Fujitsu's Vision for Next-generation IoT Network

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The Internet of Things (IoT) will greatly change lifestyles and business processes. It will necessitate moving from networks that simply connect things to networks that generate intelligence through the linking of things in the real world with information in the digital world. This requires scaling up information and communications technology (ICT) systems to enable them to accommodate the increasing number of things being connected to networks, to deal with temporal and regional fluctuations in demand, and to adapt to the diverse requirements of new services and applications that are continually being launched. In response to these challenges, Fujitsu envisions a next-generation network of distributed computing that facilitates dynamic coordination between networking and computing. This paper describes Fujitsu's vision of the next-generation network and the new value such a network creates.

1. Introduction

We are seeing the emergence of a "hyper-connected world" that can interconnect just about anything, including people, things, processes, and social infrastructures. In this world, the massive amounts of information flowing through the network will give birth to new forms of knowledge beneficial to business and society and foster the creation of new value. The driving power behind this new world will be the next-generation Internet, the Internet of Things (IoT).

In addition to people and sources of information, the IoT will connect a multitude of things, such as household appliances, streetlights, and security cameras and even sensors inside construction machinery and automobile engines. The number of such connected things is expected to increase from 10 billion in 2013 to 50 billion by 2020. In addition, a gigantic amount of data will gush forth from these new connections. For example, a self-driving car will generate about 3.6 terabytes (TB) of data every hour. The Fujitsu Technology and Service Vision annual publication presents Fujitsu's ideas on maximizing the use of information and communications technology (ICT) by using such data to enrich the lives of everyone, stimulate the economy, and achieve an intelligent society that can provide a safe and secure environment and sustainable growth.[1)]

Such a society can be achieved by having networks collect the vast volumes of data and then analyzing the data to support personal decision-making and enhance communications. This will signal an evolution from a network of "things" to a network of "knowledge" (**Figure 1**).

This paper describes Fujitsu's approach to creating new value through such an advanced network.

2. Evolution of ICT

ICT originated in a computer-centric era beginning with mainframes at the dawn of the computer age and progressed into a network-centric era typified by the client-server model (**Figure 2**). Today, with practically everyone in possession of a smart device and with knowledge readily available in the cloud, ICT is continuing to evolve as it moves into a human-centric era. This evolution can be understood in terms of back-end and front-end systems and the network that connects them.

Before the spread of the Internet, mainframe computers serving as a business back-end were connected to front-end workstations using point-to-point leased lines. Back-end systems have since evolved from servers to a cloud, and even to a mega cloud. Front-end systems have likewise evolved from personal computers to mobile phones and more recently to a

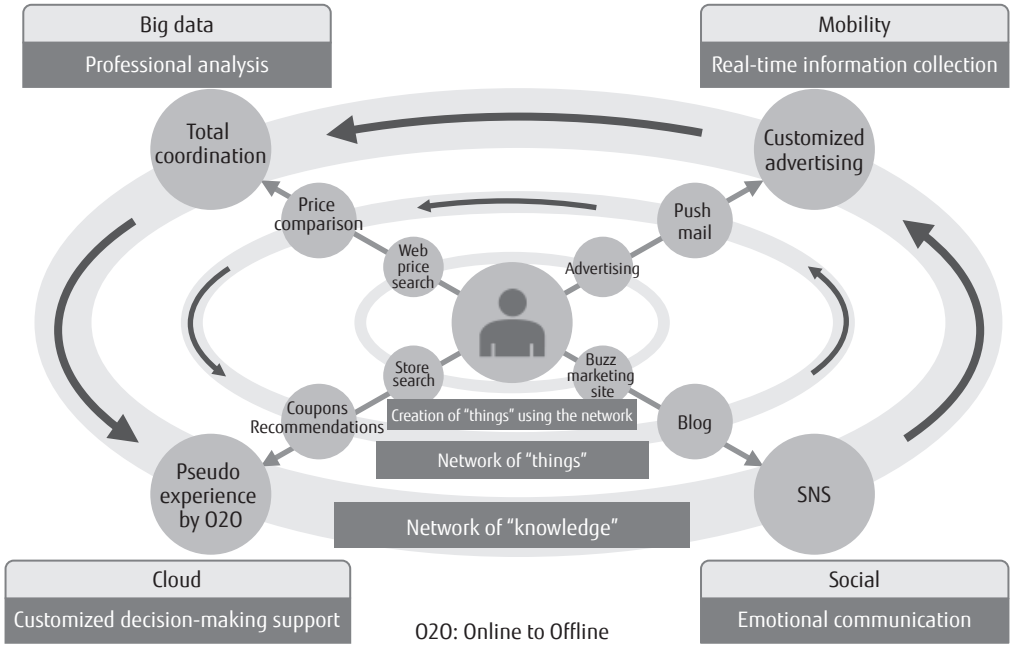


Figure 1
Creation of new value through the network.

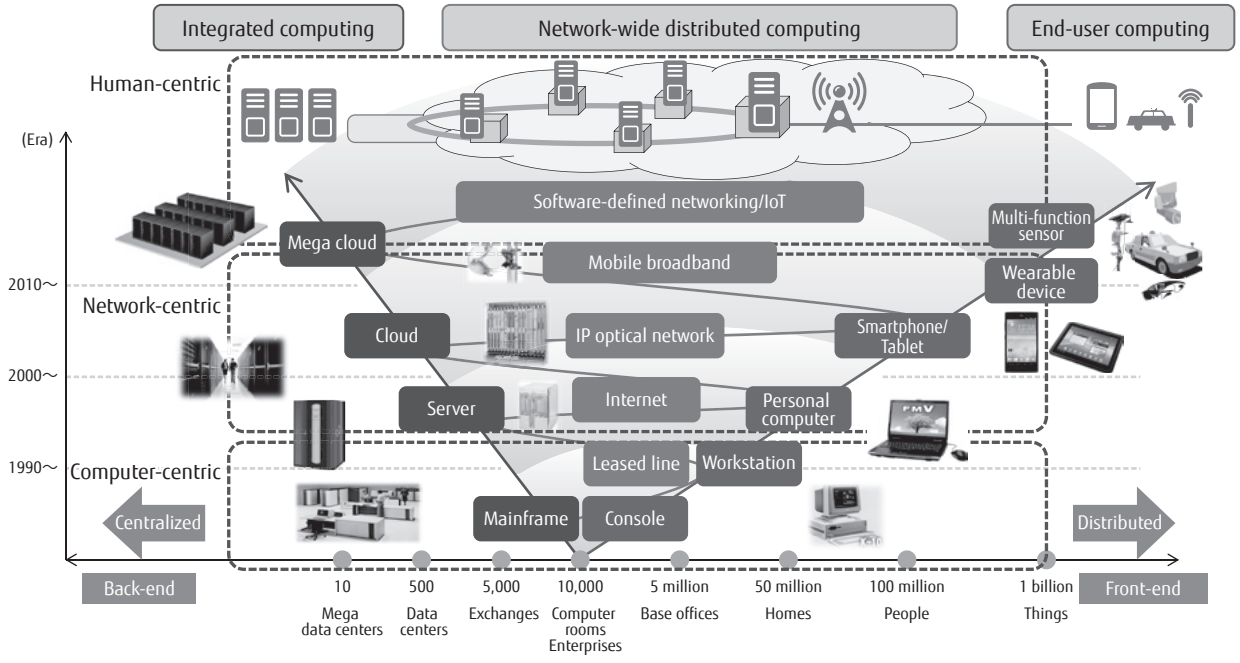


Figure 2
Evolution of ICT.

wide array of smartphones and tablets. Looking to the future, a variety of social infrastructures will be connected to the network via multi-function sensors and wearable devices.

It can be said that the ICT system paradigm evolved as networking and computing underwent

successive stages of centralization and distribution in a correlated manner.

The application of network virtualization technology to dynamically changing ICT resources is set to become mainstream. This will mark the coming of a genuine ICT cloud era in which resources are allocated in a flexible and efficient manner and devices are connected to the cloud by a virtual network.

3. Issues in developing an IoT network

The volume of data flowing in the network has increased tremendously thanks to the growth in cloud usage and the phenomenal spread of smart devices. This has resulted in data centers becoming increasingly larger and wide area networks becoming increasingly faster and larger in capacity.

The rapid progress in wireless communications technology is facilitating connectivity not only to smart devices such as smartphones and tablets but also to networks composed of non-smart devices such as sensors, thereby boosting the number of both types of devices. The data generated by networked devices are being collected and analyzed as "big data." Applications that use the information obtained from this analysis to support human decision-making and business processes are beginning to penetrate personal lifestyles and corporate activities. Traffic at data centers is predicted to increase at an annual rate of 23% from 2013 to 2018.[2)]

The connecting of people, things, diverse products and services, and social infrastructures to the network will increase their respective values while the convergence of social media and video will drive the creation of new services. However, this change in the environment surrounding ICT raises several issues.

1) Increasing scale of ICT systems

ICT systems are becoming increasingly larger in scale as virtual servers and devices supporting personal and corporate activities increase in number at an explosive rate. This growth has resulted in dynamic operational changes to system settings across data centers, making system construction and operation even more complicated. Dealing with the increasing amount of power consumed by systems is also becoming an urgent issue.

2) Fluctuation in network demand

The expanded use of mobile devices causes significant spatial and temporal fluctuation in traffic at the time of public events, natural disasters, etc. In addition, the growth of the cloud and expanded use of Web services have been accompanied by an increase in communications between back-end servers spanning multiple data centers in what is called "east-west traffic." Such conditions make it difficult to reliably predict network demand.

3) Diversification of service requirements

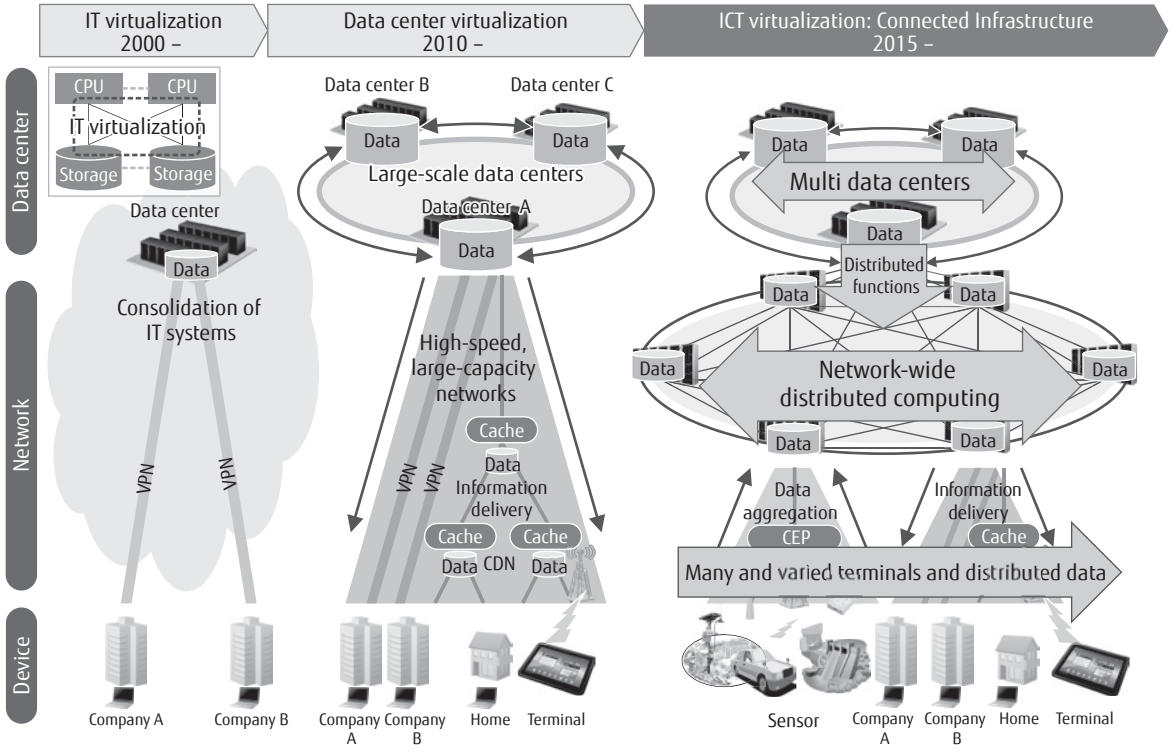
Services with diverse service requirements are springing up one after another. The network must now perform processing tailored to the requirements and data characteristics of each service. For example, large-capacity data as in streaming video must be transferred in an end-to-end manner at optimal quality, response times in financial services must be shortened, and sensor data must be collected over a wide area.

4. Next-generation network vision

Fujitsu envisions network-wide distributed computing as the next-generation network. The idea behind this vision is to dynamically provide services by organically linking multiple ICT systems that are distributed in terms of services and/or users (**Figure 3**).

The IoT era calls for highly sophisticated processing of extremely diverse device-generated data in large volumes. For example, deploying the data-processing mechanism as close as possible to the data-generation source increases device response speeds. Additionally, a mechanism can be deployed for controlling transmission timing when sending data to the cloud, and leveling the traffic through peak suppression at the network edge (terminals) can decrease network load.

In this way, distributed computing can improve ICT resource efficiency by using the right resources at the right place to process data. For example, performing statistics-based (learning-type) processing in a centralized manner at a central mega data center with massive computing resources and performing rule-based (logic-embedded) processing at distributed data centers can provide a level of performance that satisfies service requirements (**Figure 4**). Moreover, in the case of near-real-time applications that require reflexive decision-making support or applications that deliver local content closely tied to a community, processing at a distributed data center near the user is a rational approach.



VPN: Virtual private network
CDN: Contents delivery network
CEP: Complex event processing

Figure 3
Transition to network-wide distributed computing.

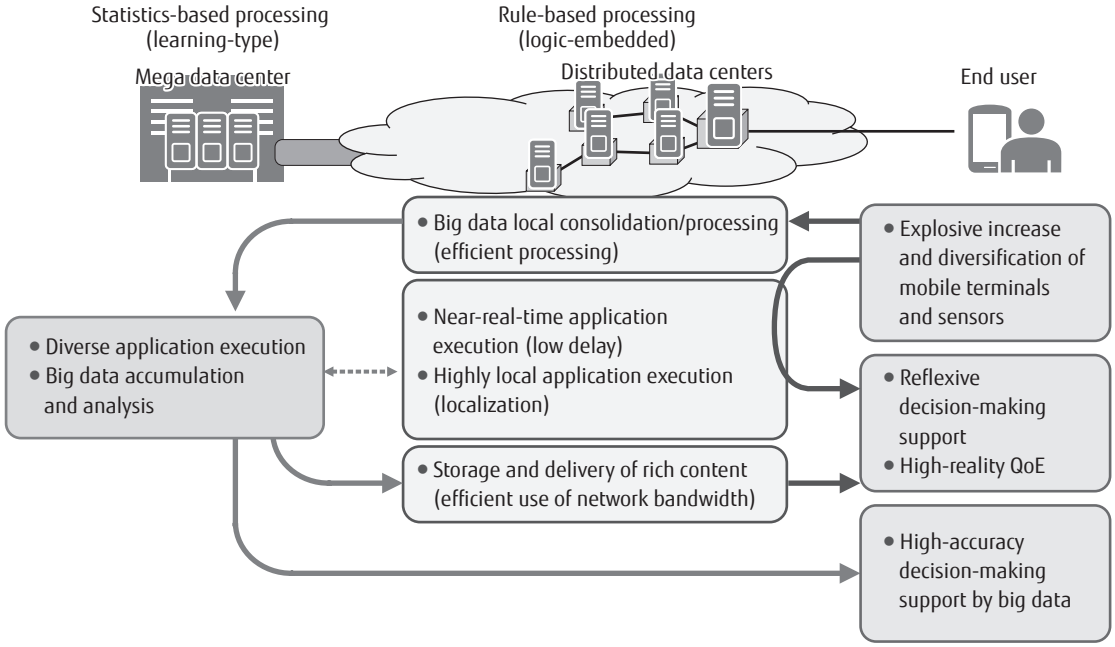


Figure 4
Network-wide distributed computing.

For example, service response time when performing stock trading or online shopping from a smart device is directly related to sales. Network-wide optimization will enhance the user's quality of experience (QoE) for smart devices. In short, providing an environment in which the end user can immediately use optimal services anytime and anywhere will maximize business value.

5. Increasing network value

An important aspect of network-wide distributed computing is raising the quality of services by flexibly deploying and controlling ICT resources in line with the businesses and services of companies and service providers and dynamically responding to changes in the flow of data collected from smart devices and sensors.

Additionally, if users are to enjoy on-demand services, it is necessary to virtualize all ICT resources and automate programmable operations through intelligent software. This idea is based on software-defined networking (SDN), which can be extended from the network to all ICT resources for end-to-end optimization and the provision of more sophisticated services to users. Such total ICT optimization will require computing that can deal with changes in the configuration of the front-end system, including devices, and changes in requests received from the back-end system, consisting mainly of the cloud. It will also require incorporating a mechanism for abstracting resources and arbitrating their use between networks.

ICT optimization will provide service providers and infrastructure providers with new opportunities for revenue growth. Additionally, converting network operations that up to now have relied on human control into software will make it possible to shorten the time required to get a new service up and running from the previous one month or so to as little as a few minutes. The automating of operations in increasingly large systems will eliminate the effect of human error on the settings.

Virtualization due to this conversion to software will likewise bring about a revolution in network systems. Network function virtualization (NFV) will convert functions within a formerly proprietary system into software that runs on a general-purpose platform consisting, for example, of Intel architecture (IA) servers.

It is important that we foster network innovation while coordinating SDN, NFV, and other types of virtualization technology with network migration.

6. Conclusion

This paper described network-wide distributed computing as proposed by Fujitsu to accommodate the full-scale IoT era. This approach to computing will make it possible to instantly define a network configuration in accordance with service requirements and to flexibly handle dynamic changes in the network as new services are added. It will also enable the provision of more sophisticated, finely tuned services as in the flexible transfer of sporadically generated data, the provision of services based on their degree of urgency and importance, and the extraction of malicious software.

At Fujitsu, we are committed to giving this vision form. We aim to continue our efforts in creating new value and to contribute to the creation of a society enabling a prosperous, enriching, and secure life for everyone.

References

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