensor measurements. The predictive diagnosis service uses data mining techniques developed by Hitachi to detect warning signs of aging or other deterioration.

Examples of Sensors and What they are Used to Measure

To provide condition monitoring and predictive diagnosis, the facility monitoring services select the sensors that best suit the social infrastructure being monitored.

As condition monitoring is used for structures such as embankments, road signs, or railway tracks that require realtime detection of changes triggered by an accident or other disaster, suitable sensors are likely to include those for measuring angle of tilt or anchor loads.

Similarly, as predictive diagnosis is used for structures such as jet fans or bridges that require follow-up observation or the detection of deterioration due to age by measuring long-term changes in their condition, suitable sensors are likely to include characteristic frequency and strain gauges.

Current system development work for facility monitoring services is focused on sensors for which there is strong demand, including those for measuring angle of tilt and characteristic frequency (see Fig. 5).

FUTURE DEVELOPMENTS

Based on past experience, the initial deployment of facility monitoring services is in the highway management sector. Hitachi also aims to deploy the services for Japanese local government road maintenance, where there is a need for efficiency improvements; for the maintenance of other types of social infrastructure with similar requirements; and overseas.

Deployment in Other Fields

Hitachi intends to expand the range of sensors supported by its facility monitoring services beyond those already mentioned. As a low-cost alternative to the expensive standalone systems used in the past, and with the ability to perform centralized monitoring of multiple sites, these cloud-based services are expected to be increasingly used for applications such as highway management by local government. When considering the operation and maintenance requirements shared by infrastructure such as bridges, tunnels, levees, dams, and airports, a committee studying the use of monitoring

Condition monitoring service

Realtime notification of changes detected when an accident or other disaster occurs.

Measurements	Events detected	Sensors used
Embankment	Monitor for landslides	Angle of tilt, rain gauge
Embankment (anchors)	Tensile forces on earth anchors, failures	Anchor load cells
Signs, streetlights	Collapse or fatigue failure of columns	Angle of tilt, characteristic frequency
Railway track	Deformation, subsidence, or listing of rails	Angle of tilt, settling

Predictive diagnosis service

Take measurements of long-term changes in condition and use to detect anomalies or deterioration due to age.

Measurements	Events detected	Sensors used
Jet fans	Deterioration or loosening of mountings	Characteristic frequency
Bridges (bracing, etc.)	Tensile forces in bracing	Characteristic frequency, tensile force
Bridges (piers)	Management of scouring	Characteristic frequency
Joints	Couplings coming loose	Strain gauge

Fig. 5—Example of Sensors Used.
Different sensors are used depending on what is to be measured and what conditions are being looked for.

technology for social infrastructure led by the Ministry of Land, Infrastructure, Transport and Tourism has highlighted the importance of inspecting sites that are (1) difficult to inspect visually or (2) difficult to access.

Hitachi believes that the solution to these issues lies in one of the features of its services, namely the use of wireless data collection. In the case of railways, for example, where special-purpose vehicles are used to take measurements to check for the warping of rails or faults in signaling or other equipment, Hitachi believes that monitoring techniques that combine sensors and wireless devices will be useful for sites such as the undersides of bridges that cannot be inspected visually.

Along with more efficient working practices and improved safety, the advantages of using facility monitoring services to perform more sophisticated operation and management are also expected to include benefits to management. In the case of the equipment used in industries such as steel or chemicals, there is also the risk of interruptions to production resulting from the failure of aging equipment. However, if the use of data mining techniques for predictive diagnosis makes it possible to repair the equipment before the deterioration manifests, this risk can be avoided and the life of plants extended (reducing operation and maintenance costs).

Overseas Applications

While the focus for facility monitoring services in Japan has been on measures for dealing with aging infrastructure, there is also scope for its use overseas on newly constructed facilities, particularly in emerging nations.

Sensor installation is less costly if done during construction. Hitachi also anticipates that measuring a facility under normal conditions before it enters use will allow its soundness to be assessed with greater certainty after it becomes operational.

Solutions that are unique to Hitachi, with its fusion of IT and infrastructure technologies, will have extensive applications in emerging economies, not only in infrastructure such as roads and railways, but also in water treatment plants, industrial equipment, and other facilities.

CONCLUSIONS

This article has given an overview of Hitachi's facility monitoring services, and described their features, example applications, and future developments.

Use of sensors, RFIDs, and other Hitachi M2M technologies has expanded the scope for collecting large volumes of measurement data that would have been difficult to obtain in the past. Furthermore, linking the cloud, big data, and various other technologies together with products and services has created solutions that only Hitachi, with its fusion of IT and infrastructure technologies, can deliver.

With its facility monitoring services, Hitachi believes it can contribute to creating safe and secure societies, not just through its business know-how built up from past experience in the social infrastructure sector, but also by seeking new applications for its services in the global market.

REFERENCE

(1) Hitachi Facility Monitoring Services, http://www.hitachi.co.jp/products/it/traceability/service/monitoring_service.html in Japanese.

ABOUT THE AUTHORS

Masaki Ogihara

Security Services Department, Security Solution Operations, Services Creation Division, Information & Telecommunication Systems Company, Hitachi, Ltd. He is currently engaged in overall management of facility monitoring services.

Masafumi Uematsu

Security Services Department, Security Solution Operations, Services Creation Division, Information & Telecommunication Systems Company, Hitachi, Ltd. He is currently engaged in management of software design and development for facility monitoring services.

Daisuke Shibata

Security Services Department, Security Solution Operations, Services Creation Division, Information & Telecommunication Systems Company, Hitachi, Ltd. He is currently engaged in management of hardware design and development for facility monitoring services.

Sachio Minami

Security Services Department, Security Solution Operations, Services Creation Division, Information & Telecommunication Systems Company, Hitachi, Ltd. He is currently engaged in design and development of the overall architecture and applications for facility monitoring services.