Research and Development to Create Value with IoT

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Abstract

Utilization of Internet of Things (IoT) technology is advancing as part of efforts to create new value in various fields, even those with little previous relation to information and communication technology. In view of this IoT era that will drive industry and society forward, NTT has defined four necessary roles in terms of requirements and technologies, and we are collaborating with our partners to build key technologies. In this article, we introduce technical development initiatives at the NTT laboratories to further advance IoT.

Keywords: IoT, sensing, edge computing

1. Introduction

With the Internet of Things (IoT), all manner of objects in society are being connected to networks, exchanging and processing information in cyberspace (the *cloud*), and producing value by visualizing objects and occurrences in the real world or by providing feedback for control. It is much anticipated that the IoT will facilitate the creation of new industries in various fields and will be a means of resolving issues faced by society as its use continues to spread.

At the NTT laboratories, we believe that a new era has arrived, in which IoT is used to visualize, optimize, and control physical objects and movement in society, and in this third-generation *driving* era, the role of information and communication networks is very different from what it was earlier. Consequently, we are conducting research and development (R&D) to meet the different requirements and develop new usage domains [1].

A study by the Ministry of Internal Affairs and Communications (MIC) of Japan [2] broadly categorized the use of IoT, based on collected data, into uses that increase the value of products by providing remote control, operation, or maintenance of robots and machinery, and uses that improve processes in companies and other organizations through visualization and optimization of business. An analysis revealed that as of 2015, IoT had been introduced into 20% of domestic products and services in a wide range of fields including agriculture, energy, manufacturing, distribution, services, and data communications, and this is expected to rise to 40% by 2020.

2. Topics for further development and initiatives in the NTT Group

However, the same study also reported many opinions indicating that scenarios for using products were not clear or that the effectiveness was questionable. Thus, to further develop IoT and expand the base of users in the future, it will be important to have environments and methods for creating value and realizing benefits, with low risk in terms of cost effectiveness, and allowing projects to start small and be verified easily. Thus, solutions to accelerate the spread of IoT must both create value with IoT, and provide methods for building IoT systems.

The NTT Group is working to create value with IoT by collaborating with partners from the earliest stages and building IoT technologies that realize value. For example, in manufacturing we are working with FANUC Corporation to develop an open platform called the FIELD system*. This system uses edge computing technology to collect and analyze the state of operations in a factory in real time, to add

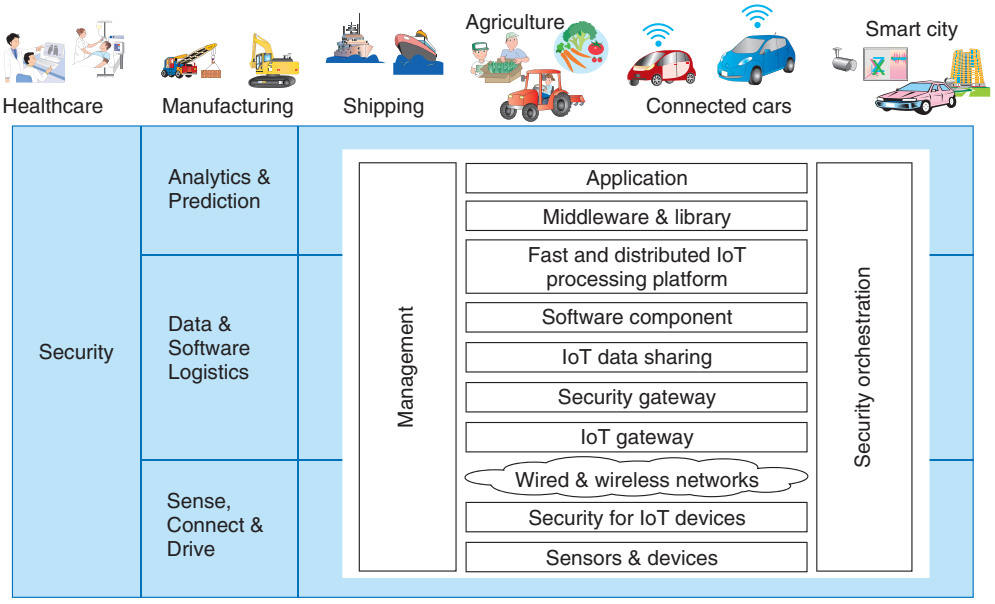

Fig. 1. Functional architecture.

efficiency and intelligence to manufacturing. By enabling applications to be downloaded to the edges, we are also working to realize *evolving factories*. This service has been offered within Japan since October 2017 [3].

To promote the use of IoT in the field of shipping, we are working with the NYK Group to develop technologies for advanced management of maintenance that take safety and the environment into consideration. This has included advanced vessel operations and fault prediction for machinery [4].

We have investigated methods for building IoT systems and have created a functional architecture for technology to meet various IoT requirements. This architecture is being used as a reference for R&D. The main functions as they relate to the real world are shown in **Fig. 1**.

The main functional elements of this architecture are sensors & devices, with functionality to digitize information from sensors and connect them to networks; IoT gateway, with functionality to convert to/from Internet protocols and connect to cyberspace; security gateway, which monitors the system in terms of communication flow and traffic behavior; IoT data sharing, which enables data to be exchanged among applications and devices with different specifications and protocols; software component, which optimizes data processing locations and software run-time environments; and middleware & library, which provides generic functionality to applications. A wide range of applications and services are expected with IoT, and not all of them will need to use all of these technical elements. The required functionalities can be combined and used with other technologies that may be on the market to suit particular applications.

The NTT laboratories are building these functions on a base of open-source and other general-purpose software to create systems that meet differing requirements in each field. We are ensuring that elements are highly generalized and meet common requirements to create a set of functional modules that can be reused. We continue to collaborate with partners in a wide range of fields to quickly realize new value with IoT, analyze and build universal functionality, and build environments in which these functions can be shared.

3. Directions for new technology and new value

We are developing technologies for each of the four roles and technologies needed to implement IoT, which are shown in **Fig. 2**. They are Sense, Connect & Drive, which digitizes data from *things* and is the interface between real society and cyberspace; Data

* FIELD (FANUC Intelligent Edge Link and Drive) system is an IoT system for manufacturers jointly developed by Cisco Systems, Rockwell Automation, Preferred Networks, and the NTT Group under a concept defined by FANUC.

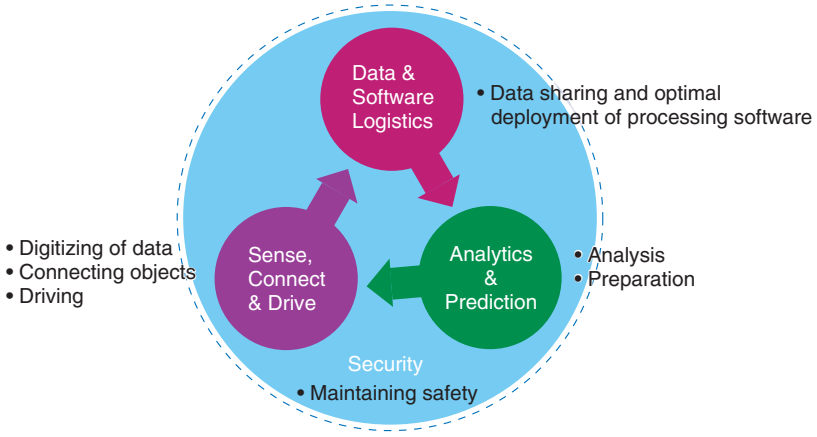

Fig. 2. Four roles and technologies in IoT.

& Software Logistics, which uses data and software and places them in the appropriate locations; Analytics & Prediction, which creates value from the data; and Security, which enables processes in society to be driven safely and securely using IoT.

3.1 Key to Sense, Connect & Drive: simple operation

Users are often quite conscious of the cost of building and operating IoT systems, so such systems need to be easy to build, maintain, and operate. It is important that sensors used to collect data can do so with simple and easy procedures. The NTT Group is conducting R&D on "hitoe" to achieve biological data sensors that can collect data simply by having the user wear a garment, and is developing scenarios for using it.

A recent example is a collaboration with Toray Industries, Inc. and Fujita Health University to visualize the state of patient rehabilitation. The data collected will be used to provide higher quality rehabilitation in hospitals and other facilities in hopes of resolving important issues in an aging society. This effort is introduced in the article, "Application for Rehabilitation Medicine Using Wearable Textile 'hitoe,'" in the Feature Articles in this issue [5].

As the use of IoT expands, expectations are also increasing to use it in locations where networks that provide connectivity to cyberspace have not previously been available. For example, the NTT laboratories are conducting R&D on communication with devices that can inspect underground infrastructure to monitor deteriorating water pipes [6]. The goal in this example is to achieve highly reliable wireless communication from an underground water-pipe valve box, where radio propagation losses are 50 dB or more. Signal processing at the above-ground base station is used, and low-power consumption for maintenance-free operation over several years is needed. This effort is introduced in the article, "Wireless Relay Technologies for Monitoring Underground Infrastructures," [7] in this issue.

3.2 Keys to Data & Software Logistics: shared data and structures, local data processing

There is much anticipation for new value created using big data with IoT, but according to an MIC study, industry and government perceive that there are issues with big-data utilization such as the cost of data collection and management and unclear cost-effectiveness of data utilization [2]. Most IoT initiatives are currently advancing separately, but to expand IoT more broadly in the future, standardization for data sharing will become more important, including standardization of data and common frameworks for handling it.

The NTT laboratories are conducting R&D and standardization work on oneM2M as a potential international standard for open data and use of data across industries. Specifications for oneM2M were created as a platform, with a set of common functions used in IoT systems.

Standards for interconnectivity with other existing standards are also being created. Systems built with the oneM2M architecture will be able to access collected data using the same application programming interfaces (APIs), and different applications and users will be able to use the same data more easily.

Applications in different fields can also access the data using the same APIs, making it easier to link with and introduce knowledge from other fields, which is important for the expansion of IoT.

The NTT laboratories are participating in R&D and standardization for oneM2M and driving the creation of standard specifications and testing, toward completion of the specifications so they will become widespread quickly [8].

Edge computing technology, which processes data locally, is also promising as a way to create new value with IoT. Compared with earlier information processing, mainly at either user terminals or in the cloud, edge computing is a technology that aims to create new effects by placing data resources and performing processing at points that are physically distributed between them.

The NTT laboratories began R&D in this area early and are testing ways to use this idea in various fields. One such joint research initiative we have with the Japan Agency for Marine-Earth Science and Technology (JAMSTEC) is a hierarchical weather simulation system that uses a hierarchical network structure. This system is introduced in the article, "Utilization of Edge Computing and IoT Sensors in Hierarchical Weather Forecasting System," [9] in this issue.

The continued development and expanding use of IoT means that in addition to many simple IoT devices, high-performance devices such as high-resolution cameras, with accompanying large volumes of data, are beginning to appear. To provide networks that support the use of such sophisticated and high-performance IoT devices, the NTT laboratories are conducting R&D on a data stream assist technology with a set of distributable functions that can achieve transmission for various data flow scenarios. This effort is introduced in the article, "Data Stream Assist Technology Supporting IoT Services," [10] in this issue.

3.3 Keys to Analytics, Prediction, Security: scalability and ease of use

The potential to create new value using big data analysis and artificial intelligence technologies is promising, but specialized knowledge and optimized algorithms become more necessary as the amount of data handled increases. Security will also need to be strengthened in order to deal with larger and more sophisticated attacks than ever before as IoT development advances. To expand IoT broadly and make it available to everyone as a social infrastructure, it will be important to build environments in which such specialized and complex processing can be used easily and efficiently.

4. Future prospects

Going forward, we will continue to conduct advanced R&D and to collaborate with partners in various fields to create new value, further develop IoT, and expand its use.

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