An Operation Service Composition Method for Home Network Operation Support

Nobuhide Nishiyama†*, Kenichi Nishikawa, Yoshihiro Nakamura, and Fumihiko Ito*

Abstract

To help users operate their home networks, which are becoming increasingly complex, we are studying a method of composing home network operation services based on descriptions provided in semantic languages on the Web. This approach will provide users with practical interfaces for operating home networks.

1. Introduction

With the spread of various network services such as visual communication services, it has recently become important to achieve end-to-end service quality management. This makes it necessary to operate home networks constructed in locations such as condominiums in addition to operating access networks and core networks. However, home networks are difficult for users to operate because they are becoming increasingly complex and most users are not experienced in operating them. In this article, we describe a method of combining multiple home network operation services, each of which is provided for a particular piece of network equipment to set and obtain its configurations, and composing practical home network operation services. This approach enables users to operate their home networks easily without being conscious of each component operation service.

2. Home network trends

These days, various types of network equipment are installed in home networks, as shown in **Fig. 1**, and they use various protocols. Various types of Ethernet-based equipment have been installed (e.g., gateways, residential routers, and layer-2 switches), which support functions such as VLANs (virtual local area networks) and QoS (quality of service) conforming to Diffserv and IEEE802.1p. Moreover, in future, various types of wireless equipment supporting functions such as QoS conforming to IEEE802.11e, HiSWAN, and Bluetooth will be installed. Thus, future home networks are likely to be able to apply various operation policies to meet a wide range of user demands.

3. Problems with home network operation

We assume that users operate their own home networks themselves to try and achieve the network operation policies they require. However, it is difficult for users inexperienced in operating networks to set home network operation policies by performing complex operation processes for each piece of network equipment. For example, establishing a 10-Mbit/s low-latency service class for a TV conference service requires complex processes such as setting assured bandwidth and flow configurations for each piece of network equipment. One method for solving such problems is to provide users with abstract operation service interfaces that enable inexperienced users to operate networks in accordance with their desired operation policies. This involves combining the operation services for all the pieces of network equipment so that users can operate their home networks easily without being conscious of each component service. For this purpose, we studied the following methods.

† NTT Access Network Service Systems Laboratories
Tsukuba-shi, 305-0805 Japan
E-mail: nisiyama@ansl.ntt.co.jp

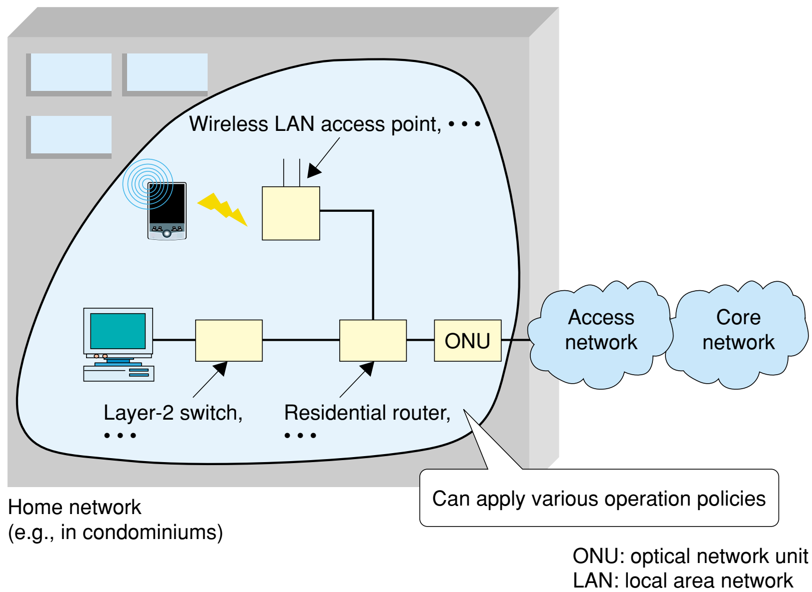

Fig. 1. Modern home network.

- A method for generating each component operation service and its description for automatic service composition
- A method for automatically composing operation services based on component service descriptions and service composition rules

To achieve these methods we designed a system architecture for home network operation service composition. We also developed a method for generating component operation services and a method for composing operation services by combining them.

4. Home network operation service composition system

We assume that the home network operation service composition system shown in **Fig. 2** will be installed in equipment such as home gateways and home servers. We also assume that the system will be implemented using Java to enable it to run on a variety of platforms. The functions of the system are described below.

- Operation service library

The library provides two types of home network operation services, which provide common operation interfaces over a variety of network equipment. We use the term "atomic service" for one that can set and obtain one of the configurations of one piece of network equipment providing the service. An example of an atomic service is a service for setting one of the QoS configurations of an individual piece of equipment. Composite services are services composed of several services, and they provide users with practical operation service interfaces. An example of a composite service is a service for QoS control between an optical network unit (ONU) and several terminals [1].

- Description database

The description database manages descriptions of items such as network resources and operation services and the relationships between them. These descriptions are provided in semantic languages. There are two types of descriptions of operation services: service class and service instance descriptions. Service class descriptions describe common forms of atomic or composite operation services. They include their service composition rules and can be used for various different home networks. On the other hand, service instance descriptions describe individual atomic or composite operation service processes. They describe instances of service classes for a particular home network. These two types of descriptions play important roles in providing various types of service compositions.

- Operation service composer

The operation service composer generates composite service instance descriptions based on service class descriptions.

- Wrapper modules

The operation interfaces provided by pieces of network equipment differ depending on the vendor and the type of equipment. This means that they use various operation protocols such as SNMP (simple net-

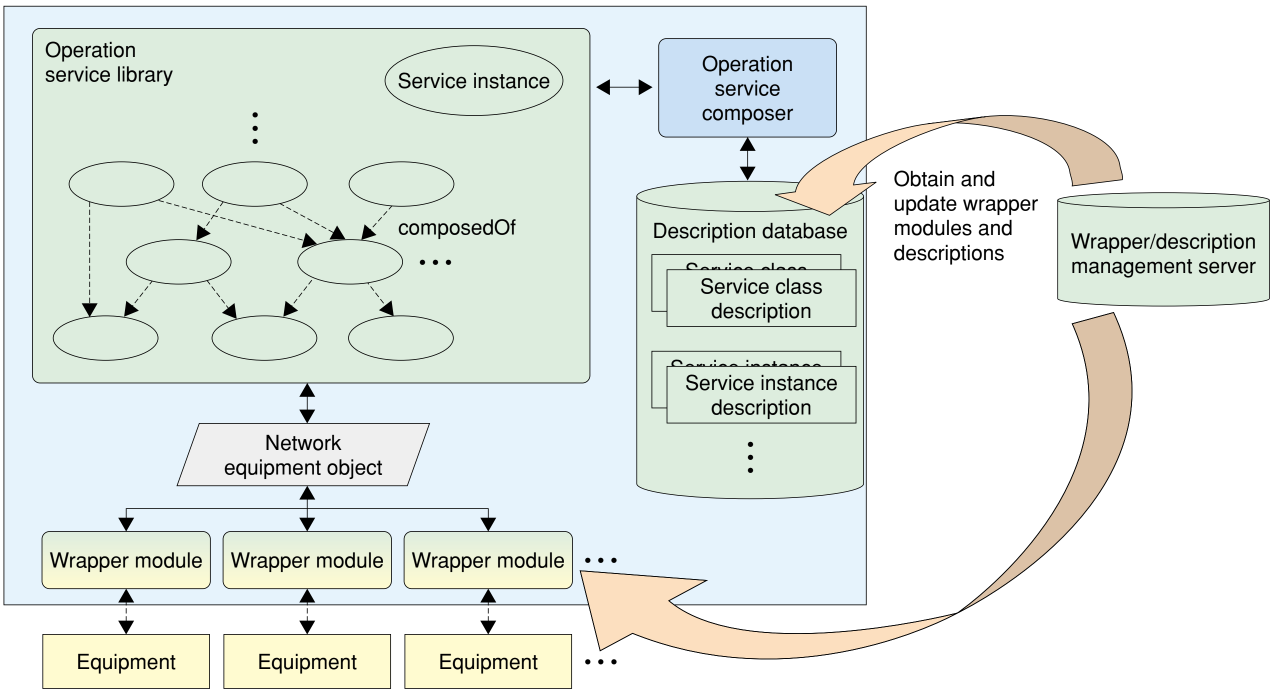

Fig. 2. System for composing home network operation services.

work management protocol), telnet, and HTTP (hypertext transfer protocol). It also means that various operation messages are exchanged over those protocols. To hide their differences, the wrapper module converts messages requesting atomic services received via the abstract network equipment object into equipment-specific operation messages. It then executes a procedure for setting or obtaining the configuration of each piece of equipment by sending the converted messages using these specific operation protocols.

5. Generation of atomic services

To generate composite services, it is necessary to generate atomic services that include self-descriptions. The generation of atomic services involves installing a software module providing the atomic service interfaces and their service instance descriptions when a new piece of network equipment is added. Here, we achieve this "plug-and-play" generation of atomic services by dynamically installing wrapper modules and atomic service instance descriptions in the service composition system. These are installed based on existing management information such as a MIB (management information base), using the OSGi Service Platform*1 [2].

6. Generation of composite services

We describe a method for generating and providing users with practical operation service interfaces, by combining the generated atomic services [3]. Network resources and operation services are described in semantic languages such as OWL (Web ontology language)*2 and OWL-S*3, which are semantic languages for Web service composition that have been studied on the Web. The flow of composite service generation shown in **Fig. 3** is described below.

1. Refer to composite service class descriptions

The service composer refers to the rules for service composition described in the service class description. The rules include the conditions for network resources and operation services needed to provide each composite service. The descriptions of the rules are provided in languages such as those using first-

*1 OSGi Service Platform: A Java framework for performing processes such as installing, starting, and stopping application packages called bundles. http://www.osgi.org/

*2 OWL: Ontology language for describing the classes and relationships between them that are inherent in Web documents and applications.

*3 OWL-S: Ontology language for service descriptions that makes it possible to discover, invoke, compose, and monitor service resources on the Web.

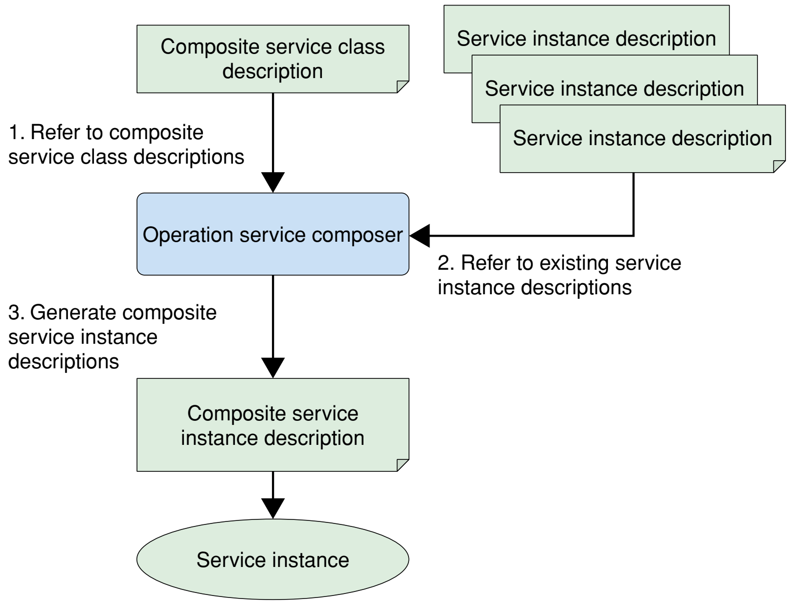

Fig. 3. Flow for generating composite services.

order logic*4.

2. Refer to service instance descriptions

Based on the above rules, the composer extracts the required network resources and refers to the atomic service instance descriptions provided by those extracted resources.

3. Generate composite service instance descriptions

The composer infers and generates composite service instance descriptions based on the above rules and service instance descriptions. It is also possible to generate composite service instance descriptions based on previously generated composite service instance descriptions. Composite services can be executed using methods such as interpreting the process description in the service instance descriptions.

7. Example of composite service

Here, we give an example of a composite service that enables us to set and obtain a particular QoS configuration over all the pieces of equipment between an ONU and the terminals. These composite services can be made by combining atomic services provided by each piece of equipment for setting and obtaining the configuration of each egress queue, which plays an important role in QoS as a packet buffer. **Figure 4** shows the flow for generating the composite service instance description for setting the configuration of the minimum assured bandwidth over the equipment on the path, based on the service class description.

*4 First-order logic: A language built around objects and relationships that lets you represent general laws or rules.

8. Conclusion and future work

To help users operate their home networks, we are studying a method of composing practical operation services by combining component operation services for setting and obtaining the configurations of each piece of network equipment. In the future, we plan to construct a semantic system for home network operation and establish the operation service composition method. In addition, we will study a method of establishing a match between the composite services and the policies entered by users. We will also study a network operation method that covers not only home network operation but also access network and core network operation.

References

[1] N. Nishiyama, Y. Suzuki, and F. Ito, “Method for user network resource management,” Technical Proc. APNOMS 2003, pp. 212-223, Oct. 2003.

[2] N. Nishiyama, K. Nishikawa, and F. Ito, “A study on user network management method realizing extensions for each user environment,” Proc. of the 2004 IEICE General Conference, Vol. B-14-16, p. 601, Mar. 2004 (in Japanese).

[3] N. Nishiyama, K. Nishikawa, and F. Ito, “A method for composing user network operation services using Web service composition techniques,” Proc. of the 2004 IEICE Society Conference, Vol. B-14-15, p. 385, Sep. 2004 (in Japanese).

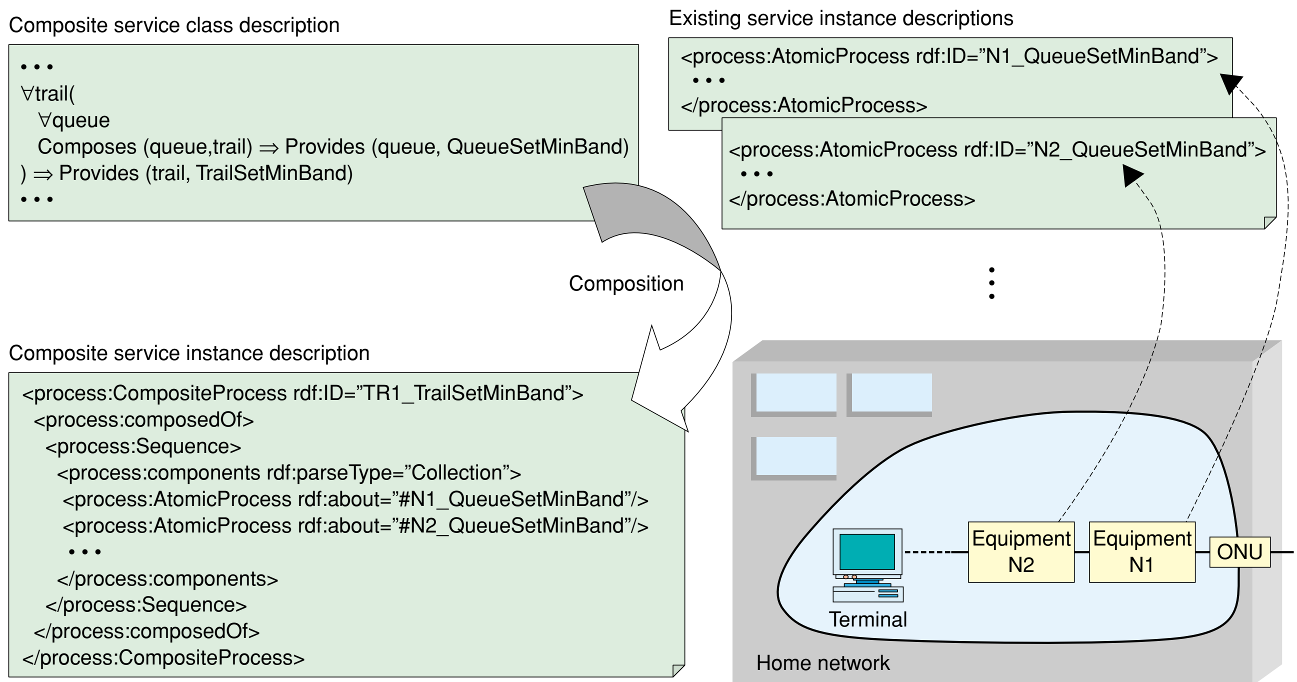

Fig. 4. Example of service composition.

Nobuhide Nishiyama
Research Engineer, Access Media Project, NTT Access Network Service Systems Laboratories.

He received the B.E. and M.E. degrees in electronic science and engineering from Kyoto University, Kyoto in 1997 and 1999, respectively. In 1999, he joined NTT Access Network Service Systems Laboratories, Ibaraki, Japan. He is a member of the Institute of Electronics, Information and Communication Engineers (IEICE) of Japan.

Yoshihiro Nakamura
Senior Research Engineer, Access Media Project, NTT Access Network Service Systems Laboratories.

He received the B.E., M.E., and Ph.D. degrees in information science and systems engineering from Tokushima University, Tokushima in 1989, 1991, and 2002, respectively. He joined NTT in 1991 and has been engaged in research on human-machine interface systems and intelligent educational systems. He is a member of IEICE and the Information Processing Society of Japan.

Kenichi Nishikawa
Research Engineer, Access Media Project, NTT Access Network Service Systems Laboratories.

He received the B.S. and M.S. degrees in information science from Tokyo Institute of Technology, Tokyo in 2001 and 2003, respectively. In 2003, he joined NTT Access Network Service Systems Laboratories, Ibaraki, Japan. He is a member of the Association for Computing Machinery.

Fumihiko Ito
Group Leader, Senior Researcher, Access Media Project, NTT Access Network Service Systems Laboratories.

He received the B.E. and Ph.D. degrees in electrical engineering from the University of Tokyo, Tokyo in 1985 and 1999, respectively. Since joining NTT Laboratories in 1985, he has been engaged in research on coherent and holographic optical signal processing for large-capacity transmission technologies. His current research involves network operation for access and home networks. He is a member of IEEE and IEICE.