TOSHIBA REVIEW

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Special Reports

Toshiba Group's Efforts Aimed at Realization of Cyber-Physical Systems (CPS) in Energy Business Domain

Committed to New Value Creation Utilizing CPS Technologies in Energy Businesses
NAKAI Akimasa

Construction of CPS Service Development Platform for Energy Systems and Promotion of Their Digital Transformation
ARAI Yasutaka
The movement toward the utilization of renewable energy as a major power source has been progressing in Japan in accordance with the government's Strategic Energy Plan, which sets forth the country's targeted energy mix by 2030. In line with this trend, there is a need for the reform of business models and the development of energy businesses in response to the social changes taking place accompanying the liberalization of electricity markets, the transition to decarbonized electricity generation and renewable energy generation systems, and the increase in companies that are not only electric power consumers but also suppliers. Furthermore, all industrial fields including the electric power industry are faced with the necessity of changing their business models in response to the advancement of digital transformation.
The Toshiba Group has set the goal of becoming a cyber-physical systems (CPS) technology company. Based on an Internet of Things (IoT) platform for energy systems compliant with the Toshiba IoT Reference Architecture, a common framework that accelerates the development and operation of IoT services, we are promoting the expansion of recurring type businesses utilizing various digital services in order to co-create new business value with our customers and partners.

Deployment of IoT Services to Power Plant Operations Based on IoT Platform for Energy Systems
AOYAMA Keizo
The Toshiba Group is aiming to become a cyber-physical systems (CPS) technology company that can solve issues in the manufacturing and social infrastructure fields by means of digital technologies. As part of this approach, the Toshiba IoT Reference Architecture (hereafter abbreviated as TIRA) has been created as a common platform to promote the development and operation of CPS.
Toshiba Energy Systems & Solutions Corporation has developed an Internet of Things (IoT) platform for energy systems that is compatible with TIRA in order to enhance IoT services for power plant operations. This platform incorporates the following features: (1) adoption of a microservice architecture to facilitate the provision of functions per service unit and the utilization of existing systems through the application of distributed databases, thereby realizing flexible responses to customers' requirements and environments, and (2) utilization of information models and external linkages by using open application programing interfaces (APIs) to collaboratively analyze data, allowing the construction of co-creation environments with customers.

O&M Service to Improve Thermal and Operational Efficiency of Power Generation Plants and Its Business Development
SEKIYA Nobuhiro
In recent years, improvement of the operational efficiency of thermal power plants has become necessary due to their important role in maintaining the electricity supply and demand balance accompanying the expanding introduction of renewable energy systems.
The Toshiba Group has utilized its technical know-how accumulated in the fields of power generation equipment and digital solutions to offer Internet of Things (IoT) solutions for the improvement of both thermal efficiency and operational efficiency by detecting signs of abnormalities in equipment. In order to expand this approach to overseas thermal power plants, we have confirmed the potential of this operation and maintenance (O&M) improvement service by means of feasibility studies using data obtained at an actual thermal power plant in Mexico whose facilities were supplied by other companies. We are now conducting verification tests to confirm that its performance is sufficient for practical application.

Digital Services for Electricity Transmission and Distribution Utilities to Reform Overall Business Processes
SHONO Takaya / SAIDA Toshiyuki
The electric power industry in Japan is faced with the need to secure the stable operation of electric power systems and improve the efficiency of work processes while rationalizing system configurations through the optimal replacement of aged facilities. Electricity transmission and distribution utilities are therefore tackling the reform of their business processes through the application of advanced technologies for digital transformation including the Internet of Things (IoT).
Based on its long accumulation of technical know-how in the domestic and overseas markets, the Toshiba Group is promoting the development of digital services to optimize the configuration of power grids and reform overall business operations. This is achieved through the construction of a so-called digital twin, which is a model that replicates equipment and its operational conditions in cyberspace. Our approach is expected to contribute to the solution of customers' issues and the provision of new value through the following services: (1) visualization of the operational conditions of substations by means of a dashboard service, (2) labor saving in equipment maintenance by means of a condition-based maintenance (CBM) service, and (3) interoperability of documents by means of a digital library service.

Optimal Operation Support System for Private Power Generation Facilities
MURAYAMA Dai / NAKAHARA Yoshiki
The majority of private power generation facilities at factories and industrial complexes have been expanded or partially renewed during long-term operation. As a result, they have complex structures and require skillful operators who can optimally control facility equipment so as to satisfy the fluctuating power and steam demand of manufacturing processes.
Toshiba Energy Systems & Solutions Corporation has developed techniques to estimate the behavior and condition of equipment in private power generation facilities utilizing its experience and knowledge of engineering work. We are providing new services to match the needs of customers and the condition of their facilities by constructing an optimal operation support system built on an Internet of Things (IoT) platform for energy systems using techniques grasping the plant's behavior, in order to realize stable and efficient operation capable of handling fluctuations in demand for power and steam.

Smart O&M Services for Realization of Sustainable Energy Systems
SHIBUYA Masato / TSUJI Hisashi
To strengthen the robustness of energy infrastructure systems, which are of crucial importance for people's daily lives and industrial activities, it is necessary for energy providers to construct sustainable systems with the capability to respond to future business environments while maintaining service quality. Demand has therefore been growing for smart operation and maintenance (O&M) services that make it possible to reduce the burden on workers and flexibly adapt to changing business environments while continuing to use existing equipment and introducing new equipment and renewing aging equipment as needed.
Toshiba Energy Systems & Solutions Corporation has responded to this situation by developing technologies for smart O&M services through the application of augmented reality (AR) using smart devices, construction of sensor networks, introduction of autonomous mobile robots and drones, and planning of equipment maintenance for electric power systems using artificial intelligence (AI). These services include (1) a service supporting workstyle reforms and productivity improvement, and (2) a service ensuring the inheritance of experts' knowledge and enhancement of maintenance work.

Plant Operation Support Services for Nuclear Facilities
SASAYAMA Takao / FURUKAWA Tomoaki / ISHIBASHI Fumihiko
Following the introduction of a new nuclear regulatory inspection system for nuclear facilities in Japan in April 2020, utilities are required to manage and analyze information on their nuclear facilities and the operating conditions of those facilities in order to proactively maintain and improve their safety and performance. Furthermore, to maximize plant value, there is an increasing need for the utilization of risk information and the optimization of condition-based maintenance (CBM) due to equipment degradation.
In response to this situation, Toshiba Energy Systems & Solutions Corporation has launched plant operation support services incorporating a plant system configuration management system and a corrective action program (CAP) support system using artificial intelligence (AI) technology, utilizing the experience and knowledge it has accumulated through the design and construction of nuclear facilities. We are introducing these systems as microservices on a newly developed Internet of Things (IoT) platform for energy systems, in order to provide customers with plant operation support services that are flexibly tailored to their needs and the equipment operating environment.

Cloud-Based Digital Service for Monitoring and Control of Hydrogen Power Generation Systems
TANOUE Tetsuharu / YATSUSHIRO Misato / KUMAZAWA Toshimitsu
In line with the Basic Hydrogen Strategy being promoted by the Japanese government, the Toshiba Group is making continuous efforts to develop technologies both to secure stable energy sources from the standpoint of energy security and to reduce carbon dioxide (CO_2) emissions, and to deliver a broad range of hydrogen power generation systems that can produce hydrogen using renewable energy and utilize the produced hydrogen as a fuel for power generation.
As part of these efforts, we have developed a cloud-based digital service incorporating monitoring and control functions that is implemented on a common platform compatible with the Toshiba IoT Reference Architecture. This service includes (1) a dashboard to grasp trends, such as the amounts of hydrogen and photovoltaic (PV) power generation, using Internet of Things (IoT) data, (2) an email notification service in the event of a problem, and (3) a remote maintenance service.

Feature Articles

High-Accuracy Distance Measurement Method Using Image Captured by Monocular Camera Based on Aberration Maps
KASHIWAGI Masako / MISHIMA Nao
Methods to perform distance measurement with high accuracy using images are generally classified into (1) methods using a stereo camera system equipped with two cameras, which have been widely used in various applications; and (2) methods using a monocular camera, including a monocular depth estimation method employing deep learning and a color-filter aperture method in which color filters are inserted into the optical path. However, there are significant issues with these approaches in terms of the need for downsizing of the camera systems and resolution of the trade-off between versatility in dealing with objects of various shapes and reduction of costs.
To rectify this situation, Toshiba Corporation has now developed a versatile method to precisely measure a distance at low cost using an image captured by a commercially available monocular camera. This method makes it possible to perform distance measurements based on blur information data related to the lens performance (hereafter referred to as aberration maps), which vary according to the object distance and image position, through analysis of the image applying deep neural networks. We have conducted evaluation experiments using actual images and confirmed that this method achieves distance measurement accuracy comparable to that attained by methods using a stereo camera system without dependence on object shapes.

Compact Multiband High-Temperature Superconducting Receiver for Radio Telescopes Capable of Reducing Radio-Frequency Interference
KAWAGUCHI Tamio / TSUBOSAKI Kazuhiro / KAMIDE Hirotaka / ASAKURA Taro
The objective of radio astronomy is to elucidate astronomical phenomena through the utilization of radio telescopes that can detect very weak radio wave signals of various frequency bands emitted by celestial bodies. However, with frequency resources becoming depleted due to the rapid increase in wireless communication terminals including smartphones in recent years, it has become necessary to coexist with these wireless systems in utilizing the limited frequency bands available.
In response to this situation, the Toshiba Group has developed a compact multiband high-temperature superconductor (HTS) receiver for radio telescopes with diameters ranging from small to large that can simultaneously observe multiple frequency bands as well as suppress radio-frequency interference (RFI) caused by other wireless systems by applying a low-loss multiband HTS filter and a cryogenic low-noise amplifier (LNA) cooled to liquid nitrogen temperature. Experiments on a prototype quad-band HTS receiver have verified that it realizes high sensitivity, with a reduction in RFI of more than 40 dB and a noise figure (NF) of less than 0.4 dB.

Sm-Fe-Ti System Compounds with Addition of Y as Promising Candidates for High-Performance Permanent Magnet Materials
HAGIWARA Masaya / SAKURADA Shinya
The advancements taking place in the energy-saving performance and sophistication of various products, including vehicles, rolling stock, elevators, have given rise to the need for compact and highly efficient motors. In this context, attention is being increasingly focused on the supply risk associated with permanent magnets such as neodymium magnets as key components in these motors because of the uneven distribution of these resources. It is therefore necessary to seek alternative materials with characteristics equivalent to or better than those of existing neodymium magnets.
With this as a background, Toshiba Corporation has developed permanent magnet materials with high iron (Fe) concentration by substituting samarium (Sm) in samarium-iron-titanium (Sm-Fe-Ti) system compounds with yttrium (Y). The newly developed compounds achieve a stable crystal structure through the addition of Y and application of the rapid quenching method, and offer high performance including a high saturation magnetization, anisotropy field, and Curie temperature. These compounds are promising candidates for permanent magnet materials with higher performance at temperatures exceeding 80°C compared with neodymium magnet materials.

Self-Starter Gateway for BMUs (SSGB) Facilitating Introduction of SCiB™ Battery System into Industrial Equipment
KIKUCHI Yusuke / EBISAWA Masafumi / INAMURA Atsushi
In the field of storage batteries for industrial equipment, the replacement of existing lead-acid batteries with lithium-ion rechargeable batteries offering higher performance has recently been progressing. From the viewpoint of securing the safety of lithium-ion rechargeable battery modules, a battery management unit (BMU) is essential in order to strictly control the voltage and temperature of the lithium-ion battery cells in accordance with the operating conditions of each cell.
To facilitate the replacement of lead-acid batteries in industrial equipment with SCiB™ lithium-ion rechargeable battery modules equipped with a BMU, Toshiba Corporation has developed a self-starter gateway for BMUs (SSGB) that makes it possible to handle BMUs more simply and more effectively. The SSGB is suitable for introducing SCiB™ battery systems into a wide variety of industrial equipment, particularly industrial vehicles including forklifts and automated guided vehicles (AGVs), due to the following functions: (1) a simple communication interface function to easily connect the BMU to user equipment, (2) a self-startup function to eliminate the need for external power supplies, and (3) an overdischarge prevention function.

Development of Mobile Hydrogen Fuel Cell System for Marine Vessels to Eliminate Need for Fossil Fuels
SHIMOMICHI Tsuyoshi / YAMASHITA Kyohei / OTSUKA Naoto / HIDAI Shoichi
In response to the increased emissions of greenhouse gases by marine vessels in recent years, demand has arisen for the development of propulsion technologies that do not use fossil fuels.
Toshiba Energy Systems & Solutions Corporation, in cooperation with the Tokyo University of Marine Science and Technology and NREG Toshiba Building Co., Ltd., is making efforts to contribute to the realization of a hydrogen society through the practical realization of a fuel cell ship. In order to verify the performance durability of fuel cells in the marine environment, we installed two stationary H2Rex™ hydrogen fuel cell systems, each with a capacity of 3.5 kW, on the *Raicho N* electrically powered ship and conducted demonstration tests over a period of two years from October 2016. After the successful conclusion of these tests, the H2Rex™ systems were disassembled and inspected. The results showed that no deterioration in performance associated with the conditions of use in the marine environment, such as hull vibration, temperature and humidity, seawater salinity, and so on, had occurred. As the next step, we are now conducting validation experiments on a newly developed mobile hydrogen fuel cell system achieving greater compactness that has been installed on the *Raicho N*.

Static Var Compensator Contributing to Introduction of Renewable Energy Power Generation Systems
FUKUSHIMA Daishi / TAMURA Yuji
The introduction of renewable energy sources has recently accelerated toward the realization of a low-carbon society. Particularly in Japan's Kyushu region, grid-connected distributed power generation systems such as photovoltaic (PV) systems have been progressively installed, taking advantage of the long hours of sunlight in that region. This, in turn, has resulted in increased demand for static var compensators (SVCs) in order to maintain the grid voltage within the appropriate level by suppressing voltage fluctuations caused by such PV power generation systems.
Toshiba Energy Systems & Solutions Corporation has developed a static var compensator (SVC) equipped with a large-capacity thyristor-controlled transformer (TCT), which makes it possible to achieve space saving and reduce introduction costs, and delivered it to the Kumamoto Substation of Kyushu Electric Power Co., Inc. The newly developed SVC offers the following features: (1) enhancement of harmonic performance, achieved by applying a series reactor and a C-type AC filter and increasing the impedance of the TCT transformer, (2) optimization of specifications for control of PV systems, and (3) shortening of the period required for construction by using package houses. We have confirmed the effective operation of this SVC through the results of analyses, factory tests, and system interconnection tests at the site.

Frontiers of Research & Development

Face Recognition System for Highly Efficient Subject Confirmation in TV Program Production Phase

Direct Bonding of Resin Materials with Poor Adhesibility by Atmospheric-Pressure Plasma Treatment