Convergence Service Platform

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The environment surrounding the information and communications technology (ICT) business has been changing during the past few years against the backdrop of an increasingly complex and borderless society. Fujitsu is developing an ICT platform on its trusted cloud that collects and analyzes large amounts of sensor data from people wearing radio-frequency identification chip sensors and devices. To deliver in a timely manner an ICT environment for real-time processing of massive amounts of data, Fujitsu intends to form tie-ups with business partners as needed rather than develop the necessary platform completely on its own. From a technological aspect, Fujitsu aims to achieve high-speed processing by using new technologies such as parallel distributed processing with complex event processing and Hadoop software.

1. Introduction

From the beginning, the computer has been used to do its work of humans. In simple terms, the electronic calculator took over the work that had been done by manual calculations and the abacus, and the later development of computational software and corporate business systems made the computer an even more convenient tool. Computer progress can be divided into hardware-related advances (improved performance in central processing units [CPUs] and other devices) and software-related advances (development of applications). It is now becoming possible, moreover, to use hardware in a variety of ways due to the appearance of cloud computing and virtualization technology. Software, meanwhile, is expanding beyond its traditional role of doing the work of humans to provide direct support of our daily lives.

Fujitsu proposes a "Human-Centric Intelligent Society" to make people's lives more prosperous and pleasant. This paper introduces one means of achieving this—a "Convergence Service Platform" as an information and communications technology (ICT) platform using Fujitsu's trusted cloud environment.[1)] We first introduce examples of how ICT can be useful in people's lives and then describe the business model that Fujitsu envisions, the proposed Convergence Service Platform itself, and issues to be addressed.

2. Usefulness of ICT in daily life

How can ICT directly support our daily lives? We here take up this question in relation to new phenomena in society that have recently been attracting attention.

In the form that we envision, ICT becomes a natural, unnoticeable part of day-to-day life, helping to make it more prosperous, pleasant, and enjoyable.

Over the last year or so, consultations with Fujitsu customers and partners have revealed an increase in social phenomena not normally thought about in the past. Some examples are

listed below:

- Creation of low-carbon cities
- Safe-and-secure environments for enriching life
- Ways of achieving eco living
- Environmentally conscious products and services
- Effective use of resources
- Visualization of human behavior (behavior prediction and behavior support from behavior analysis)
- Assessing an object's state and problem prediction

These phenomena are outside the business-system domain in which Fujitsu has traditionally been involved—they directly make customers' products and services better.

Fujitsu has been involved in back office computing systems but now is becoming involved in front systems, which support our daily lives. They represent the way in which the business activities in individual industries are giving birth to multiple tie-ups between industries as the structure of society becomes increasingly complex, and they are consequently leading to new business opportunities. In relation to the above, two examples of sensing technologies are given below.

1) Assessing and analyzing the states of objects

The states of people and objects can be assessed by deploying appropriate technologies and enhancing the social infrastructure. Furthermore, by connecting objects like automobiles and electrical appliances to a data center via a sensor network and by collecting and analyzing state-related data output from them, trends and the intentions of the people using such objects can be understood. This capability promotes the appearance of services and products not previously considered.

2) Determining energy savings and environmental contributions

The depletion of fossil fuels and other resources and atmospheric warming due to greenhouse gasses are global problems, and there is a growing need in Japan as well as other countries for ways to effectively use resources for the sake of the environment. The use of sensor technologies in our daily lives has already begun as an energy-saving measure, for example, by detecting human movement to turn electricity ON/OFF, to control escalators, and to adjust the temperature in cooling and heating systems.

In the discussion above, we touched upon sensor technologies, but in more general terms, we consider that ICT can blend into our daily lives to provide services that can help all of us lead more prosperous and pleasant lives.

3. Business model

How will Fujitsu contribute to people's lives and the social structure undergoing the paradigm shift described above? What kind of ICT should Fujitsu provide to its customers, both companies and individuals? One way is to contribute through the effective use of data, but it must be kept in mind that data can come in various forms. In the case of a business system, for example, there are administrative data, sales data, marketing data, and so on. In the case of social networking and blogging sites on the Internet, there are all sorts of data related to human concerns.

If such data can be analyzed to determine underlying trends as well as inherent principles and rules, it should be possible to infer people's attitudes and preferences and thus to predict and support human behavior. Moreover, if the states of objects can be understood, it should be possible to predict problems in those objects and provide them with information (e.g., software upgrades, information displays on terminals).

Against this background, Fujitsu has undertaken the development of a cloud-based ICT platform that will enable users to analyze large quantities of information (sensor data) collected from a variety of devices, as illustrated in **Figure 1**. This "Convergence Service

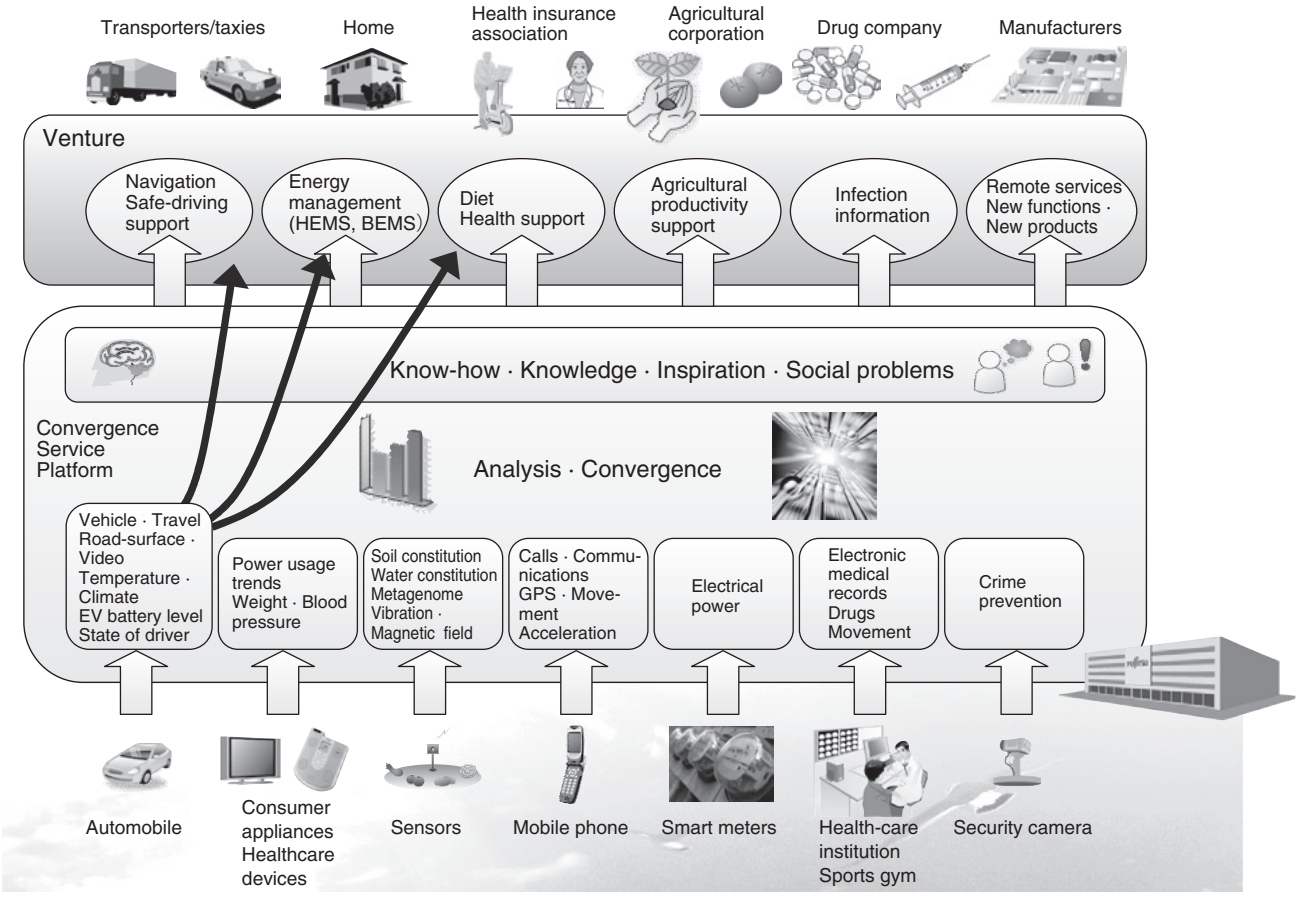

Figure 1
Concept of Convergence Service Platform.

Platform" will reduce (analyze) a customer's data and add value to it to make that customer's products and services even better. It will also provide information to third parties to promote the creation of new business domains.

Fujitsu has been conducting three verification trials in relation to its proposed Convergence Service Platform.

1) In-house personal health record (PHR) verification trial

Today's boom in health services and concerns about healthcare including rising costs is occurring not only in Japan but also throughout the world. Fujitsu has been using PHR data to investigate the rise in healthcare costs and develop solutions by focusing on the difference in medical expenses before and after a patient becomes sick. As a result, Fujitsu has come to realize that the most important factor in keeping healthcare expenses in check is the prevention of disorders before their onset. Armed with this knowledge, Fujitsu has been collecting and analyzing data from about 2600 employees using healthcare devices and mobile phones since the latter half of fiscal year 2010 to improve healthcare guidance and encourage lifestyle changes. The overall objective of this trial is to reduce the cases of metabolic syndrome and thereby lower healthcare expenses. This analysis of PHR data from diverse perspectives is starting to generate analytical results by gender, region, etc.[2)]

2) Taxi-probing verification trial

Originating from a previous verification trial consigned by the Ministry of Economy, Trade and Industry (METI), the idea of this

trial is to collect sensor data (location, occupancy status, etc.) from taxis operating throughout the country and to analyze the data collected for use in predicting traffic jams. At present, data is being collected from only taxis, but this trial will soon be expanded to public buses, commercial trucks, and to even personal passenger vehicles so that not only traffic jams but also the ways in which automobiles and people move about can be predicted. The location information corresponds to the movement of people and objects, and the knowledge obtained from that information can be used to improve customer services.

Fujitsu is not simply concerned with vehicle movement patterns—it is also studying the creation of novel services by determining the correlation of location information with other types of sensor data.[3)]

3) Energy management verification trial

Catch phrases like "smart cities" and "smart communities" have already come into common usage, and the realization of an environmentally conscious low-carbon society is now being discussed on national and global scales. Fujitsu is studying the creation of an energy-saving, prosperous society as part of its business dealings with existing power companies and with Fujitsu customers in the manufacturing and distribution industries. Achieving low-energy systems is an important issue common to all industries, and their achievement must be pursued in diverse ways from many angles. The visualization of energy, the elimination of waste, and the support of behavior promoting an eco-friendly society require a comprehensive approach that takes into account environmental factors, preferences, culture, etc. on individual, home, community, municipality, and national levels. They can be achieved by creating business models and applying advanced knowledge, experience, and ICT. Fujitsu is participating in these efforts both in Japan and abroad. A platform for supporting these endeavors is the Convergence Service Platform.

4. Functions and configuration of Convergence Service Platform

Here, a platform that provides comprehensive support of various types of data usage is called a "Convergence Service Platform," and the users of this platform are called "tenants."

4.1 Functions

The following functions are required to enable many tenants (companies) to analyze large amounts of data and make effective use of that data in real time.

1) Collection and detection of data and phenomena in real time
2) Storing of large amounts of data
3) Processing of large amounts of data within a certain time interval
4) Visualization, analysis, and evaluation of processing results
5) Application of processing results to a variety of services
6) Simple and flexible design and management of data-processing schemes
7) System preparation and management in accordance with tenant requirements

4.2 Configuration

The overall configuration of a platform for achieving the above functions is shown in **Figure 2**. This platform consists of 12 subsystems running on Fujitsu's Infrastructure as a Service (IaaS).

1) Sensor front end

When people act, a variety of things used in conjunction with those acts, and resources, like money, which such actions or things make necessary, simultaneously move. The states or conditions of these "entities" can be collected from all sorts of sensors and terminals and from existing systems. The information collected in this way can have a variety of forms, so using it in a cross-disciplinary manner requires that the

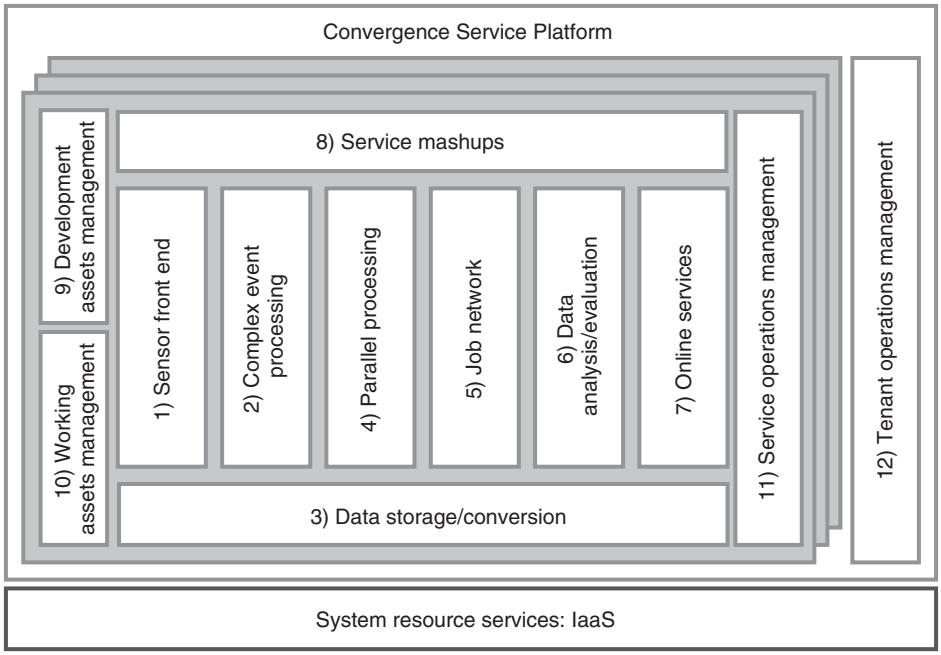

Figure 2
Convergence Service Platform.

forms be rearranged and supplemented in some way. The Convergence Service Platform will provide a sensor-front-end subsystem to perform these tasks.

2) Complex event processing

Data needs to be monitored as "events" so that the entering of certain states can be detected and an appropriate action can be taken. For example, the detection of congestion on a certain road on the basis of sensor data for that location and for the related movement of taxis could lead to a change in taxi pickup routes or dispatch rules. The platform will provide a subsystem for complex event processing that enables event-related patterns to be detected and connected to actions.

3) Data storing/conversion

Given that data are continually collected from sensors and systems, the amount of data that has to be processed is immense compared to that of existing business systems (several hundred TB versus several tens of PB). Furthermore, in contrast to expressing fixed forms of business data, the adding of new sensors or modifying of existing ones may necessitate the addition or modification of data items to be collected. Plus, in terms of using data, different formats may be required at different times instead of a fixed format being required at all times. A conventional relational database, while appropriate for storing and using a large amount of data conforming to the same items and table structures, is ill-suited for storing and using data as different requirements arise. In this field, and recently in the Web-services field as well, key-value stores (KVSs) (which enable an application to store its data in a schema-less way) have come to be used. Additionally, when data is used from various perspectives, data concealment and anonymity techniques become necessary. The Convergence Service Platform will provide a data storage/conversion subsystem that makes use of such technologies.

4) Parallel processing

To enable prompt processing and the use of large amounts of stored data on request, it is necessary to think in terms of parallel processing as opposed to conventional batch processing,

which involves the creation of intermediate files and the use of a serial data flow. The partitioning and parallelization of data by region, time zone, etc. has been done in the past, but know-how and time were required to design the data and processing flows. There is consequently a need for a system that can describe and execute data and processing flows as an application within a relatively simple framework. Development efforts in this regard are quite active, and Apache Hadoop, an open source product that is coming to be successfully used in a variety of fields, is attracting much attention. The Convergence Service Platform will provide a parallel processing subsystem that uses Apache Hadoop and incorporates the latest development results.

5) Job network

In addition to parallel processing, the platform will provide a job network subsystem that can combine a variety of conventional jobs and simplify the processing of large amounts of data.

6) Data analysis/evaluation

Research is progressing on algorithms for analyzing data from diverse perspectives and making predictions on the basis of the results. The Convergence Service Platform will incorporate such algorithms in an ongoing manner. There is also a need for data visualization and a level of system operability that enable the analysis results to be effectively presented to the data user. This will enable the user to acquire knowledge and develop know-how. To this end, the platform will provide a subsystem that gives the user much freedom in data analysis and evaluation by overlaying base information such as map data with the results of analysis and offering a variety of views such as three-dimensional, time-series, and cross-sectional.

7) Online services

A variety of services will be developed for end users on the basis of analysis results. End users are now accessing and using diverse services from all kinds of terminals including smartphones, Web browsers, and personal digital assistants (PDAs). In line with this trend, the Convergence Service Platform will provide a Web-based subsystem for online services.

8) Service mashups

The platform will provide a service-mashup subsystem that enables users to freely combine diverse cloud services on the Internet with on-premise systems to create new services.

9) Development assets management

Subsystems 1) – 8) above will execute applications in combination with data processing systems, and the way in which they are combined will differ in accordance with the data to be analyzed, the analysis techniques, and the analysis results as well as the requirements of the offered service. For example, if data are to be input from existing systems by file transfer and subjected to only parallel processing, then subsystems 3) and 4) would be sufficient, but, if front-end sensors are also incorporated in the service, then subsystems 1) and 2) would also be needed. In the past, the design of such a system and the building of the associated infrastructure including servers, storage, and networks would require considerable time. The Convergence Service Platform will provide a subsystem for managing development assets to simplify this process by defining subsystem configurations on the basis of data flow.

10) Working assets management

This subsystem will provide the user with views that make possible the unified operation and management of currently running applications together with associated data and the system configuration.

11) Service operations management

The platform will also provide a subsystem for managing service operations as a function to be used by the manager of each tenant to comprehensively manage end users, the services provided to them, and billing.

12) Tenant operations management

As described above, the Convergence Service Platform will enable a combination of subsystems to be defined as a system that can be configured and used separately as desired by each tenant. On top of this, such a system could be used by multiple tenants (multi-tenant function). For this reason, the Convergence Service Platform will provide this subsystem as a unified means of managing and controlling the operations of all tenants using the platform.

As described above, Fujitsu is developing a Convergence Service Platform that will be flexible enough for many customers by providing subsystems for different types of processing, enabling those subsystems to be combined into systems, and providing a multi-tenant capability for those systems.

5. Future activities and issues

In making platform services available, it is necessary to consider what kind of services should actually be provided. The ease of creating applications is also an important element in the early provision of services. With this in mind, we offer the following items as future issues to be addressed.

5.1 Flexibility

Considering the need to support diverse usage scenarios, development activities that only make use of existing knowledge and ideas will easily get bogged down. A flexible system that expands the development framework is essential, including, for example, the surveying of customer opinions and collaboration with startup companies possessing new technologies and/or unique expertise.[4)]

5.2 Development

1) Multi-tenant capability

The collection of mass amounts of information requires that the information of different customers be analyzed while consolidating that information in a secure manner.

2) Problems in OSS and ISV support

Fujitsu envisions the use of open-source-software (OSS) and independent-software-vendor (ISV) products in addition to its own products. A system supporting such diverse use of products must be created.

3) Establishment of operation and monitoring methods

The operation and monitoring of services in a cloud environment must be studied from both the technical and system viewpoints in addition to the multi-tenant considerations described above.

4) Security (protecting personal information, etc.)

Storing mission-critical information requires solid management methods, and achieving a secure cloud environment is essential. The objective must be to provide services while concealing personal information by some technical means.

5) Provision of APIs/SDKs

To facilitate the development of various types of applications capable of handling large amounts of data, full provision of application programming interfaces (APIs) and software development kits (SDKs) is important from the viewpoints of number of services and provision of diverse sites.

5.3 User agreements, intellectual property, patents

User agreements should take into account points of concern, joint studies related to permission for the secondary use of stored data, and know-how on protecting intellectual property.

Furthermore, it is sometimes difficult for the central player of a new venture to be aware of existing patent applications or the possibility of patenting newly developed systems or technologies. Various studies need

to be performed to address these possibilities. Additionally, as the information handled by data-processing systems may include personal information, discussions on the protection of private information continue in the wake of the Personal Information Protection Law enacted by the Japanese government in 2005.

5.4 Professional human resources

The breakdown and analysis of information consolidated on this platform requires not only tools but also the wisdom of experts in diverse fields and professionals who have the capability to discover heretofore unnoticed relationships between data items. Fujitsu expects the value of its Convergence Service Platform to be demonstrated in combination with business intelligence (BI) and business analytics (BA) methodologies.

6. Conclusion

This paper described Fujitsu's proposed Convergence Service Platform targeted at the creation of a "Human-Centric Intelligent Society." This platform is being earnestly developed in the spirit of "One Fujitsu" by many collaborators within the company including Fujitsu Laboratories. Fujitsu looks to expand this platform beyond Japan as a global service platform.

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