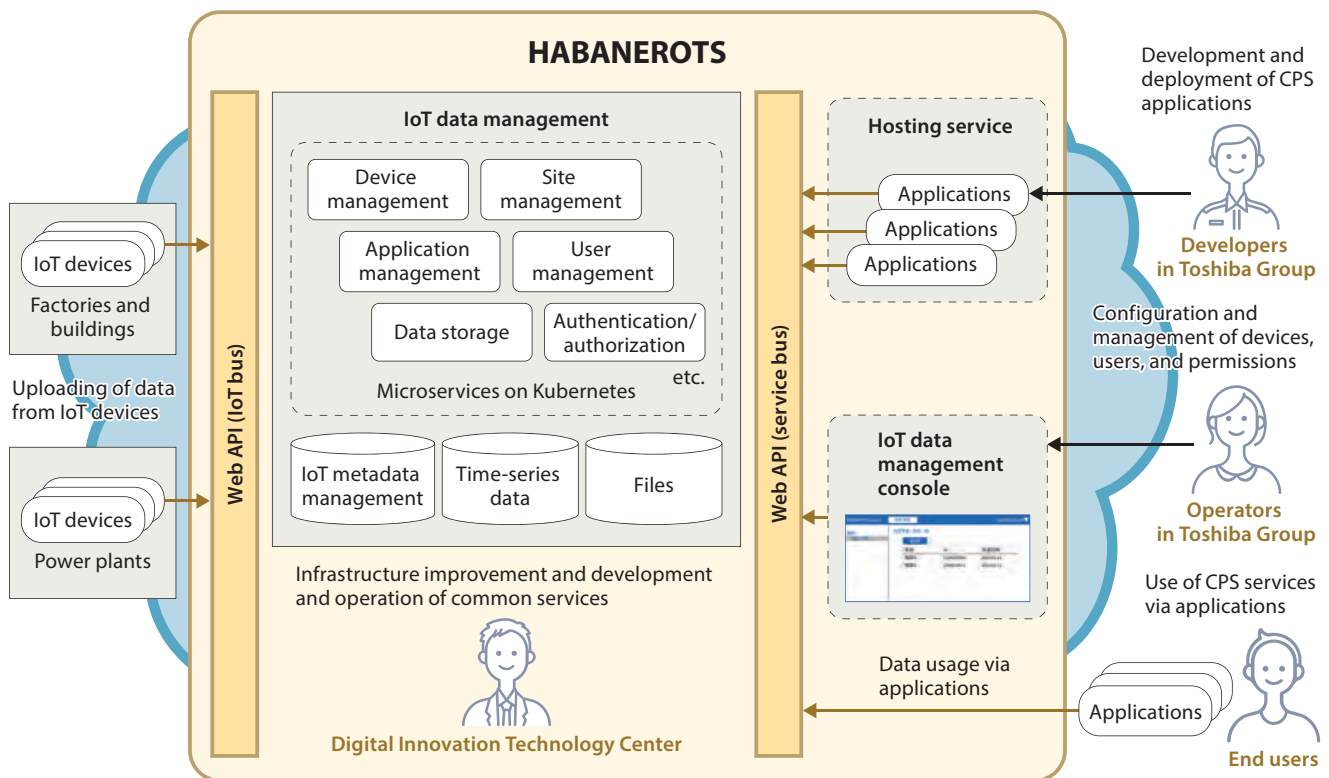


2. Digital Solutions

2.1 HABANEROTS: Toshiba Industrial IoT Platform Service



Overview of HABANEROTS compliant with TIRA

Toshiba Corporation has been developing functions independent of specific cyber-physical systems (CPS) as common components compliant with the Toshiba IoT Reference Architecture (TIRA) while participating in several CPS service development projects.

These common components constitute HABANEROTS, previously known as Habanero, an industrial Internet of Things (IoT) platform service. HABANEROTS is mainly provided as one of the implementations of TIRA in the form of Web application programming interfaces (APIs). It consists of the following three services:

- IoT data management service
This is a Web API service that provides common functions required to realize CPS as well as primitive functions necessary to monitor, and utilize data from, IoT devices.
- IoT data management console
This console provides a Web graphical user interface (GUI) for managing IoT devices, users, applications, permissions, and other aspects of an IoT network.
- Hosting service
The hosting service makes it possible to provide CPS services developed with HABANEROTS Web APIs in the cloud environment.

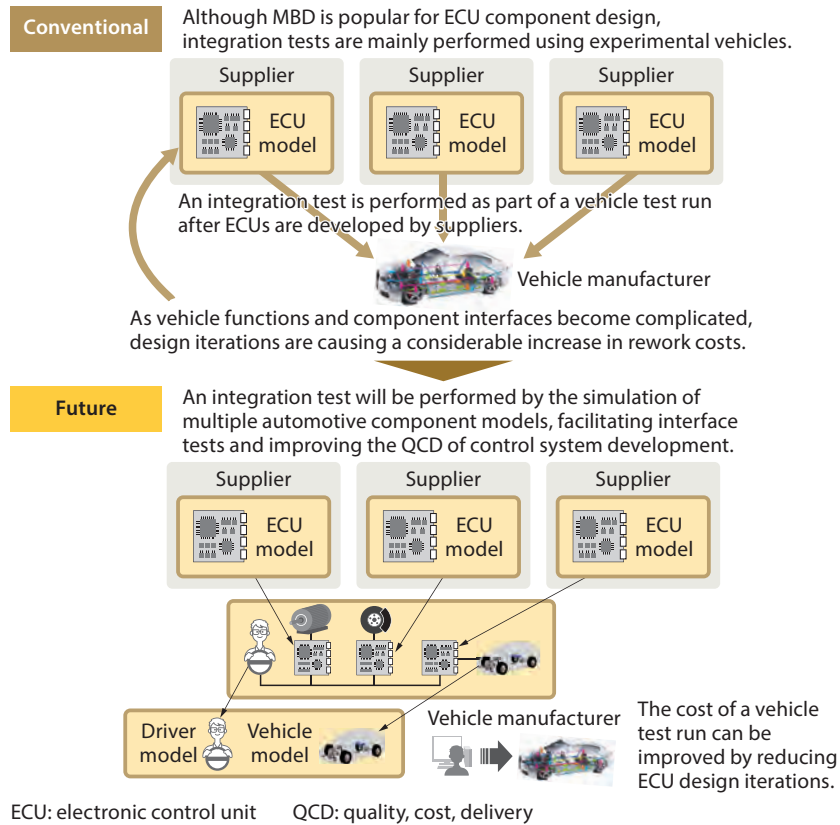
2. Digital Solutions

One of the challenges in the development of HABANEROTS was ensuring versatility to make it applicable to any CPS in the wide-ranging business domains of the Toshiba Group. HABANEROTS accommodates the requirements for multiple CPS services for building management and electric power systems in the field of social infrastructure. In addition, it has been designed based on Web APIs that have been used in the field of consumer IoT systems such as home energy management systems (HEMS). As a result, HABANEROTS achieves versatility without compromising security, allowing both social infrastructure and consumer CPS services to use common functions. For the cloud service platform that supports the Web APIs, HABANEROTS adopts Kubernetes and other open-source container orchestration technologies to ensure high availability, scalability, and resilience. The use of open-source technologies is important for CPS infrastructure and will allow us to accumulate know-how on their usage and improve our operational capabilities for CPS.

Kubernetes is a registered trademark of the Linux Foundation in the United States and other countries.

2. Digital Solutions

2.2 VenetDCP Distributed Co-simulation Platform for Development of Vehicle Control Systems



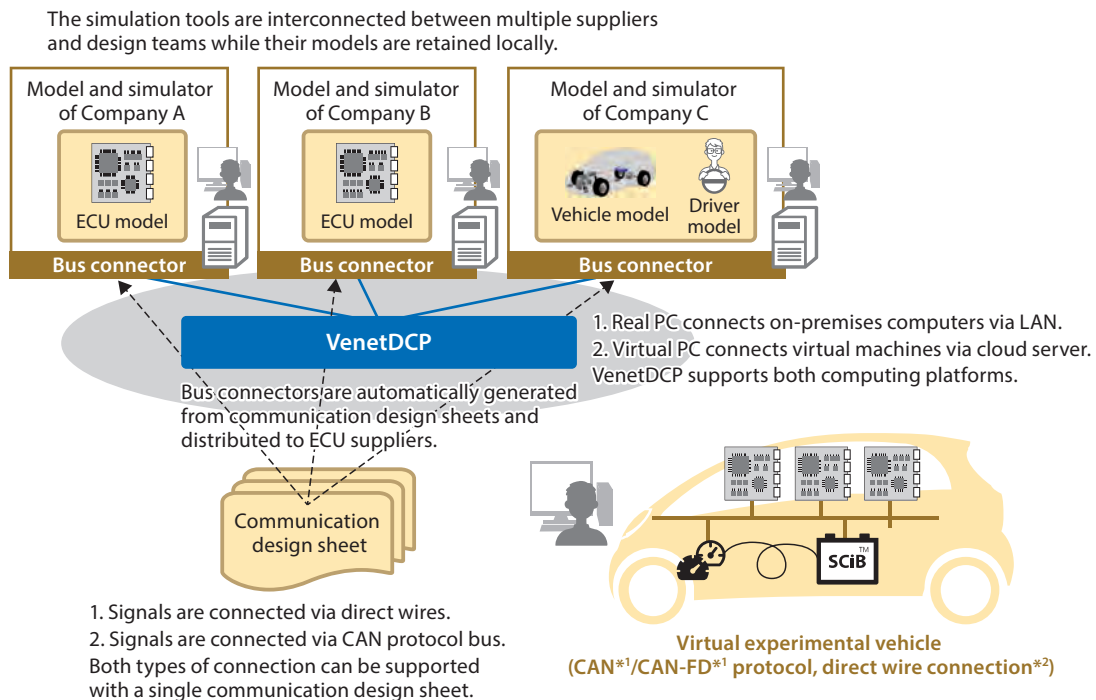
Current and ideal situations of MBD for automotive control systems

CASE, i.e., connected, autonomous, shared, and electric mobility, which will change the automotive industry, is spurring the need for model-based development (MBD). MBD is a development method using the simulation of automotive control, automotive components, vehicle dynamics, and traffic environments such as roads, pedestrians, bicycles, traffic signs, and other vehicles, thereby reducing the time and costs required for the development of vehicle control systems. However, many successful applications of MBD have been limited to the designing of a single control unit.

As a result of the trend in recent years toward vehicle systems incorporating a large number of components from multiple suppliers, the automotive industry is seeking to perform large-scale simulation of multiple interconnected models. However, there are many challenges to be overcome to realize such simulation, including the need for cooperation among multiple suppliers to enable vehicle-level simulation and difficulty in collecting all of the necessary models.

Since models are embodiments of design specifications, many suppliers are unwilling to provide their models to external parties. Furthermore, it is a highly complicated task to accurately connect a huge amount of signals (variables) transmitted across vehicle control systems.

2. Digital Solutions



*1: The CAN platform also supports CAN-FD.

*2: Direct signal connection lines between components or ECU models

CAN: Controller Area Network

CAN-FD: CAN with Flexible Data Rate

SCiB™: Lithium-ion rechargeable battery supplied by Toshiba Corporation

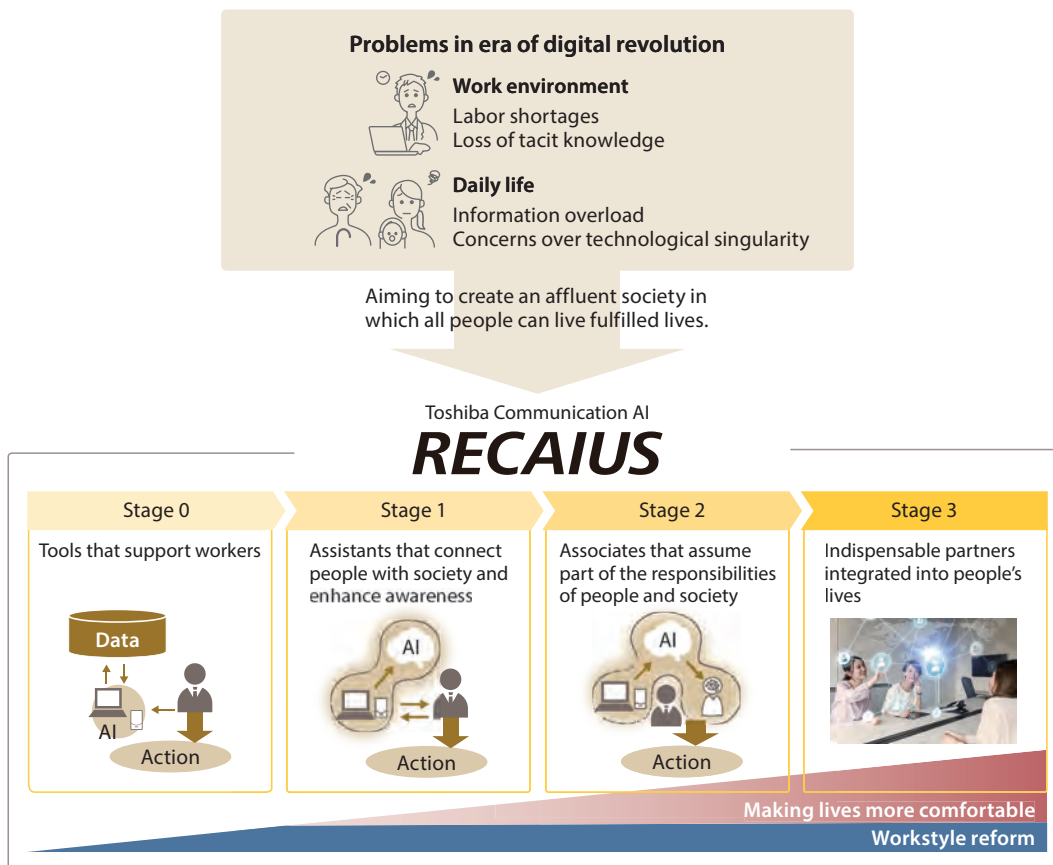
Overview of VenetDCP for distributed model simulators

To solve these problems, Toshiba Digital Solutions Corporation has developed VenetDCP, a distributed co-simulation platform, which interconnects multiple models and tools via the Internet and performs a simulation as if all the models were working together as a single vehicle. VenetDCP automatically generates the distributed simulation environment based on communication design sheets to emulate actual data transmissions occurring in a vehicle such as transmission delays, data collisions, and baud rates while allowing suppliers to retain their models on their own computers. Consequently, vehicle manufacturers can perform virtual tests in cooperation with component suppliers prior to actual vehicle tests while suppliers can verify their components according to the test scenarios of vehicle manufacturers. In addition, VenetDCP allows suppliers to perform system-level tests, interconnecting the models of other suppliers. VenetDCP also supports the use of a cloud server to create a more convenient environment for distributed simulation.

To enhance the usefulness of VenetDCP as an engineering digital twin, we will continue to provide various APIs designed to improve its suitability for configuration management.

2. Digital Solutions

2.3 New RECAIUS Service to Enhance Communication with Customers and Facilitate Workstyle Reform



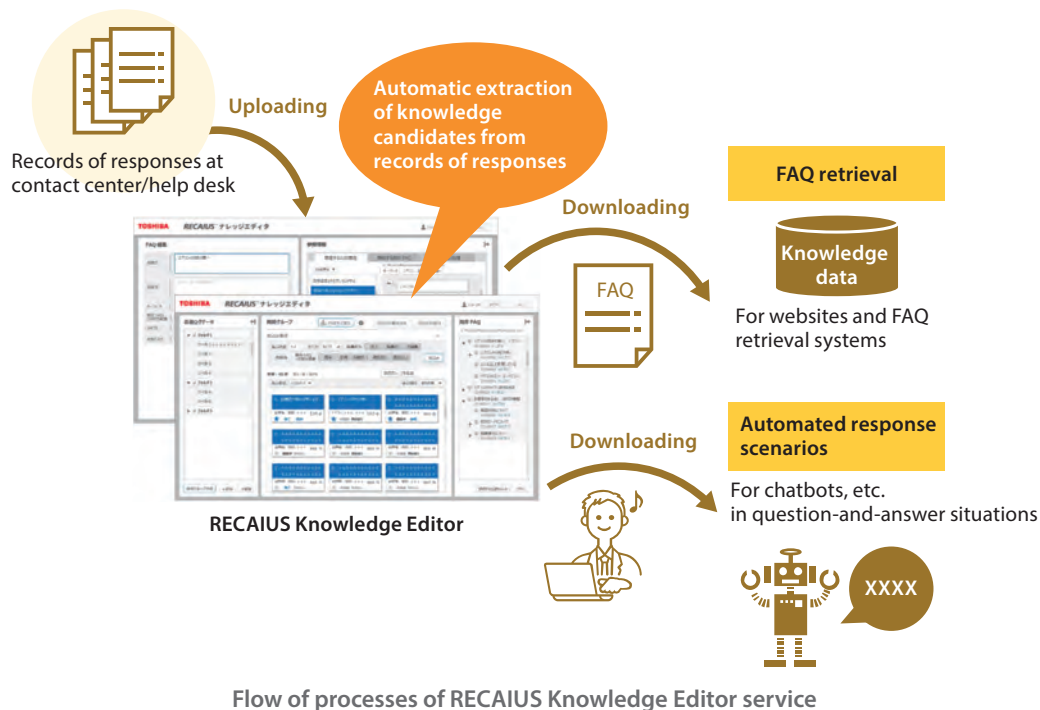
Prospective services targeted by RECAIUS Toshiba Communication AI

RECAIUS Toshiba Communication AI is a product family aimed at creating an affluent society in which all people can live fulfilled lives. Toshiba Digital Solutions Corporation has successively improved RECAIUS Toshiba Communication AI in response to the substantial changes taking place in society such as the declining birthrate and aging population in Japan and other countries.

We have now developed RECAIUS Knowledge Editor, a Web application to support authors in creating useful frequently asked questions (FAQs) efficiently using records of inquiries received by a company's contact center or help desk.

Useful FAQs improve the efficiency of the contact center or help desk, equalize the quality of responses provided by its staff members, and enhance customer satisfaction. In addition, such FAQs help to reduce the number of customer complaints and therefore realize a friendly working environment for the staff.

2. Digital Solutions



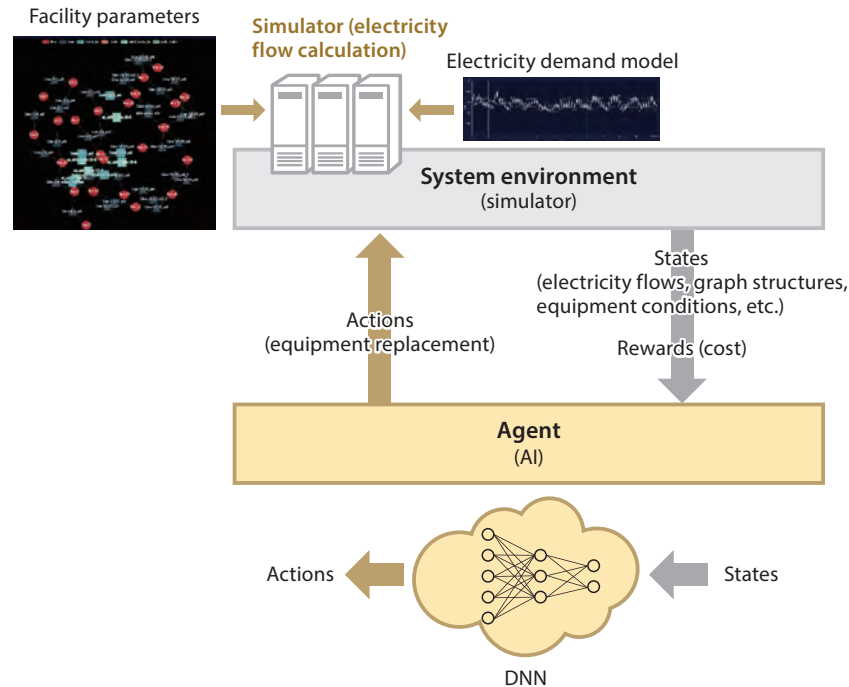
To create a useful FAQ, an author needs to analyze numerous records of inquiries, select frequently asked and new questions, and describe FAQs in an easy-to-understand manner. It is a difficult and time-consuming task. For example, more than one month is required to analyze 10 000 inquiries.

To solve this problem, RECAIUS Knowledge Editor analyzes records of inquiries using natural language processing (NLP) and machine learning. As a result, it can extract frequently asked and possible new questions from the records of 10 000 inquiries within a few minutes. This allows the author to concentrate on the creation of a useful, easy-to-understand FAQ using the extracted information.

RECAIUS Toshiba Communication AI is the fruit of many years of research and development efforts, embodying our philosophy of contributing to the enrichment of all people's lives.

2. Digital Solutions

2.4 Facility Planning Technology Based on Deep Reinforcement Learning



Outline of facility planning technology for electric power systems

Toshiba Digital Solutions Corporation has developed a facility planning technology based on deep reinforcement learning (DRL) that is applicable to electric power transmission and distribution (T&D) network facilities. The newly developed DRL technology learns the overall cost minimization plans and time schedules for the installation, removal, and replacement of individual T&D network systems, etc. while iterating the generation of system change plans, state transitions, and cost evaluations using an artificial intelligence (AI) agent and a system environment.

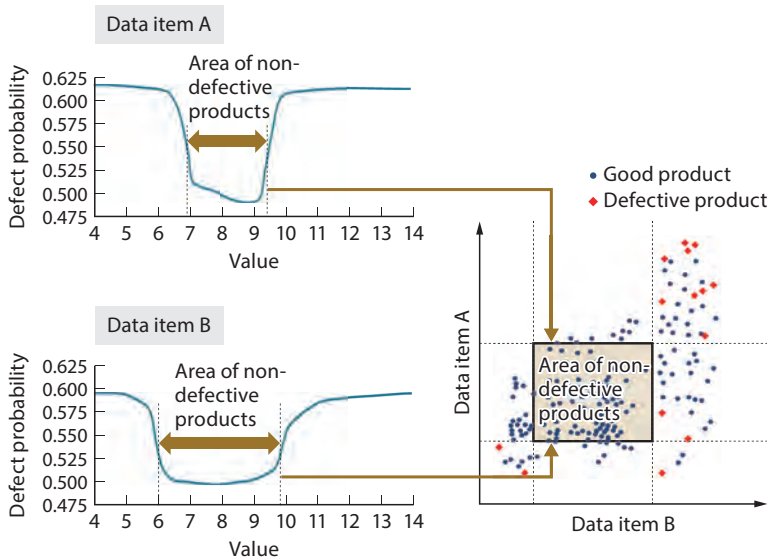
The AI agent uses newly developed graph-structured deep neural networks (DNNs) suitable for the modelling of graph-structured systems, while the system environment consists of a simulator incorporating the parameters of individual T&D network facilities, cost models, electricity demand models, etc.

Although the system structure changes according to the changes made to the facility, the conventional reinforcement learning based on either Q-tables(*) or fully connected DNNs cannot handle structural changes. In contrast, the graph-structured DNNs that expand the graph attention networks learn and build graph-structured models capable of handling changes in system structures without re-learning.

(*) A reinforcement learning method using tabular representations of value functions whose variables are system states and actions

2. Digital Solutions

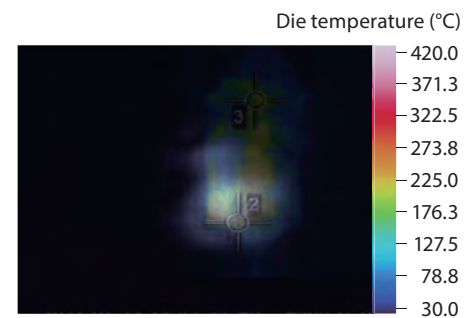
2.5 Technologies Providing Users with Grounds for AI Inference to Support Their Decision-Making



(a) Defect probabilities by data item

(b) Non-defective area settings

Function to show area of non-defective die-cast products



Function to show area of attention on die-casting mold for prediction of whether molding is good or bad

Toshiba Digital Solutions Corporation has developed technologies to determine whether the results of die-cast molding^(*) are good or bad and to detect anomalies in the die-casting mold temperature. These technologies use one of the features of SATLYS Toshiba Analytics AI services, comprising a technique that provides users with grounds for the results inferred by AI to support their decision-making.

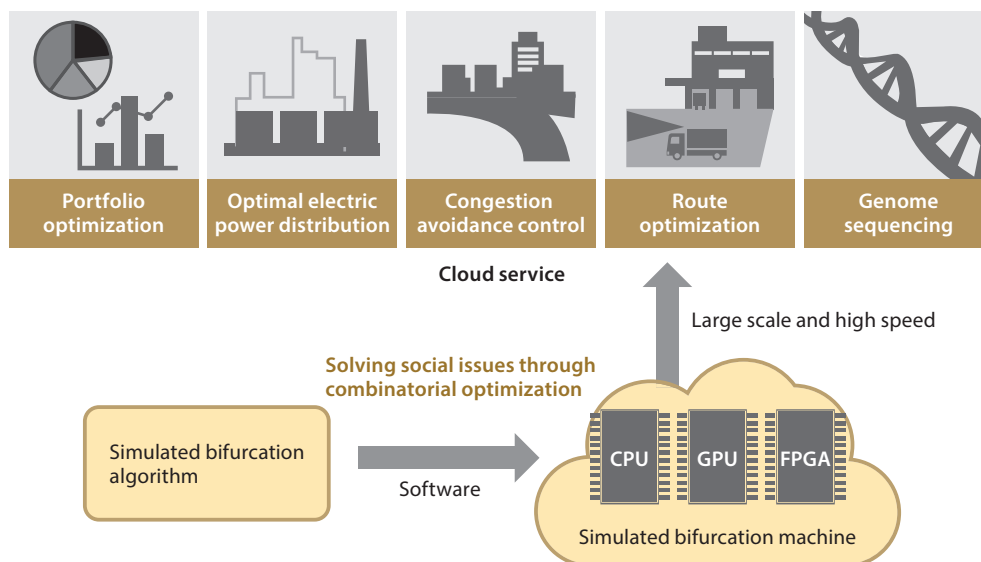
The first technology utilizes AI to determine whether the results of die-cast molding are good or bad based on data on the manufacturing and equipment conditions. It also identifies the data items that are closely related to the occurrence of defective products as well as the ranges of data values that are likely to produce good products by using the above-mentioned technique to provide users with grounds for inference. This allows users to determine the priority of the manufacturing conditions and the ranges of their settings that should be changed in order to reduce defective products.

The other technology utilizes AI to detect anomalies in the die-casting mold temperature by analyzing thermographic images of the molds to show areas of attention, so that users can identify the locations of the causes of anomalies in the molds. This provides users with useful information for improving the mold design and cooling method.

(*) A metal casting process that injects molten metal into the cavity of a mold under high pressure to produce large quantities of high-precision castings in a short time

2. Digital Solutions

2.6 Release of Simulated Bifurcation Machine to Solve Large-Scale Combinatorial Optimization Problems at High Speed



Examples of application of SBM to solve large-scale combinatorial optimization problems at high speed

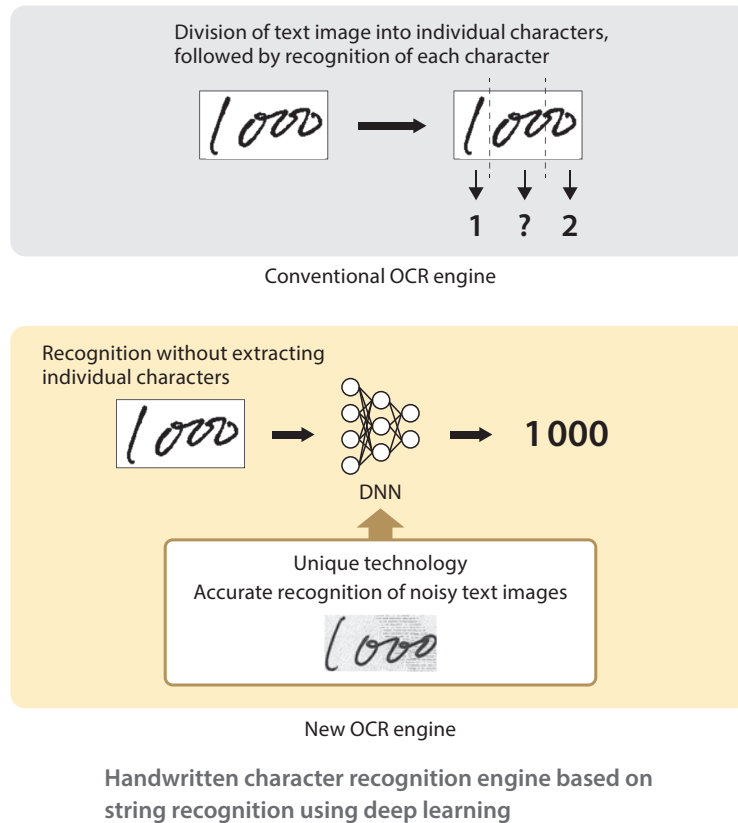
To solve social issues such as logistics route optimization, financial portfolio optimization, and molecular design for drug discovery, it is necessary to find the best solution from a huge number of combination patterns. Such combinatorial optimization problems are difficult to solve with conventional methods because of the huge amount of computation required. Therefore, a new method that scales well and runs fast has been much awaited.

Under these circumstances, Toshiba Digital Solutions Corporation has developed a simulated bifurcation machine (SBM) incorporating a newly invented algorithm capable of obtaining good approximate solutions to large-scale combinatorial optimization problems at high speed without the need for special hardware. We have released the SBM on AWS Marketplace operated by Amazon Web Services.

We have commenced field trials of the SBM aimed at solving social issues in various fields in collaboration with partner companies, universities, research institutes, etc. in the form of joint research and joint development.

2. Digital Solutions

2.7 New OCR Engine Capable of Recognizing Handwritten Text with High Accuracy



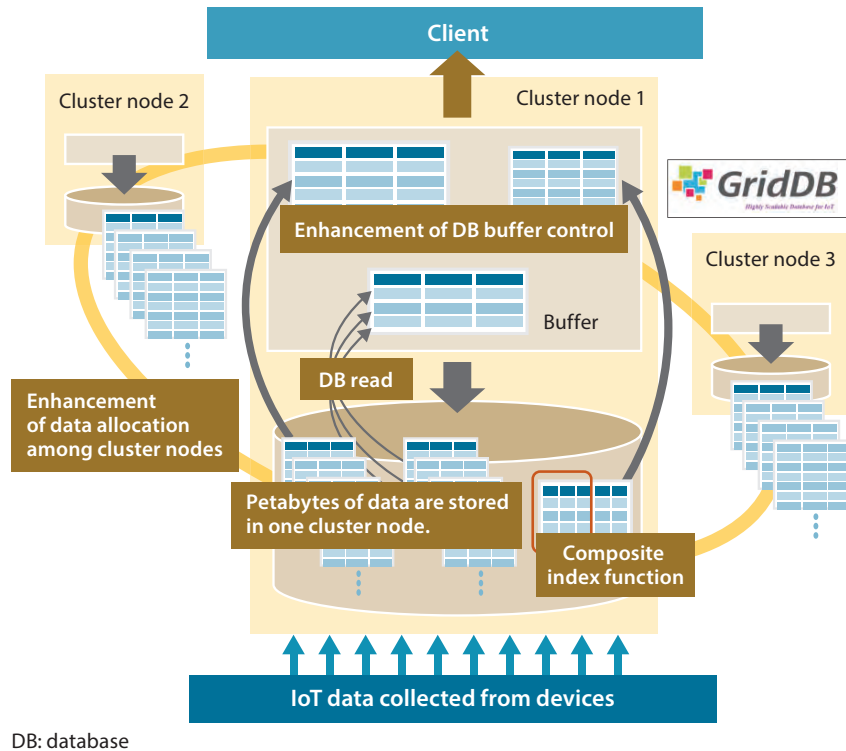
Toshiba Digital Solutions Corporation has developed a new optical character recognition (OCR) engine using deep-learning technology, which provides a considerable improvement in the accuracy of handwritten text recognition. This OCR engine recognizes text images without dividing them into individual characters, improving the recognition of connected characters that were previously extremely difficult to recognize. In addition, knowledge processing enhances the accuracy of address and name recognition, which is required in various fields.

We have also developed an adversarial training algorithm to train a deep neural network (DNN) using regularization, achieving more consistent performance for the recognition of noisy text images such as images of text written on patterned or stained paper.

We have already applied the new OCR engine to our cloud OCR service and will incorporate it into robotic process automation (RPA) and other solutions.

2. Digital Solutions

2.8 Technologies for Management of Petabytes of IoT Data for GridDB



Technologies for GridDB scale-out database to manage petabytes of IoT data with small clusters

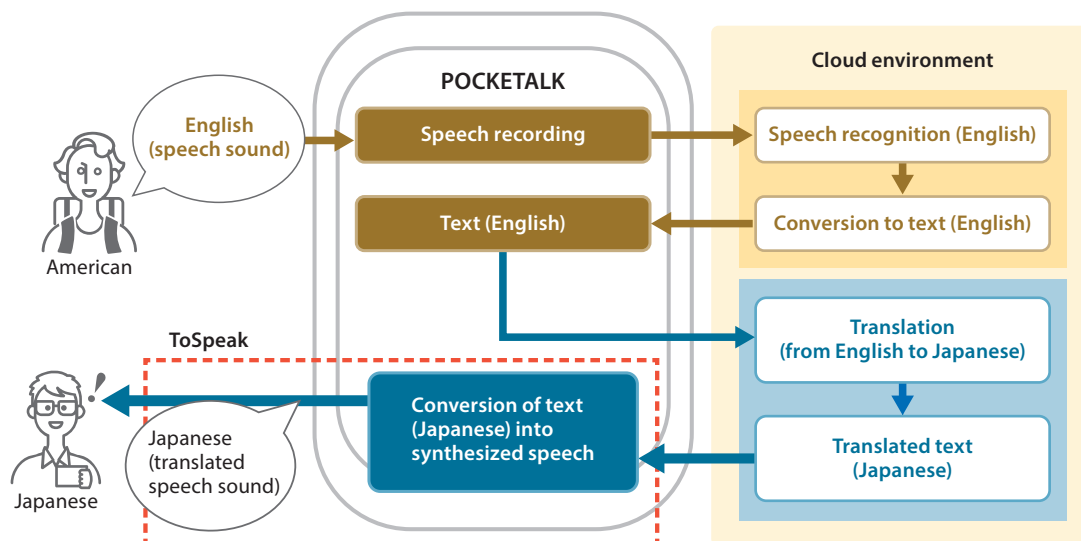
Toshiba Digital Solutions Corporation provides the GridDB scale-out database to enable users to handle growing volumes of frequently collected IoT data. However, the amount of data stored in IoT systems increases exponentially over time while the number of IoT devices also increases during long-term system operation. Since it is costly to configure a database with a large cluster size, IoT systems with a small cluster size are desirable to handle such data. It is therefore necessary to increase the upper limit of the database size that can be managed in a single cluster node.

To meet this requirement, we have optimized the internal data management structure of GridDB by reducing the amount of resources required. To improve system performance for large-scale data, we have also developed technologies for the enhancement of database buffer control, data distribution to cluster nodes, and composite and other data indexes.

The enhanced data management enables both petabyte-class data management and millisecond-order data processing with a small cluster size. The newly developed technologies are incorporated into GridDB SE/AE 4.3.

2. Digital Solutions

2.9 Portable Speech Translator Utilizing ToSpeak RECAIUS Speech Synthesis Middleware



Flow of Japanese-English speech-to-speech translation using mobile terminal equipped with ToSpeak RECAIUS speech synthesis middleware

The speech synthesis middleware provided by Toshiba Digital Solutions Corporation is capable of producing smooth, natural-sounding, and high-quality speech. In addition, it operates with a small memory footprint and low computational costs, making it ideal for embedded systems. Therefore, our speech synthesis middleware is widely used for various services, including telematics for Japanese car navigation systems.

Sourcenext Corporation has now adopted ToSpeak, our RECAIUS speech synthesis middleware, for the POCKETALK series of portable speech translators to realize speech synthesis for Japanese and American English. ToSpeak delivers various translated sentences in smooth and natural speech. Furthermore, it can operate easily on the existing general-purpose processor and memory in the portable speech translator without connecting to a network.

Accompanying the increasing performance of terminal devices, opportunities for the use of ToSpeak in creating highly responsive speech interfaces for user devices are expected to increase dramatically.

In the future, we will expand our lineup of products and further increase the number of languages supported.