The NetroSphere Concept and Network Architecture

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Abstract

The NetroSphere concept was devised by NTT laboratories to guide the development of communication network technology for the future. The aim is to provide customers and service providers with a network that provides the services they require at high speed, with high reliability, and at low cost by adopting an architecture in which a diverse range of functions can be used flexibly. This article outlines the aims of the NetroSphere concept and the network architecture that supports these aims.

Keywords: NetroSphere, future networks, B2B2X

1. Introduction

Overall, network services are affected by five main issues, which are as follows.

1.1 Flexibility to changes in demand and/or environment

Recently, the rise of OTT (over-the-top) content delivery has led to large changes in the communication environment, including carrier networks becoming *dumb pipe* networks and the transition of communication businesses and services from telephone-centric to data-centric models. It is getting harder to predict how things will change in the future. Currently, network infrastructures are configured from equipment dedicated to individual functions. Achieving high reliability and high capacity per equipment unit means that equipment tends to be expensive and large-scale. Also, services have been provided using a vertically integrated network model, referred to as a *silo-type* network. In a silo-type network, it is difficult to add or modify the network's functions or capacity to accommodate new services, and since some parts of the equipment cannot be used by other services even if they have a low usage rate, this can result in the overall network becoming inefficient when there are large changes in communication demand and the communication environment.

To address this situation, even carrier networks have recently been the subject of research and development (R&D) and standardization efforts relating to virtualization techniques such as network functions virtualization (NFV) and software-defined networking (SDN), and it is expected that advances will be made in the functional separation of network equipment. However, in a carrier network, the deployment of functions and the connection configuration are still designed for conventional dedicated equipment and are subject to the requirements of carrier networks such as high reliability and high scalability. As a result, even an advanced level of functional separation will not change the conventional silo-type configuration. This is perhaps why modularization has not yet advanced to the point where networks can be freely configured. Furthermore, since the network equipment that is currently used has a short end of life (EoL) cycle, there is a frequent need for EoL-related development, and the EoL of a single component becomes the EoL of the entire network infrastructure, resulting in increased network costs. In the future, there will be a need for flexible low-cost networks that can adapt to changes in demand and changes in the environment.

1.2 Service provision period

In preparing to launch a new network service, it can take months or even years to develop the new functions that are required. This makes it impossible to adapt immediately to the changing needs of service providers. This is also partly because the introduction of new functions is strongly tied in with the road map for dedicated products used by network functions. It is therefore hoped that a network can be implemented where it is possible to respond promptly to the diverse needs of service providers and reduce the service provision preparation period.

1.3 Diversification of user equipment

With the growing diversity of user equipment, including equipment installed at the customer's premises (CPE: customer premises equipment) and on-premises equipment, the increased number of firmware updates and other maintenance operations on this equipment is becoming a challenge. Furthermore, it is predicted that the development of the Internet of Things (IoT), where communication takes place between all sorts of objects, will result in growing diversity and scale of user equipment and the ways in which it is used. It is therefore necessary to develop a network architecture that can adapt to new modes of use such as IoT while minimizing the load on user equipment by providing on-premises type functions on the network side.

1.4 Operation

Even for the operation of communication services, there is a need for a mechanism that can be implemented with a small number of maintenance operators in order to reduce the operating expenditure (OPEX). To make fundamental changes to management operations so as to eliminate the need for human involvement, it will be necessary to implement measures such as mechanisms that do not require maintenance workers to be on call all night long, and to work towards a skill-less system where site work can be performed by anyone.

1.5 Security

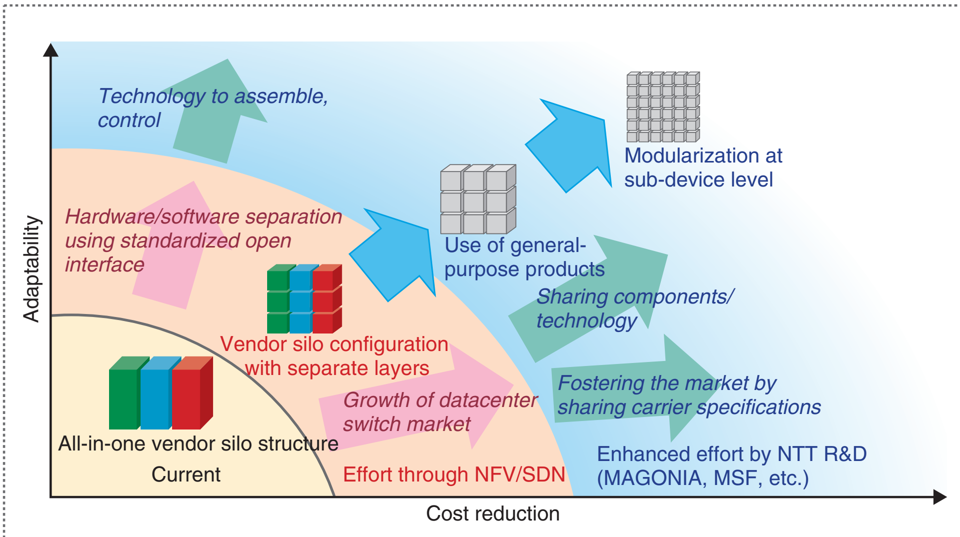
It is predicted that cyber security threats will continue to grow in the future. For example, it is said that it may be necessary to deal with large-scale cyber-terrorism affecting an entire network. In addition, for network structures that comprise a growing proportion of software, there is a need for new mechanisms and standards for reliability assurance, and for the efforts needed to support them.

2. The NetroSphere concept

At NTT laboratories, we are making progress in researching the construction of the future network infrastructure while continuing to make further progress in the abovementioned areas such as supporting diversity and providing flexibility to encourage joint creation. We also consider that it is necessary to take a fresh look at the status of networks and equipment and the role of communication providers that work with these networks. For this reason, we formulated the NetroSphere concept.

In future networks based on the NetroSphere concept, our aim is to create new value while protecting our customers from risk while synergistically adapting to changes in the outside environment above and beyond the traditional *connecting* role of networks. Network configuration functions are handled by splitting them into the smallest possible components and distributing each component to its optimal location. These network components can be freely combined to configure virtual equipment that provides the necessary functions and networks that are required by service providers. Furthermore, by having a shared resource pool of small network components that are only combined as and when they are needed, we can respond rapidly to the needs of customers and service providers and provide the necessary functions and capacity in a flexible way. Since each individual component has a simple function, this allows a wide variety of suppliers to enter the market, which is expected to lead to cost reductions. Moreover, it can drastically reduce the equipment costs by allowing redundancy and higher capacity to be achieved with high efficiency (**Fig. 1**).

Instead of a conventional silo-type structure, the network is split into hardware and software layers that are thoroughly separated into different functions, components, and modules to facilitate the entry of more players into the communication field, even from different industries. This will fundamentally reform the total cost structure of telecommunication services, reducing CAPEX (capital expenditure) and OPEX to less than one-tenth of their traditional levels, while providing a one-stop solution for operations that operate and maintain services. In this way, even for B2B2X (business-to-business-to-X) business models where various service partners and communication providers collaborate to provide services, we aim to achieve an order-of-magnitude improvement in the performance and speed of services by implementing a service development environment that can meet the



MSF: Multi-Service Fabric

Fig. 1. Approaches to achieving the NetroSphere concept.

needs of diverse service partners flexibly, promptly, and at low cost.

Specifically, by providing network and service functions as raw materials, the network structure is split into a software layer (virtual layer) and a hardware layer (real layer). In the real layer, commodity hardware (servers, switches, etc.) that is made jointly available to every service is clustered together to make the maximum possible use of light (wavelengths), and is efficiently arranged so as to minimize the use of photoelectric conversion (**Fig. 2**). The virtual layer allows the dynamic on-demand creation of building-block software components without being tied to any particular area, thereby enabling the implementation of *pick and mix* configurations by controlling and operating services according to a diverse range of requirements.

3. Network architecture and technical issues of NetroSphere concept

The network architecture of the NetroSphere concept and the technical issues associated with it are described below (**Fig. 3**).

3.1 Low-cost network resistant to changes in demand or the environment

The NetroSphere concept is based on a low-cost network architecture enabling services to be provided flexibly even if traffic levels suddenly increase tenfold or more or if there are changes in the way traffic circulates, and enabling services with low latency to be provided at low cost for the era of 5G communications and for the large number of communication terminals that will come into use with the expansion of IoT. Our aim is to reduce the cost of core networks that need to be expanded to handle more traffic by one-tenth, and to reduce the overall cost of networks including access and transmission equipment by one-third by 2020.

This will reduce costs by making network functions available as completely general-purpose raw materials, and by implementing network-wide resource pooling to adapt to fluctuations in demand so that the network utilization rate can be maximized. Specifically, the network is separated into service-specific functions and transmission and control functions that are shared by all services.

Depending on the demand and the needs of service providers, each function is implemented from architecture that can be freely combined (MSF: Multi-Service Fabric), or the network functions are separated from the hardware as software components so that by leasing server resources it is possible to provide a highly reliable system with efficient redundancy that is highly scalable and has low overhead. This results in a highly reliable server architecture (MAGONIA) [1]. Moreover, with the use of advanced visualization

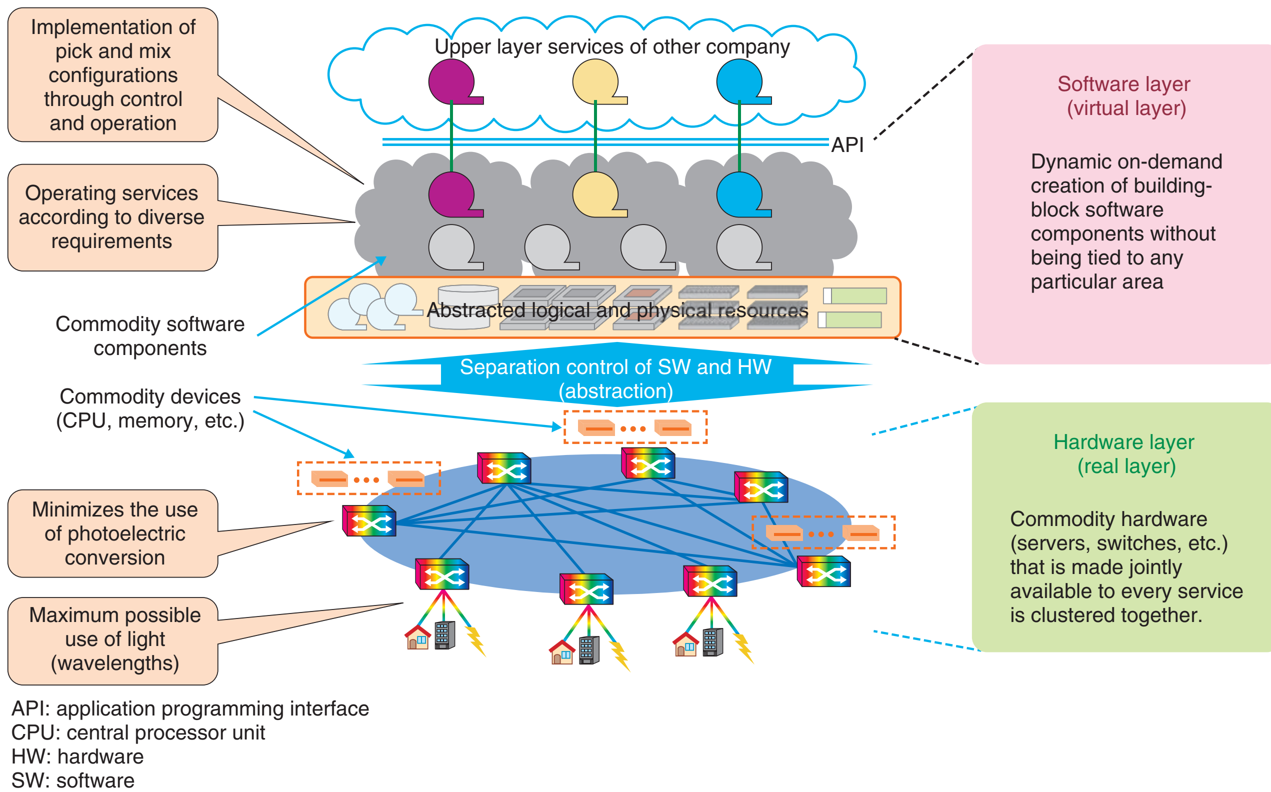


Fig. 2. Network vision based on the NetroSphere concept.

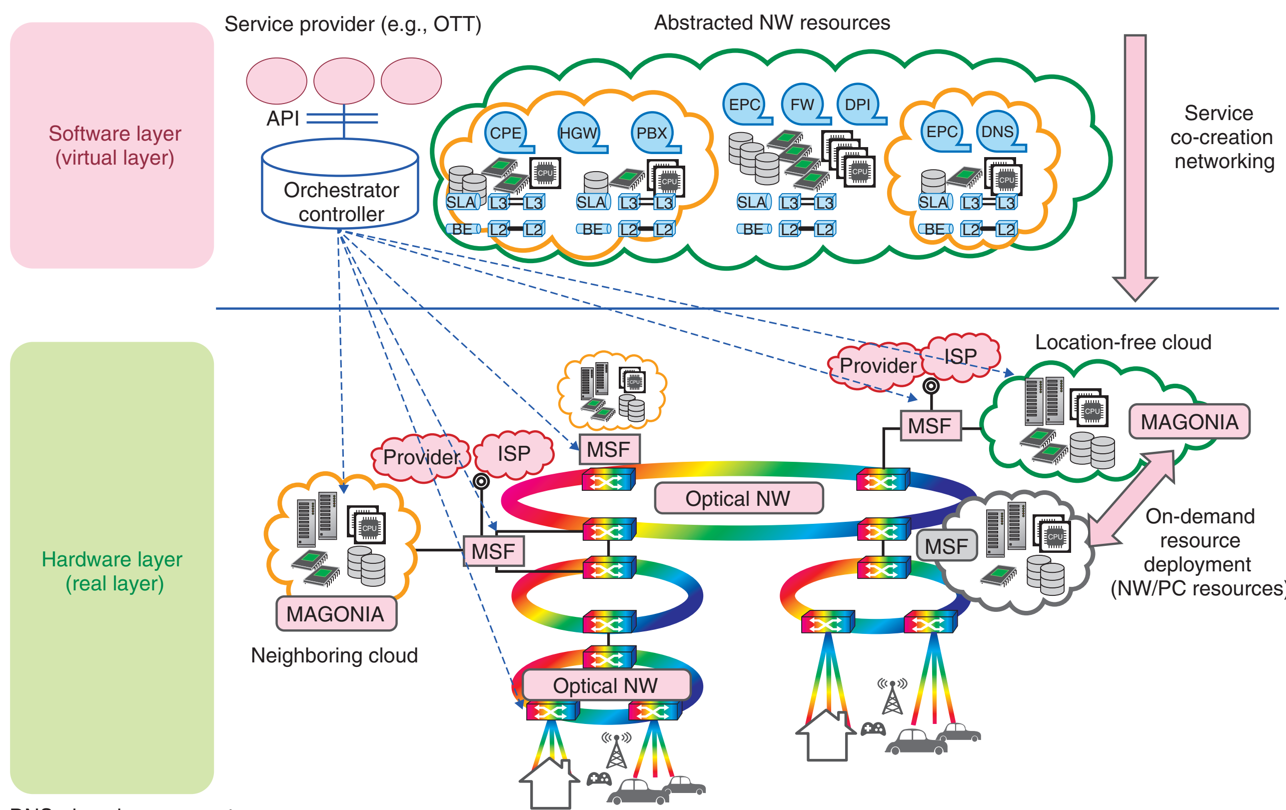
and analysis techniques such as the analysis of big data inside and outside of networks that are becoming increasingly complex, it is becoming possible to minimize the risk of equipment failure and traffic fluctuations by implementing control whereby resources are allocated proactively through resource optimization techniques, proactive traffic control technology, and network science.

3.2 Adapting to the needs of service providers and reducing the service development period

The NetroSphere concept aims to reduce the service development period and produce a network architecture that allows new services to be provided in a short period of time. To enable the provision of BTO (build to order) services that meet the needs and desires of service providers, we aim to adapt to the needs of service providers and develop services in a shorter time by preparing a mechanism for treating network service functions as building blocks for virtual functions that can be flexibly combined. We therefore propose service co-creation networking technology (**Fig. 4**) that can promptly and flexibly adapt to the needs of service providers by freely combining modularized network functions (functional blocks) depending on the service criteria and the state of network resources. This results in a network architecture in which the service provider uses virtualization technology to provide a logical slice of the same network environment as the physical network and is able to change, add, and modify in-service combinations of network resources while maintaining the SLA (service level agreement). For example, it makes it possible to deploy and configure network functions and bandwidth at optimal locations according to the attributes of the application that provides the service, depending on criteria such as the service's latency time and traffic exchange requirements.

3.3 Provision of user functions (on-premises, etc.) as network services

When functions are conventionally implemented using on-premises equipment or are deployed in a service provider's cloud, virtualization is used to provide these functions as network services, so that the latest functions are always available, resulting in a



DNS: domain name system
DPI: deep packet inspection
EPC: evolved packet core
FW: firewall
HGW: home gateway
ISP: Internet service provider
NW: network
PBX: private branch exchange
PC: personal computer

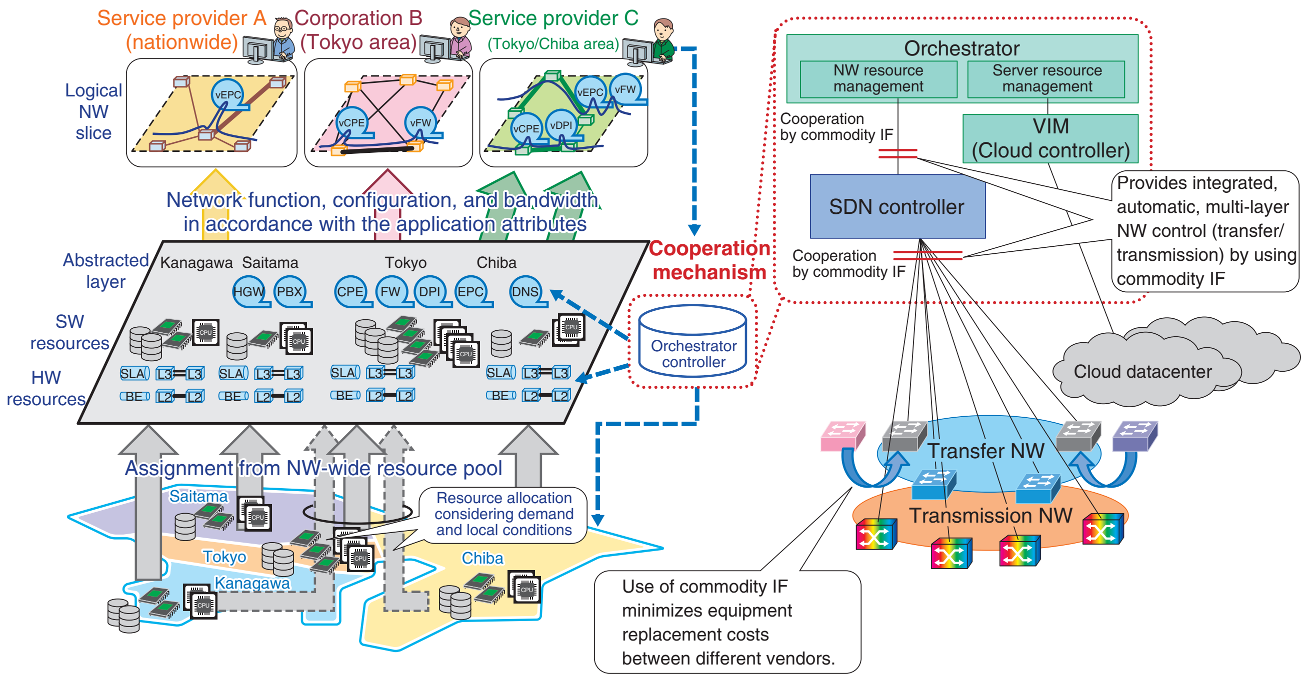
Fig. 3. Future network architecture based on the Netrosphere concept.

paradigm shift from ownership to use. This reduces the service cost and makes it more secure. For example, by deploying a user's on-premises CPE functions and the like on the network side, we aim to reduce the maintenance and operation work involved in tasks such as keeping the settings up to date. Moreover, by implementing a mechanism whereby raw material functions can be freely combined within the network, it is possible for diverse service providers, including newcomers to the field, to create new services (e.g., a service that combines vCPE with a firewall), and by adapting promptly and flexibly to diverse service demands in IoT, it is possible to create networks with new added value.

3.4 Streamlining and visualizing the effects of automated operations

In the NetroSphere concept, for operations related to network maintenance, we aim to provide an architecture that makes the utmost use of automation so it can be operated by a small number of personnel. We propose providing a network-wide resource pool so that operations can be automated to produce an operation architecture that facilitates efficient network operations with fewer personnel who do not need to be on 24-hour call (integrated control technology).

We also implement an environment in which the network usage situation can be visualized, and where service providers and the like can freely use the network. This can be implemented by automating the setting of related equipment associated with



IF: interface
VIM: virtualized infrastructure manager

Fig. 4. Service co-creation networking technology.

managing and augmenting the relationships between the functional elements that implement a service and the relationships between functions, allowing the service provider to visualize the network status (service quality, areas affected by equipment failure, etc.). When there is an equipment failure, prompt service recovery and equipment replacement at the affected location will become unnecessary through the use of a spare resource pool to automatically restore the network and reconfigure the network redundancy. By visualizing these network operation activities (navigation/annotation functions), we can also promote the visualization and improved efficiency of operations.

3.5 Providing a safe and secure communication environment

Our objective with the NetroSphere concept is to ensure overall security across the network against new, more sophisticated cyber threats in the future, and thus, we are aiming to achieve a mechanism that can respond quickly and flexibly even to new threats through cooperation between the network and cloud. We are also aiming for a mechanism whereby diverse people and things connected to a network (IoT, etc.) can use the network safely, and we are implementing a secure network environment that can respond to a diverse range of attacks, including concerted attacks where terminals are hijacked, and attacks on virtualized platforms.

We are promoting the establishment of reliable new design and evaluation techniques suited to diverse service providers and to the development of network virtualization technology (e.g., NFV, SDN). Furthermore, we are working to establish network technologies that are resistant to natural disasters and that can minimize their impact on services. For example, by adopting a design that minimizes the possibility of a network being cut off between hubs, we can mitigate the impact of large-scale disasters on communications, and we are establishing techniques for reconfiguring network resources according to the disaster location in order to minimize the impact when the disaster occurs.

To implement a network that is environmentally sustainable, we are implementing network architecture that uses low power to maintain a suitable level of performance during normal operation and that keeps connections alive while maintaining the minimum level of performance in the event of a disaster.

For further power savings and cost reductions, we are working on the introduction and growth of HVDC (high-voltage direct current) systems as a replacement for conventional 48 VDC (volts direct current) and AC (alternating current) power supplies.

4. Future prospects

To realize the NetroSphere concept, it will be necessary to proceed with reforms together with many of the players in the communications industry. In particular, to promote the spread of network functions based on general-purpose modular components, we are promoting initiatives such as the development of common specifications and international standards for carriers adhering to similar concepts.

Also, to accelerate the development of technology, we are establishing broad links with partners from various specialist fields such as domestic and overseas vendors and research organizations in order to develop technology through joint R&D efforts and verification trials.

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He received a B.E. in administration engineering from Keio University, Kanagawa, in 1988 and joined NTT Software Laboratories the same year. He studied software development support environment for CHILL (CCITT High Level Language for telephone switching systems) using a UNIX workstation and the Internet during 1988–1994. He moved to NTT Multimedia Business Department, where he developed a video on demand system over an optical fiber network with Microsoft. He also worked at NTT WEST and NTT Resonant (board members of Live Life Japan), and was actively involved in developing a local area information sharing portal, a video conference system over Internet protocol (IP) networks with document sharing function, web service products, and live entertainment ticket sales information portal services. After returning to NTT, he had led open source projects and produced committers in Tomcat, Java, and JBoss community. He has been in his present positon since 2012, and manages entire R&D activity about all network issue.

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