IoT Platform for Comprehensive Coordination of IoT Systems

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In the era of the Internet of Things (IoT), Fujitsu has been offering the FUJITSU Cloud Service IoT Platform (hereafter, the IoT Platform) since August 2015. It is capable of accumulating and leveraging all kinds of data. The latest improvement to the platform has made the development of IoT systems very simple, with a focus on easy coordination of the IoT Platform with user applications for more effective data utilization (for analysis, visualization, and so on). The result is effortless coordination that covers the entire IoT system. We have also improved service accessibility to overcome area-dependent distribution, with a view to international marketing. As a result, we have achieved more efficient development of IoT applications, and the service can now be provided in a way that is free from regional constraints. This paper presents the FY2016 development/enhancement plan for the IoT Platform, describing various advantages gained through it. It also discusses the platform's role in realizing IoT-system-wide coordination. Finally, the paper concludes with observations on future enhancements so that the IoT Platform continues to be an ideal platform that is compatible with a diverse range of IoT systems.

1. Introduction

As technologies in areas such as sensor devices, networks, and clouds keep on evolving, we are now in the age of the Internet of Things (IoT), in which information about humans, things, and the environment is digitized and connected to networks. Initiatives that utilize such information to contribute to innovations for corporate activities and social life by visualizing things that consumers, companies, and societies want or need to achieve are gaining momentum.[1)]

In response to this situation, Fujitsu began offering in August 2015 the FUJITSU Cloud Service IoT Platform (hereafter, the IoT Platform), which consists of platform services for the accumulation and utilization of all kinds of data.[2)] The IoT Platform is offered as an IoT-dedicated Platform as a Service (PaaS) on the FUJITSU Digital Business Platform MetaArc (hereafter, MetaArc)[3)] for business and social activities, and it is positioned as a core component for realizing the fusion of Systems of Record (SoR)[note 1)] and Systems of Engagement (SoE)[note 2)] aimed for by MetaArc.

This paper first describes the FY2016 enhancement plan for the IoT Platform. Next, it covers the introduction effects, and lastly, introduces future developments.

2. Current status of IoT Platform and functional enhancement plan

Initially, the following functions were developed and provided for the IoT Platform to meet basic functional requirements as a platform for the accumulation and utilization of data.[4)]

1) Application programming interface (API) for data accumulation and utilization
2) Data accumulation and utilization through schema-less database optimized for the collection of information from a variety of devices
3) Access control of respective resources in their data storage locations

note 1) A conventional information system designed mainly to record facts. It is based on a data-centric approach that focuses primarily on accuracy.

note 2) A system designed to strengthen business relationships among participating people. It is based on a user-centric approach that focuses primarily on immediacy.

4) Dynamic Resource Controller (DRC) for achieving optimal dynamic allocation of data processing loads in large-scale environments

With these functions, it became easy and quick to accumulate and utilize data in IoT systems.

However, to make the most of IoT systems, all the following elements must be organically linked into a coordinated whole: the devices that are the data sources, the IoT gateways (hereafter, IoT-GW) that send their data to the cloud, the IoT platform that receives the data in the cloud, and further, the analysis applications used to analyze the actions of people from the received data to achieve further work efficiency. Moreover, to this end, applications must be developed according to the specifications of the IoT Platform. This raises solution development hurdles and as a result, the expectation is that the IoT Platform will not be able to fully demonstrate its true value as a broadly used platform. To remedy this, the affinity of the IoT Platform in terms of collaboration with other systems and services and ease of development using it must be taken into consideration. Put the other way around, the higher the affinity and ease, the greater the value of the IoT Platform within the IoT system, and the better that platform is for broad use. To this end, in FY2016, we will focus on application development support in the cloud for system-wide coordination of the IoT System, and overseas deployment, with a view toward service expansion, discussed below.

- Cloud Foundry (CF) coordination

CF[5] is the name of open source software that provides an application execution environment service as a PaaS service running on FUJITSU Cloud Service K5 (hereafter, K5), which is an Infrastructure as a Service (IaaS) on MetaArc.[6]

The main feature of CF is that it allows flexible and quick application development and provision of services by providing an environment in which applications developed in a variety of languages can be instantly deployed and executed. Here, the term "services" refers to coordination with other PaaS or Software as a Service (SaaS), and SoR already owned by customers. As mentioned above, the IoT Platform is also a PaaS service on MetaArc, and therefore carrying out cooperative verification with CF is important for building SoE applications (**Figure 1**).

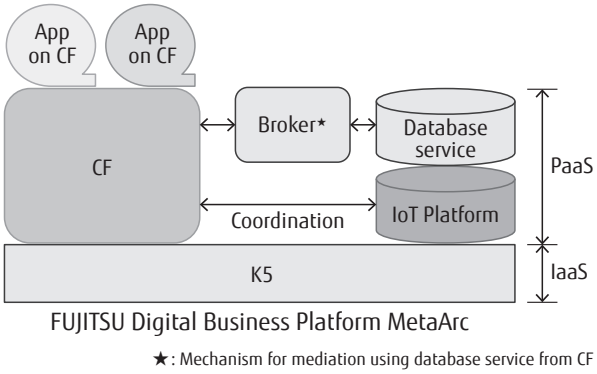

Figure 1
CF coordination.

- API Management Service (hereafter, API Management) coordination

API Management is a service that provides a gateway for interconnection by absorbing differences between Web APIs, and similarly to CF, it is provided as a PaaS service on K5.[6]

API Management includes the following features.

1) Coordination with the APIs of various Web applications, mobile applications, and conventional SoR customers
2) Absorption of the differences in API specifications of each system, such as authentication, security, transaction, and payload differences
3) Rapid development of Web APIs in SoE construction

The IoT Platform also includes open APIs for data accumulation and utilization. For the coordination of existing SoR and SoE such as IoT systems, it is necessary to absorb the differences between the individual APIs of each system. Making API Management support the APIs of the IoT Platform eliminates the need for additional development for coordination purposes and allows rapid coordination (**Figure 2**).

- API extension of IoT Platform

Application development for comprehensive coordination of IoT systems aims to improve usability by coordinating the various PaaS mentioned above and the IoT Platform. At that time, the IoT Platform itself will not be widely used unless it is a system that can easily be used from applications.

From the beginning, the IoT Platform has provided APIs to users for the data accumulation and utilization part. However, regarding the creation of data storage

locations and settings for data access control, event processing, and so on, no APIs are provided and only settings on a screen on a service portal provided on the Web are supported. Thus, control of the extensions of the data to be collected and access security is not possible from applications, and challenges in terms of usability remain. Accordingly, the creation of APIs that take care of such settings is important for the realization of a system that is easy to use from applications (**Figure 3**).

- Overseas deployment of IoT Platform

The IoT Platform having been built initially only on K5 in Japan, so its use basically remained within Japan. As the IoT Platform is premised on connections from the Internet, use of the IoT Platform on K5 in Japan from overseas is possible. However, as the area covered by the system grows wider, issues such as network bandwidth and delays will arise, which may hinder use in some locations. Further, there are also cases when use is restricted by local regulations (for example, in Europe, it is prohibited to send and store locally collected data outside Europe). Therefore, actual use of the IoT Platform overseas requires the deployment of IoT platforms on IaaS in each country.

In this regard, we plan to first deploy K5 in the UK, and to gradually deploy the IoT Platform to various overseas locations from the UK in coordination with the rollout of K5.

- Introduction effects

When developing applications for comprehensive coordination of IoT systems, the above-mentioned functional enhancements make the incorporated IoT Platform quite easy to use. In addition, it is now easy to import SoR data into SoE using the IoT Platform thanks to API Management, which absorbs API differences between systems.

For example, an application that extracts sensor data stored on the IoT Platform and visualizes them in graph form has been built on CF (**Figure 4**). Normally, it would have been necessary to build a Web application from the ground up, but by using the CF and IoT Platform coordination mechanism, such an application

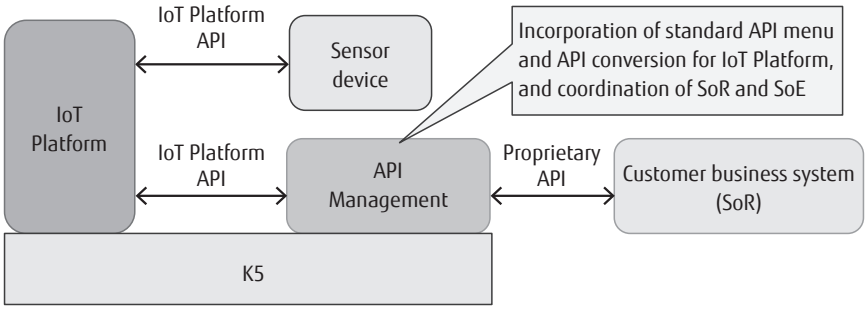

Figure 2
API Management coordination.

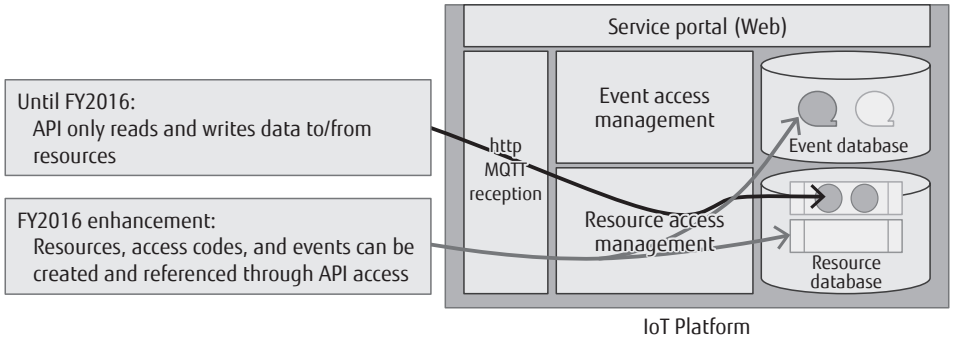

Figure 3
IoT Platform API extension.

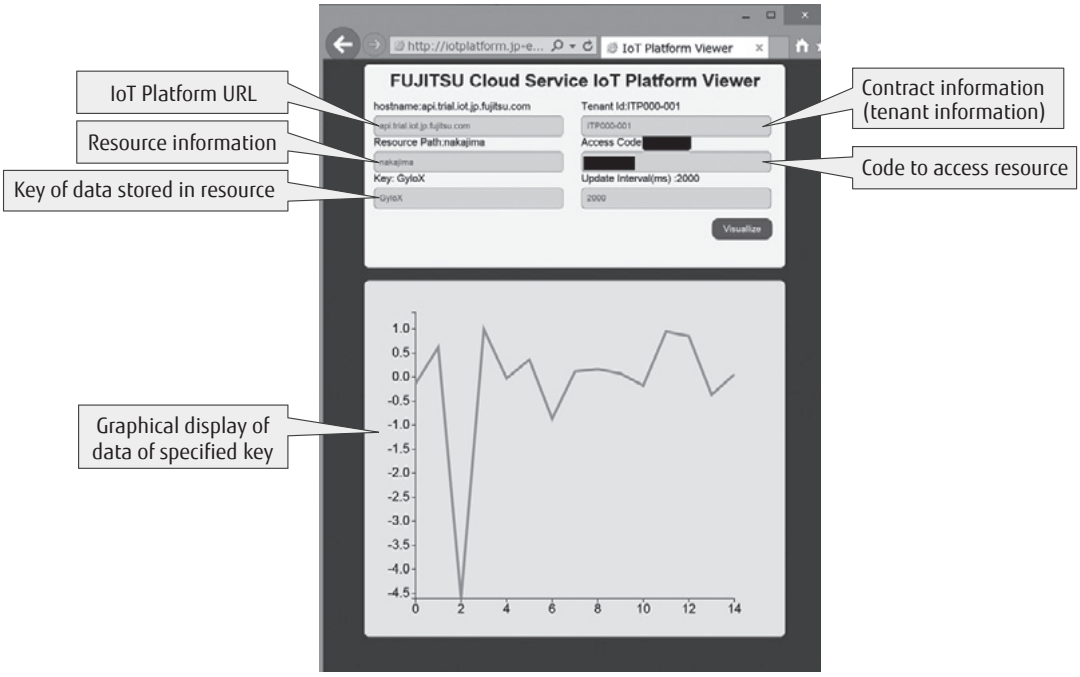

Figure 4
Screen shot of CF coordination.

can now be built by a single person in a little over one week, including time of learning CF.

3. Future prospect

The IoT Platform began as a new platform for the IoT era that accumulates and utilizes data from various devices. Currently, we are aiming to strengthen coordination with applications for the coordination of IoT systems in order to provide an optimal platform for customers wishing to build IoT systems.

Going forward, we will further improve usability as a system and strengthen coordination across wide areas including overseas.

- Promotion of further overseas deployment

The overseas deployment of the IoT Platform is basically being planned in coordination with the overseas deployment of K5. However, negotiations regarding areas where K5 has not been deployed and areas where K5 deployment is late will be carried out flexibly, with a view to expanding the IoT Platform separately from the overseas deployment of K5.

- Expansion of distributed control using DRC in wide-area, large-scale IoT systems

The IoT Platform provides a DRC function for optimal dynamic allocation of data processing loads in large-scale environments. However, only an optimal dynamic allocation function that works between cloud applications that use a single IoT Platform and GW is offered. As previously mentioned, if multiple IoT Platforms are being offered in various areas including overseas locations, cases that involve the use of multiple IoT Platforms across a wide area are expected to arise.

In such case, it will not be possible to comprehensively judge and coordinate the statuses of multiple IoT platforms with the current DRC function. Therefore, optimal dynamic allocation must be carried out individually in each region and comprehensive optimization across all areas is not possible. Thus, assuming the use of IoT Platforms across multiple areas, it is necessary to implement comprehensive coordination premised on the linking of multiple IoT Platforms, and to expand the DRC functionality to allow comprehensive optimization of the whole system.

Further, the DRC support not only distributed allocation of processing, but also referencing of the entire body of raw data in situations where it is impossible in practical terms to upload large amounts of raw

data to the cloud. Therefore, enabling the distributed allocation of the data itself, and also the search and accumulation of data allocated in a distributed manner is necessary in order to realize a wide-area large-scale IoT system (**Figure 5**). In this figure, we have "Processing 1" and "Processing 2" as processing to convert and analyze the data collected from the customer's applications. The DRC function allows changing the location where the processing is performed between the GW and the cloud according to the customer's application load. By contrast, in this extension of the DRC function, it is assumed that even if the change destination GW belongs to another IoT Platform, it will be supported by creating an extension. Moreover, while all the sensor data is conventionally assumed to be aggregated on a central IoT Platform, here the assumption is that, through extension of the DRC function, the sensor data will be deployed in a distributed manner across the GWs and IoT Platforms of various region and provided via a central IoT Platform as needed from the customer's applications.

- IoT-GW management and authentication mechanism

The IoT Platform carries out the accumulation of various types of data and their utilization from applications via APIs in the cloud. Therefore, the service provision range is basically only the IoT Platform in the cloud. However, as an IoT system, the transmission of data from a large number of devices and sensors to the IoT Platform via IoT-GWs and the like is the basic assumption. Consequently, an IoT-GW management mechanism for checking the operating status of the IoT-GW that carries out mediation, and an IoT-GW authentication mechanism that allows only authorized IoT-GW access, are required for operation in practice.

Naturally, the ability to perform updates and changes for the applications or operating system running on the IoT-GWs, in addition to managing the operating status of IoT-GWs, would greatly simplify IoT system operation. This would be extremely useful, especially considering the nature of IoT systems that include a large number of IoT-GWs and devices over a broad area. Therefore, these features will be highly needed in order to enhance the value of IoT Platforms in the future.

4. Conclusion

This paper has described the enhancement plan for the FUJITSU Cloud Service IoT Platform, an IoT data utilization platform service, its effects, and future development plans. Through the described measures, Fujitsu aims to further strengthen the IoT Platform, evolving it from an IoT platform for the utilization of data, to a utilization platform for applications for comprehensive coordination of IoT systems, seamlessly collaborating with PaaS of various types.

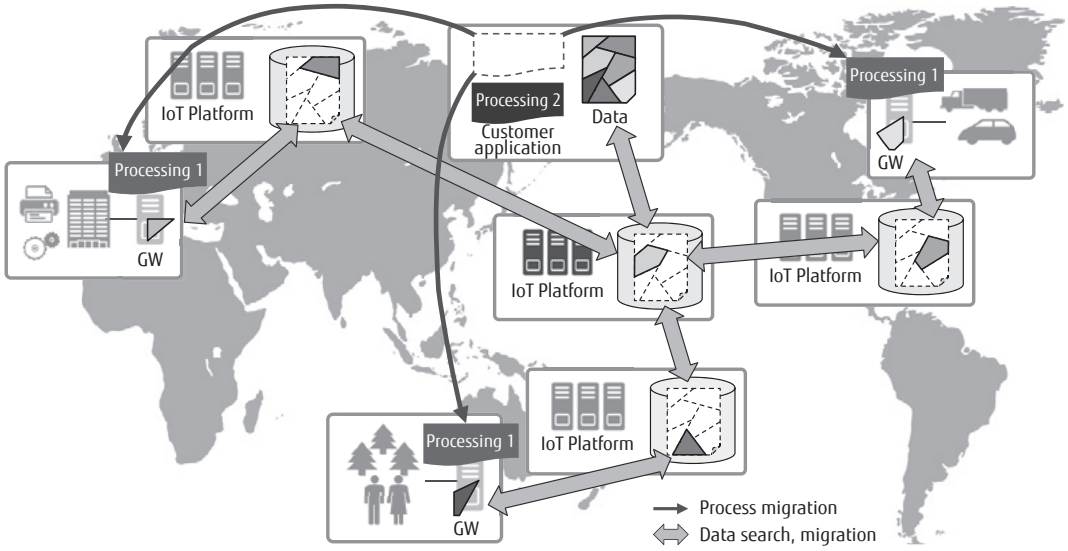

Figure 5
Enhancement plan for DRC function.

Going forward, Fujitsu will aim for the overseas deployment of the IoT Platform, the provision of wide-area and large-scale IoT systems, system-wide load optimization, and data storage optimization. At the same time, Fujitsu will actively work toward quickly supporting even wider areas and larger scales of systems as IoT grows more common, in a bid to offer our customers ever greater value.

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