Cloud Computing Platform Technology Initiatives at NTT Laboratories

Kenichi Ohto, Yuzo Koga, Takeshi Kaji, and Takuji Kishida

Abstract

To realize flexible, agile, low-cost, and safe and secure cloud services, NTT laboratories are involved in various research and development (R&D) initiatives in cloud computing platform technologies through open innovation. This article explains the approach of these R&D initiatives for implementing the NTT laboratories' cloud computing vision, and also gives an overview of our current work on cloud controller and virtualization technologies.

Keywords: cloud, open innovation, virtualization technology

1. Introduction

A cloud provides information and communication technology (ICT) resources such as a central processing unit (CPU) and memory of a server machine, as well as storage promptly through a network in the configuration required by customers. Customers can reduce their capital and operational expenses and increase competitiveness in their various business endeavors by using cloud services. To strengthen the competitiveness of the NTT Group's global cloud businesses, research and development (R&D) is underway at NTT laboratories to realize a world-class cloud computing platform that is flexible, agile, low-cost, safe, and secure (**Fig. 1**).

2. R&D through open innovation

Technologies in the cloud field are advancing rapidly. The lifecycles are getting shorter, and the technologies are becoming more complex. In such conditions, we believe it is important in principle to avoid large-scale, independent product development, and to promote open innovation so as to utilize excellent products and/or open technologies from around the world. This will enable us to shorten the periods of product development, reduce costs and various risks, catch up with the latest technologies, and avoid vendor lock-in. We also believe it is very useful for NTT Group businesses to utilize know-how that is fed back from our activities to verify and/or support both products and technologies. The approach of the NTT Software Innovation Center in these R&D initiatives is summarized in **Fig. 2**.

(1) *Verify and support* involves verifying technologies and supporting customers in adapting them in accordance with their needs and technology trends. (2) *Provide with open source software (OSS)* involves providing products by combining them with existing OSS, contributing to helpful OSS communities, and advancing technical development in cooperation with the communities. (3) *Provide with proprietary products* involves providing products by combining them with excellent new products, which are discovered and verified at an early stage in cooperation with other groups such as NTT Innovation Institute, Inc. (NTT I^3) in the USA. Finally, (4) *Develop in laboratories* involves R&D limited to technologies that promise large growth and are in their early developmental stages. We also take into consideration the

[Flexibility] Realize cloud computing environment that provides ICT resources in the required configuration
- Provide ICT resources divided and deployed centrally in a datacenter

[Agility] Rapidly build new systems as well as migrate existing systems
- Configure and deploy an entire system with multiple servers on an on-demand basis through a user's portal
- Centrally monitor and operate ICT resources deployed in dozens of location

[Low-cost] Improve datacenter utilization
- Eliminate server resource fragmentation in operation
- Actively use open technologies that effectively reduce costs

[Safety and security] Store and process confidential data securely
- Realize system configuration and disaster recovery spanning datacenters by linking with global networks
- Realize confidentiality so that even cloud operators cannot access data, and availability so that the data can be recovered even if some is lost
- Accumulate operational histories on data, enabling verification of whether all operations were legitimate

Fig. 1. NTT laboratories' cloud computing vision.

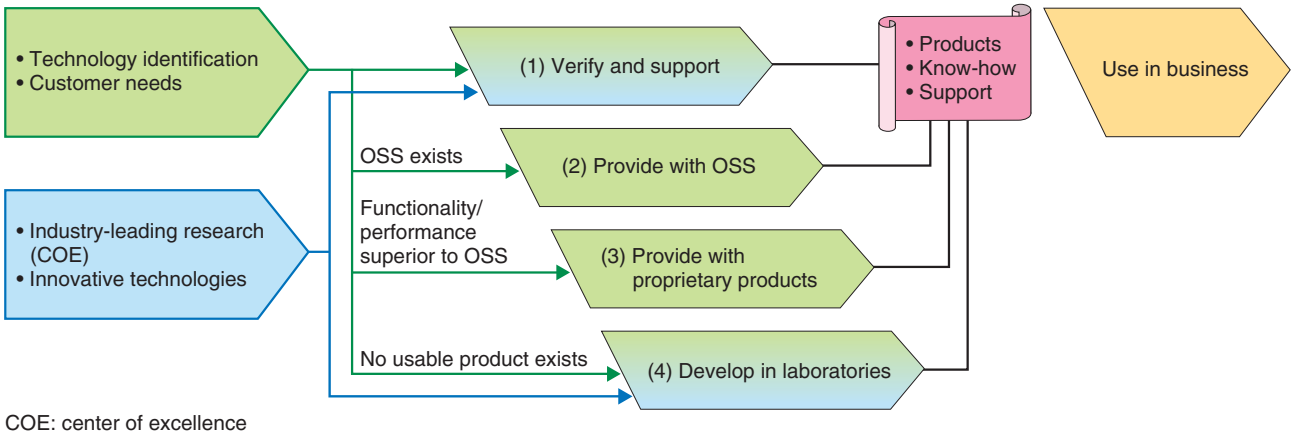

Fig. 2. Approach to R&D initiatives.

publication of our developed products as OSS. NTT laboratories are incorporating the security technologies introduced in the Feature Articles in the July 2014 issue [1] of this journal and are working on the cloud computing platform technologies described in these Feature Articles, based on the R&D initiative approach shown in Fig. 2.

3. Cloud computing platform technology

Cloud computing platform technology consists mainly of *cloud controller* and *virtualization* technologies. Virtualization technology divides and provides ICT resources freely for use, which are centrally deployed in a datacenter. Virtualization technology has expanded from the CPUs and memory of server machines to various ICT resources such as

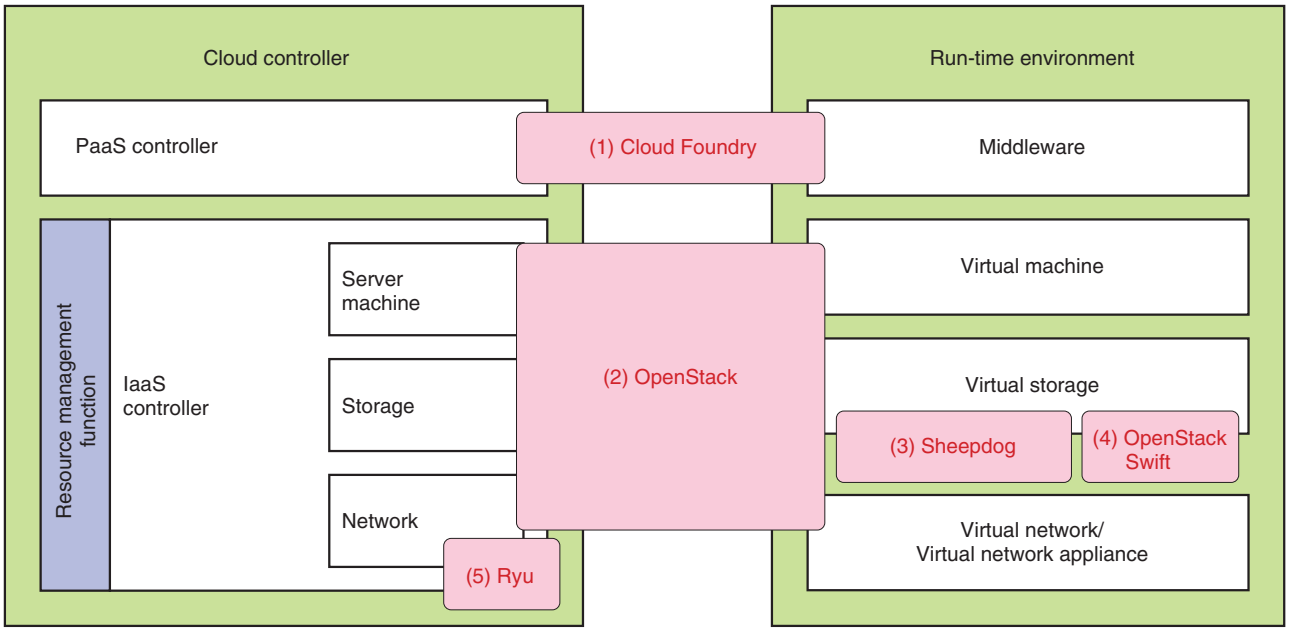

Fig. 3. Cloud computing platform technology initiatives.

networks, storage, and network appliances. Cloud controller technology controls these virtualized ICT resources and makes them available in cloud run-time environments, in accordance with customer requirements. Cloud controllers are used for both private clouds, which use cloud technology on a customer's own information systems, and public clouds, which are operated by cloud service providers. The range of applications has recently expanded to include hybrid clouds, which incorporate a mix of private- and public-cloud services. Cloud service providers are using these cloud computing platform technologies to provide services such as Infrastructure as a Service (IaaS), Platform as a Service (PaaS), and Software as a Service (SaaS).

4. Open architecture initiatives

NTT laboratories make various ICT resources available through standard interfaces and will continue to incorporate the latest technologies that emerge in the future. To achieve this, we are engaged in R&D on cloud computing platform technologies based on open architectures (**Fig. 3**).

(1) Cloud Foundry is an open PaaS administrative function that provides middleware on a cloud run-time environment. It includes run-time environments for applications programmed in the Ruby or Java languages, and for middleware such as databases. The "PaaS Platform Based on Cloud Foundry" article in these Feature Articles describes Cloud Foundry extensions for application management and operations automation. Additionally, the article describes other improvements for development and operations processes, which are promoted in cooperation with NTT I^3 [2].

(2) OpenStack is an open IaaS management function that controls virtual machines, storage, and networks in a cloud run-time environment. The article on OpenStack activities introduces R&D initiatives on functionality needed to apply OpenStack to public clouds, such as multi-plugin support for virtual networks, transaction functions, and resource management functions. Initiatives for private clouds and to enhance overall enterprise IT infrastructure are also introduced [3].

(3) Sheepdog provides distributed block storage, and (4) OpenStack Swift provides object storage; both are virtualized in a cloud run-time environment. The article entitled "R&D Efforts in Storage Virtualization Technology" introduces efforts to improve the operability and reliability of Sheepdog by implementing multipath features, which enable connection to multiple servers, and by using remote locations, which help prevent service outages and data loss. It also introduces efforts to make OpenStack Swift

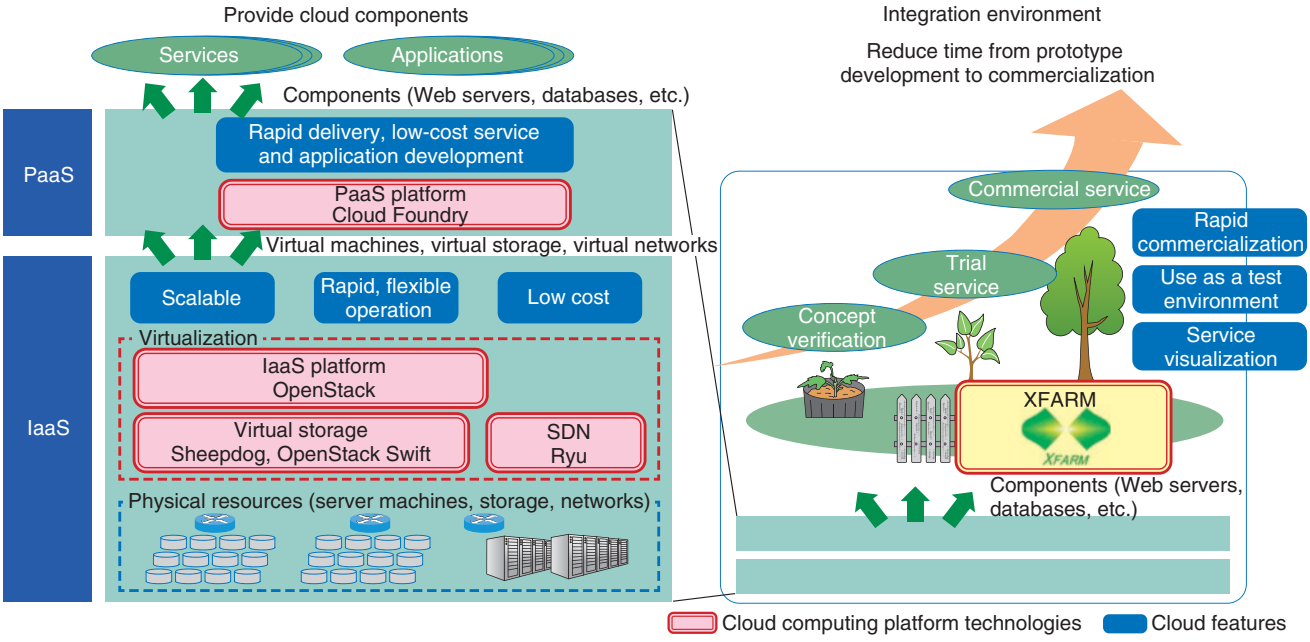

Fig. 4. In-house cloud "XFARM" concept.

operation more efficient and to reduce costs for multiple, large-scale, autonomous and distributed storage servers [4].

(5) Ryu is platform software that implements software-defined networking (SDN) to manage the operation of network devices centrally through software. It provides functions such as network path control and traffic monitoring using the OpenFlow protocol specified by the Open Networking Foundation [5]. Details of Ryu initiatives were introduced in a Feature Article [6] in the August 2014 issue of this journal.

5. XFARM initiatives

We now introduce *XFARM*, an in-house cloud to enable researchers to use and improve R&D results from NTT laboratories for themselves. XFARM provides environments for demonstration or service development, using aggregation technologies such as virtualization, to share servers and other ICT resources, to increase efficiency, and to reduce R&D costs. We have gained know-how in cloud operations ourselves by operating XFARM, and by integrating this know-how with research results regarding various cloud computing platform technologies, services, and applications, we will be able to use it to evaluate usability, visualize services, provide test environments, and develop commercial applications in shorter periods of time. The XFARM concept is shown in **Fig. 4**. An example of a research result incorporating XFARM is the cloud controller described above that links OpenStack and SDN. Using a cloud controller, researchers can secure ICT resource components on demand, and can build separate, independently configured virtual networks per user. This not only increases the efficiency of R&D activities, but also helps in quickly solving problems experienced by researchers such as inadequate performance.

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