Technologies and Solutions Accelerating Customers' Digital Transformation

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Under the Mid-term Business Plan 2019, OKI stated that it "aims at becoming 'IoT OKI'" with its strength in combined technologies of sensing, networking and data processing. The goal is to support customers' digital transformation utilizing IoT as a driver, thereby securing stable profitability and creating new businesses especially in the social infrastructure market.

OKI has steadily accumulated fundamental technologies necessary for the construction of IoT systems through long years of running its existing businesses. Additionally, changes in the external environment such as development of an always-on connection environment thanks to narrowband networks typified by recent sensor networks and to broadband networks capable of high definition video transmission as well as the dramatic evolution of AI technology typified by deep learning have made positive impact. Now, OKI is ready for co-creating with customers IoT systems that are truly useful for customers' services and businesses.

This paper introduces OKI's approach to IoT through OKI's distinctive technologies and solutions that accelerate customer's digital transformation.

Requirements for Accelerating Digital Transformation

"Accurate measurement of data necessary for analysis," "continuous operation in various environments," "linkage with existing operation and maintenance systems," and "sufficient consideration for security" are some of the requirements in the IoT systems that social infrastructure-associated businesses utilize for digital transformation.

At the entrance into digital transformation, accurate analysis of the current situation is necessary. The information digitization of the entire process from measurement, transmission, storage to analysis contributes greatly to the accuracy of the current situation analysis, and that is the reason why it is called digital transformation. Monitoring the effects of the transformation actions and repeating the transformation cycles will accelerate the customer's digital transformation. For this purpose, continuous operation of sensors and always-on connection to the IoT system via various networks are required. Unlike office equipment, which is mainly installed indoors, the installation of sensors and network equipment used for the social infrastructure is often outdoors in harsh natural environments. In addition, the communication environments are also diverse, especially when utilizing wireless, whose environment fluctuates by time. A system that always operates continuously even in such various environments is required. Furthermore, in many cases, social infrastructure is already operated and maintained by various systems. In the IoT system that operate in connection with these systems, interfaces must be adjusted after thorough understanding of the business expertise necessary for system operation and reliability equal to or higher than the existing system is required. Moreover, in systems related to social infrastructure, sufficient consideration must be given to security since the effects of system stoppage or abnormal operation are critical and widespread in many cases.

IoT Business Platform

In the IoT business platform, each component is systemized so that various types of IoT systems can be quickly constructed. The configuration is shown in **Figure 1**. The IoT business platform consists of sensing, networking, data processing/operation components. The fundamental technologies that OKI has accumulated through many years of business are leveraged in each component of the platform.

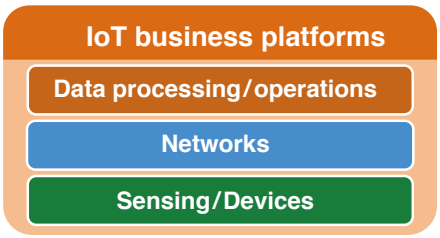

Figure 1. IoT Business Platform Configuration

The sensing component leverages optical, acoustical, radio wave and image signal processing technologies accumulated through communication and other

businesses. Technical expertise built up in the communication business to realize highly reliable always-on connection is put to use in the network component. Technologies related to server construction, data processing and system operation utilized in the data processing/operation component comes from years of providing solutions to government agencies and financial institutions.

Applying the IoT business platform, which can be considered a compilation of technologies and knowledge accumulated in the past, to the customers' problem solutions and repeatedly collecting, accumulating and analyzing on-site data will contribute to the customers' digital transformation.

Distinctive Technologies and Solution Systems

This section introduces OKI's distinctive technologies incorporated in the IoT business platform and OKI's distinctive solution systems utilizing the IoT business platform.

(1) Distinctive Technologies

A distinctive technology in the sensing area is the "optical fiber sensing technology." Installation of optical fibers in the measurement environment enables temperature, strain, vibration, etc. to be measured. A typical sensor contains electronic components in the sensing part that makes durability in high temperature and underwater environments an issue. On the other hand, optical fiber sensing employs optical fibers composed of quartz glass and plastic material in the sensor, which eliminate the environment problems. Furthermore, a single stretch of an optical fiber can cover a wide measurement area. The optical fiber overcomes both the restrictions in the installation environment and cost associated with having to install numerous sensors to cover a wide area, thus expanding the measurable social infrastructure area. It is particularly effective in areas such as temperature management of large-scale plant facilities, fire detection in factories and warehouses that cover large areas, structural integrity monitoring of bridges, tunnels, etc. and underwater acoustic measurements for coastal security. Applying and integrating modulation/demodulation technology cultivated in the optical communication field, OKI has developed a technology that enables wide-area real-time measurements, which were previously impossible.

"Acoustic sensing technology" includes OKI's technical expertise obtained while working with noise elimination, directivity beam forming and sound analysis technologies mainly to identify underwater objects. Integrating sensing technology centered on these acoustic signal-processing technologies cultivated over the years with data processing technology based on machine learning including the recently evolving deep learning, OKI is developing unique technologies tailored to a variety of uses. These technologies can be applied to the social infrastructure area making it possible to automate hammering inspection of structures such as tunnels and bridges, detect/predict factory equipment abnormalities, detect drones and perform underwater sound communication.

"Video sensing technology" is a technology that uses a general-purpose camera as a sensor. Video sensing technology consists of video transmission technology for compressing and transmitting video signals, and video recognition technology for recognizing people and objects from video signals. OKI has developed a video IoT-GW equipped with these two technologies for connecting network cameras, which have become increasingly high-definition in recent years. The video IoT-GW outputs video recognition results and video quality according to usage and characteristics of the connected network. It is effective for performing video monitoring of social infrastructures in various installation environments and as a platform for edge computing that performs sophisticated recognition/analysis at the sensor end instead of the cloud server.

Distinctive technologies in the network area are the 920 MHz multi-hop wireless (SmartHop®*1)) technology and DSRC technology used for communication between vehicles and road infrastructures. The SmartHop® technology ensures reliability by automatically switching the communication route when there is a change in the radio propagation due to change in the surrounding environment. DSRC technology ensures reliable communication between moving vehicles and roadside infrastructures. Taking into consideration installation on bridges and rivers where securing AC power may be difficult, SmartHop® technology is equipped with a power-saving feature to operate only with batteries or solar cells. Combining the ON/OFF control technology of the low-power-consumption acceleration sensor with the sleep control technology of the multi-hop wireless, a "wireless acceleration sensor unit" that does not require battery replacement is realized for monitoring infrastructure integrity of bridges, etc.

With respect to security of data processing/operation, cyberattack-monitoring technology backed by OKI's internal operational records is provided to customers. A distinctive technology is the automatic security log analysis. Security log is a record of security events output from the

*1) SmartHop® is a registered trademark of Oki Electric Industry Co., Ltd.

antivirus software, firewall, intrusion detection system, various servers, PC operating systems and applications used in the company. The information is useful for network administrators to monitor cyberattacks. However, the volume of information is too large to be fully monitored by humans. Technology that utilizes AI to analyze the large volume of security logs and interactively provides useful information for maintaining and managing the network, such as displaying only necessary parts in detail according to the operations of the administrator, have been built up through internal operational experience. An easy-to-use system based on the results is provided to the customers.

(2) Distinctive Solution Systems

Digital transformation using the IoT business platform will accelerate through the continuous analysis of data measured by sensors. Solution systems that effectively collect and analyze on-site data are introduced below.

The "ITS platform" is a system for collecting and analyzing probe information collected from vehicles via various networks including private networks operated by business operators and public networks operated by communication carriers. For road management companies and businesses such as transport companies that manage operation of commercial vehicles, service to analyze daily operation information of vehicles to predict/avoid traffic congestion and support safe/energy-conservative driving is provided. In addition to responding to the talent shortage of experienced managers and drivers, utilization of AI to analyze the large volume of collected data may lead to a new style of operation previously not derived by humans.

The "comprehensive disaster prevention system" centrally manages collected information such as rescue worker and municipality activities, river levels and weather for sharing in times of disaster. The linkage of environment resistant sensors, highly reliable networks and existing municipal disaster prevention systems makes the system possible.

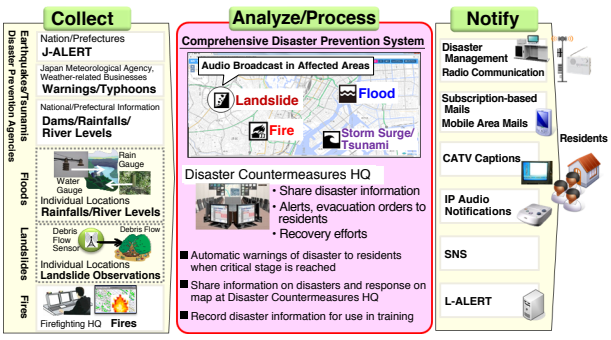

Figure 2. Comprehensive Disaster Prevention System

"Store IoT system" supports the operation of retail stores. The shortage of labor at retail stores is serious, and store managers are looking hard for ways to run their stores with a small number of staffs without compromising service quality. The system uses various sensors to gather real-time information such as customer attributes, checkout status that ties directly with customer satisfaction, employee status, and temperature/humidity management status related to food hygiene. Then, using AI, the system predicts the occurrence of the next situation for appropriate placement of store clerks, thus enabling the store to maintain customer satisfaction with minimal staff. The system also deals with the shortage of experienced store managers.

The "abnormality detection/prediction system" is available for use at manufacturing sites. Data collected from vibration and acoustic sensors placed in manufacturing equipment enable abnormalities to be detected or predicted. The system will help reduce excessive maintenance checks and operational losses due to failures. Normal maintenance checks of manufacturing equipment are often carried out at a uniform frequency based on experience despite the fact that the status differs by individual equipment. Monitoring the operational status of manufacturing equipment with sensors and analyzing the collected data, maintenance matching the status of individual equipment can be performed.

The "on-site monitoring system" can be used at construction sites to monitor workers' flow lines and status of trucks/cranes for the safety management of workers. Managing the safety of workers at construction sites where skilled technicians are increasingly lacking is a major challenge. Currently, the situation is dealt with allocating safety observers to each site. However, limit to the duration of human concentration as well as the environmental situation of the site such as lighting, dust and noise can hamper situational awareness, hence lead to improper work instructions. With a system that utilizes AI for data analysis, it is possible to grasp the events at the construction site through the combination of various sensors, which would be difficult with only the so called five human senses, thus contributing to labor saving and reliability of safety management.

Finally, there is the "medical office ICT system" that collects data at medical facilities and streamlines medical office work. The lack of experts such as doctors and nurses is accelerating along with the aging population. Under such circumstances, medical office work that does not require medical expertise is increasingly being outsourced, but standardization of work is lagging. This leaves room for

efficiency improvement through the implementation of ICT. The implemented system will carry out analysis of office work from on-site data to determine which work can be streamlined. This will accelerate digital transformation of medical offices.

Future Developments

OKI has systemized the various fundamental technologies it has accumulated since its founding 136 years ago into an IoT business platform. The platform is provided to customers in a form that matches their site and supports the customers' digital transformation through analysis of the data collected at the site. In the future, further developments are required for each technical area constituting the IoT business platform as outlined below.

Sensing technology needs to resolve functional restrictions that constrain what can be measured and locational restrictions that constrain where measurements can be taken.

In order to resolve the functional restrictions, developments in increasing the functionality of physical sensors to convert the sensing target's quantity into the sensors' physical quantity change and enhancing the processing of the signal outputs from the physical sensors are required. Increasing the functionality of physical sensors requires advanced knowledge of physical properties, materials, and chemistry. Therefore, as part of the effort for open innovation, OKI is considering actively adopting technologies developed by other participating organizations. On top of this, signal-processing enhancements will be developed based on OKI's accumulated expertise to realize sensing functionalities that meet customer needs.

To resolve locational constraints, improvements in miniaturization, energy saving and environment resistance are required. Miniaturization will enable sensors to be placed in locations where installation space is limited. In addition to miniaturizing the sensing device, controlling the generated heat will be the key to miniaturizing the sensors. This will be possible through enhancements of the energy saving design that suppresses the generated heat itself and the heat dissipation design that releases the generated heat. Besides enabling a more compact design, energy savings will make it possible to place sensors in locations where AC power cannot be supplied. It will also allow the sensors to operate for long periods without the need to replace the small battery and allow the application of energy harvesting technologies such as solar power and vibration power generations. Energy saving will be realized with the adoption of energy-saving components and control of the sensing and communication times to shorten the sensor's power ON time. For improving environment resistance, degree of freedom in the environment where the sensors can be installed will be improved. Since sensors are electronic devices, the installation environment was often restricted by such factors as temperature, humidity, and vibration. Enclosing the sensors in a housing utilizing high environment resistance technology as shown in **Figure 3**, it will be possible to install the sensors even in places where environmental condition is severe. OKI has experience in working with such a high environment resistance technology.

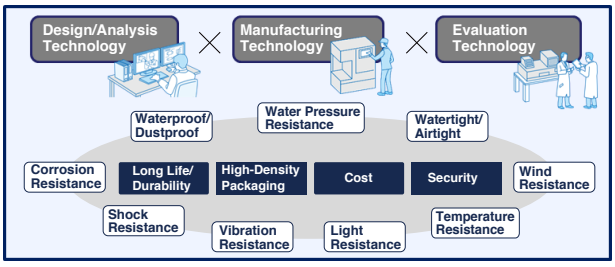

Figure 3. High Environment Resistance Technology

Regardless of where the sensors and GW are installed, network technology is required to provide always-on connection while enabling an economical two-way communication. Public carrier networks represented by 5G and private networks represented by SmartHop® and DSRC, as well as service dedicated to low-speed communication such as LPWA (Low Power Wide Area) that is recently undergoing rapid development will be optimally combined to realize an economical system. A management server that centrally manages sensors connected to different networks will also be provided.

Finally, it is no exaggeration to say that the success or failure of digital transformation depends on data analysis. Application of AI technology, which is showing remarkable progress in recent years, is effective for data analysis. "High quality data," "high precision analysis algorithm" and "high performance hardware" are indispensable in the utilization of AI technology. Data will be acquired through good co-creation relationships with customers. For the analysis algorithms, internally and externally developed technologies will be selectively applied according to purpose. Especially, new open source technologies have become increasingly available in recent years. Data scientists knowledgeable with various data analysis methods, including the utilization of open source technologies, will become necessary, and training will be

undertaken. For high performance hardware, experience with the development of the video IoT-GW described in this article will be utilized, FPGA (Field-Programmable Gate Array) suitable for AI processing will be adopted and environment resistant design including heat dissipation will be enriched to provide easy-to-use products that can be installed anywhere.

Conclusion

With the previous solution business, customer problems were heard beforehand. From the hearing, strategies to solve the problem were prepared. Then a corresponding system was designed and developed. The added-value the system provides is fixed at the time of delivery to the customer and maintenance thereafter is to maintain the function the system had when it was delivered. On the other hand, the IoT system continues sending on-site data obtained from sensors to the analysis server via a continuously connected network even after installation at the customer's site. Therefore, it is an effective system for repeating the transformation PDCA cycle of “Plan,” “Do,” “Check” and “Action” based on the collected data. Since the acceleration of the customers’ digital transformation is more probable through the continuous use of IoT system after delivery rather than at the time of delivery, OKI expects relationship with customers will further deepen after delivery. OKI wishes to continue contributing to the customers’ digital transformation long after the delivery. ◆◆

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TIPS【Glossary】

DSRC: Dedicated Short Range Communications
One-way or two-way wireless communication technology specifically designed for vehicular use.