Service Node Architecture Technology for Disaggregated Network Service Functions and Fixed-mobile Convergence Networks

Toshihiro Yokoi, Konomi Mochizuki, Takayuki Nakamura, Satoshi Nishiyama, Kensuke Takahashi, and Takeshi Osaka

Abstract

With the goal of increasing the variety of network requirements and desired value added in the Innovative Optical and Wireless Network (IOWN), our goal is to provide quick network services by providing in-house network functions by using software. This article introduces Beluganos®, a network operating system for white box switches, and the Value-added Pluggable Network Platform Technology to achieve this goal.

Keywords: network OS, fixed-mobile convergence, one-stop operation

1. Introduction

The Innovative Optical and Wireless Network (IOWN) is intended to be commonly used for information communications technology infrastructure services in various industries, and one of its applications is as a fixed-mobile convergence network that seamlessly accommodates fixed and mobile networks and enables end-to-end cloud and Internet connectivity.

Fixed-mobile convergence networks require the on-demand provision of network services that meet a wide variety of requirements in any location, including Internet of Things (IoT) terminals, which will become increasingly important as social infrastructure in the future; drones and other robots; and e-sports and other services that require high-speed and low-latency communication.

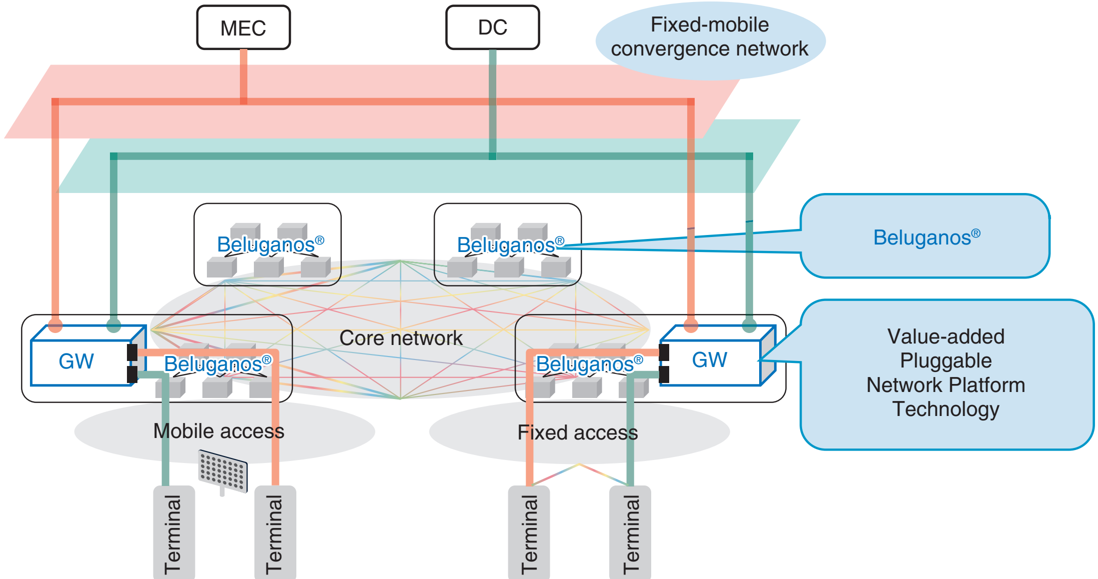
To meet these requirements and provide network services quickly, we are developing integrated service-node-configuration technologies using white box hardware and network control software in the cloud to make it possible to softwareize the functions of traditional hardware-centric carrier networks and assemble networks flexibly.

This article introduces Beluganos®, a network operating system (OS) for white box switches, as shown in **Fig. 1**, and the Value-added Pluggable Network Platform Technology.

2. Overview of NTT's in-house network OS (Beluganos®)

Beluganos® is being developed to target a wide range of white box network equipment including datacenter switches, carrier routers, and transmission equipment.

There are two main advantages to using white box network equipment. One is that hardware and software can be separated, so we can use hardware and software freely. For example, even if the hardware is no longer manufactured, the OS software can continue



DC: datacenter
GW: gateway
MEC: multi-access edge computing

Fig. 1. Overview of fixed-mobile convergence network architecture.

to be used, so changes to the monitoring system and maintenance of manuals can be reduced. The other is that with the freedom to select hardware, we can purchase components, including transceivers, for a long time at low cost. These features reduce the total cost of development, installation, and operation.

There are two issues when using a commercial network OS as software. The first issue is that, as with conventional network equipment, new functions are added or problems are fixed at the vendor's convenience, so the carrier, which is the user, is not always able to use it when necessary. The second issue is the lack of operational capabilities. White box network equipment typically has different hardware and software vendors. Commercially available network OSs have the necessary functions, but they lack the implementation of operational functions such as monitoring and path visualization that carriers require in their operations.

To solve these problems, NTT is developing Beluganos® as an in-house network OS. This enables NTT to add and modify functions at the right time while implementing the operational functions required by carriers. The following sections describe the operational features that are enabled when applying Beluganos® to the switches that make up the Internet protocol (IP) fabric in a datacenter.

3. Beluganos® features (operational)

The IP fabric uses a generic routing protocol to build multipath Layer 3 (L3) networks over Clos network topologies. The overlay's virtual network is also configured using the EVPN/VXLAN (Ethernet virtual private network/virtual extensible local area network) protocol to create an L2 flat network, improving operability and addressing the mobility issue of virtual machines.

However, in such an overlay network, two issues occur.

- Unknown underlay network through which traffic is passing.
- No fast fault-detection function per overlay tunnel.

To address these issues, we implement the loopback, pathtrace, and continuity-check functions as the overlay network operations, administration, maintenance (OAM) functions (**Fig. 2**).

The loopback function pings the overlay tunnel, and the pathtrace function traces the overlay tunnel. This enables us to see which underlay link traffic is passing through. We also implemented a function to simulate load-balancing results by inserting information simulating real traffic into packets. This enables us to see through which underlay link a packet

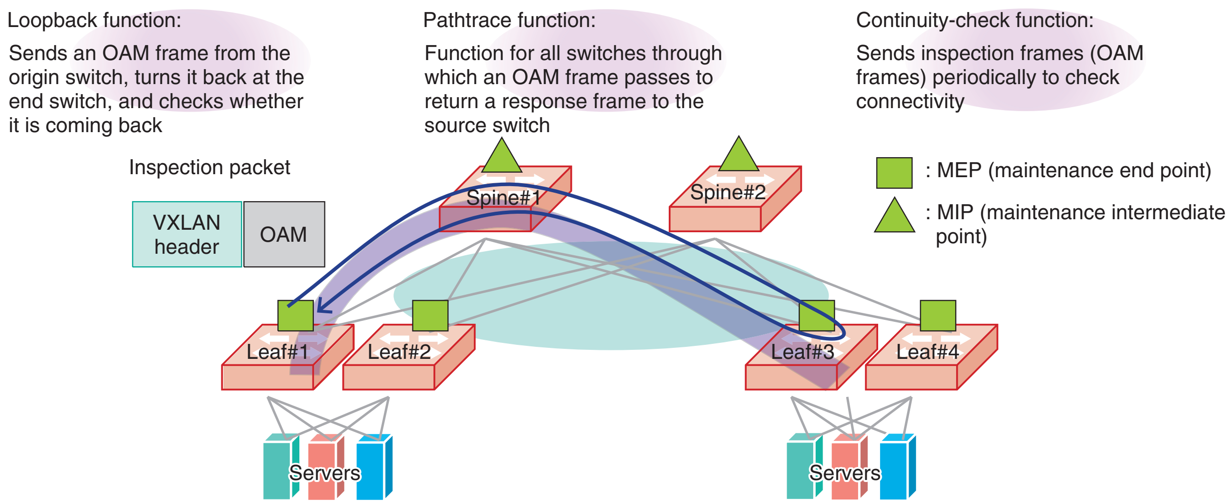


Fig. 2. Overlay network OAM functions.

traversing the tunnel goes.

The continuity-check function sends packets back and forth to periodically monitor the health of the overlay tunnel by specifying the endpoint of the overlay tunnel. It also detects a failure if these packets do not arrive for a certain amount of time. Previously, we needed a health-monitoring function to operate independently on all multiple underlay links. This continuity-check function, however, enables monitoring of all underlay links between them by specifying an overlay tunnel. Thus, unexpected failures can be rapidly detected regardless of the underlay configuration and service impact can be minimized.

4. Technology roadmap for Beluganos®

Toward the future use of open hardware control in IOWN, development will proceed on two axes: expanding the number of controllable devices and developing operational technology.

The first is the expansion of controllable devices. With an eye on future control of optical and photoelectric conversion devices, this development will accumulate expertise by developing a network OS that can control switch application specific integrated circuits (ASICs) as well as high-function router ASICs.

Regarding operating technology, we will advance cooperation with controllers. We developed a technology to enhance the operational sophistication of a single node but aim to achieve more efficient end-to-end wavelength utilization by applying it to network orchestration and transmission equipment.

5. Value-added Pluggable Network Platform Technology

To provide communication environments for IoT services, self-driving cars, smart factories, etc., the quality and functional requirements for carrier networks are expected to diversify. To provide networks in a timely manner to service providers offering diversified services, conventional carrier networks face the following challenges.

- Since individual network devices were used in accordance with requirements, the number of device types increased as requirements diversified, and network operations became more complex.
- The lead time is difficult to shorten because network-equipment settings are designed and configured individually on the basis of the requests of the operators and businesses.

We are developing the Value-added Pluggable Network Platform Technology that provides a variety of network functions on demand to address these issues.

6. Components of Value-added Pluggable Network Platform Technology

This section introduces the four components of the Value-added Pluggable Network Platform Technology shown in **Fig. 3**.

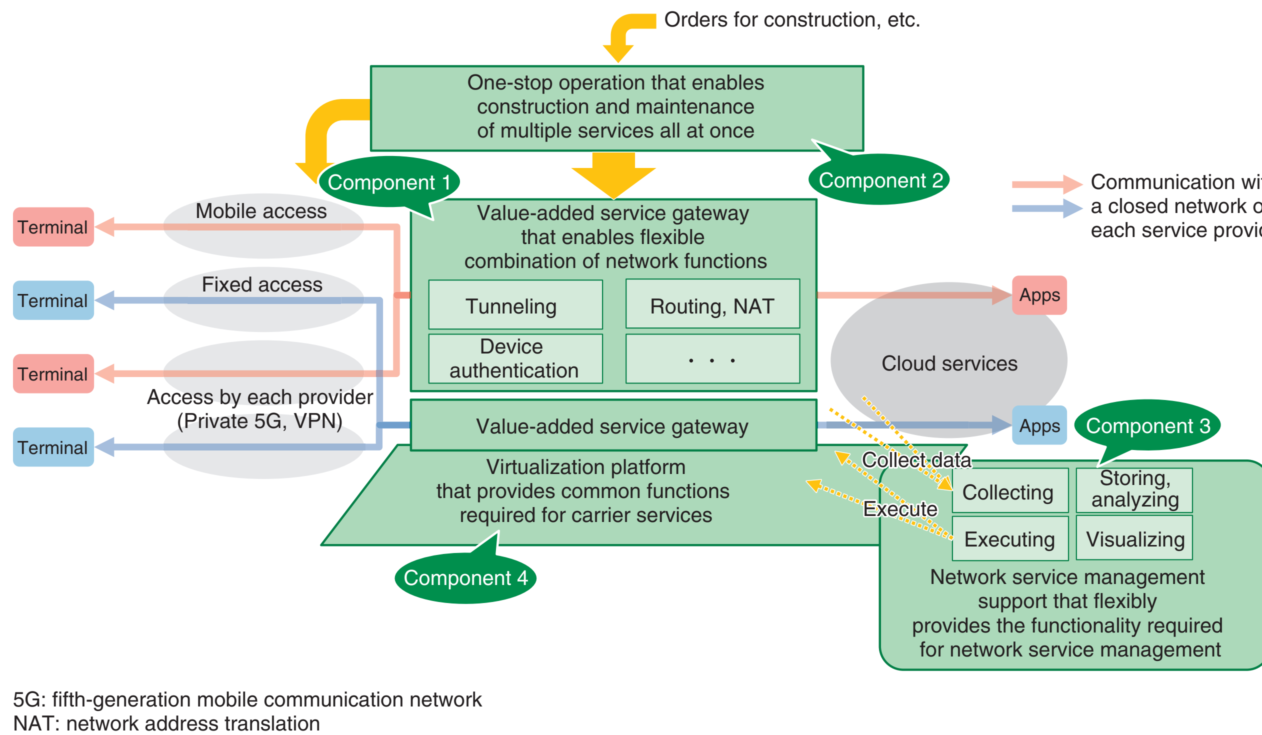


Fig. 3. Four components of Value-added Pluggable Network Platform Technology.

6.1 Value-added service gateway

The first component is a value-added service gateway that enables a flexible combination of network functions. This component is provided as a virtual gateway for each service provider that is built on-demand on a commodity server. By combining functional elements divided into containers to form the network functions of this virtual gateway, functionality can be added flexibly and rapidly. For service providers who require a secure closed network, for example, a virtual gateway with containers equipped with tunnel termination and device authentication necessary to configure a closed network can be built on-demand at the start of network use. The virtual gateway also enables network service control such as route assignment and quality-of-service control on the basis of authentication results, etc., to meet the needs of a variety of service providers.

Lifecycle management, such as creation, deletion, and configuration changes of virtual gateways, can be executed via the controller. The controller provides a RESTful (representational state transferful) application programming interface (API), which is widely used in web-based application development. In developing the controller, we incorporated web-based technologies such as Swagger and Flask to reduce development and maintenance costs.

6.2 One-stop operation

The second component is a one-stop operation that enables service providers to build and maintain multiple services, such as networks, clouds, and applications, all at once. This component exposes APIs compliant with the TM Forum (TMF) APIs as northbound APIs and provides service providers with abstracted APIs necessary for setting up each service to be coordinated. When there is an increase in the number of services to be coordinated, this component can support such services by simply adding a conversion adapter to the TMF API for the APIs provided by the coordinating services. This component also has maintenance functions through closed-loop control such as monitoring, analysis, decision, and action. By developing and combining operation functions appropriate for each service as microservices, for example, it will be possible to implement autonomous recovery measures in the event of a failure of a service to be managed.

In the Value-added Pluggable Network Platform Technology, one-stop operation automatically creates the virtual gateway settings to match the virtualization platform to which they are deployed. This enables service providers to build the desired network without having to be aware of differences in virtualization platforms.

6.3 Network service management support

The third component is the management support required to provide network services, such as analysis, reporting, and visualization of logs and metrics collected and stored from the virtualization platform and each machine and automatic execution of software updates and operational procedures. To support various virtualization platforms, this component can flexibly respond to changing requirements by enabling the combination and replacement of tools suitable for each OS, hypervisor, container, and application.

6.4 Virtualization platform

The fourth component is a platform for load balancing, state management, failure recovery, and health monitoring, which are commonly required to ensure reliability, operability, and performance as a carrier service for applications deployed in a virtualized environment. This platform makes it easy to expand network functions.

7. Future prospects for Value-added Pluggable Network Platform Technology

The goal with the Value-added Pluggable Network Platform Technology is to achieve higher speeds to cope with increasing communication traffic and more advanced maintenance and operations to further improve the efficiency of network operations. Specifically, we are investigating the use of hardware accelerators, such as field-programmable gate arrays, that can process high-speed traffic and developing operational technologies that can adapt to changes in the environment by analyzing collected data through artificial intelligence.

Trademark notes

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