Network Control System Configuration Technologies for Advanced Network Operation

Yuhei Hayashi, Taku Kihara, Atsushi Suto, Yuki Takei, and Yuta Watanabe

Abstract

To provide services on the All-Photonics Network, which handles traffic with much higher capacity and lower latency than what is currently possible, it is necessary to further improve the quality management of a carrier network. This article describes two technologies being developed at NTT Network Innovation Center. One is the Network Information Collection and Analysis Platform Technology for efficiently collecting traffic-flow statistical information, telemetry, and communication delay for network operation. The other is the Network Control Platform Technology for automating and optimizing network operation and network control.

Keywords: real-timed information collection and analysis, operation and control automation, transport network

1. Introduction

The All-Photonics Network (APN), one of the three core technologies for the Innovative Optical and Wireless Network (IOWN) advocated by NTT, will introduce optical technology in everything from networks to terminals [1]. Compared with the conventional network infrastructure, the APN will have an overwhelmingly broad bandwidth and lower communication latency for handling a dramatically large amount of traffic, and the required communication quality will also be at a level far higher than what is currently possible. To provide services to users on these networks, more efficient and higher-level network quality management and network operation are required.

2. Network Information Collection and Analysis Platform Technology and Network Control Platform Technology for advanced network operation

For advanced network quality management and operation, it is necessary to keep track of the network status and take appropriate actions (e.g., route control). For example, we collect and analyze network information such as communication delay and traffic amount, and if signs of network-communication-quality degradation are observed, we switch user traffic to other routes that will not affect network-communication quality. In the APN, sensitive network control will be required because there is a large amount of user traffic that must be managed with strict network-quality requirements.

This article describes two technologies, as shown in **Fig. 1**: the Network Information Collection and Analysis Platform Technology for efficiently collecting and analyzing traffic-flow statistics, telemetry, and communication delay for network operation and

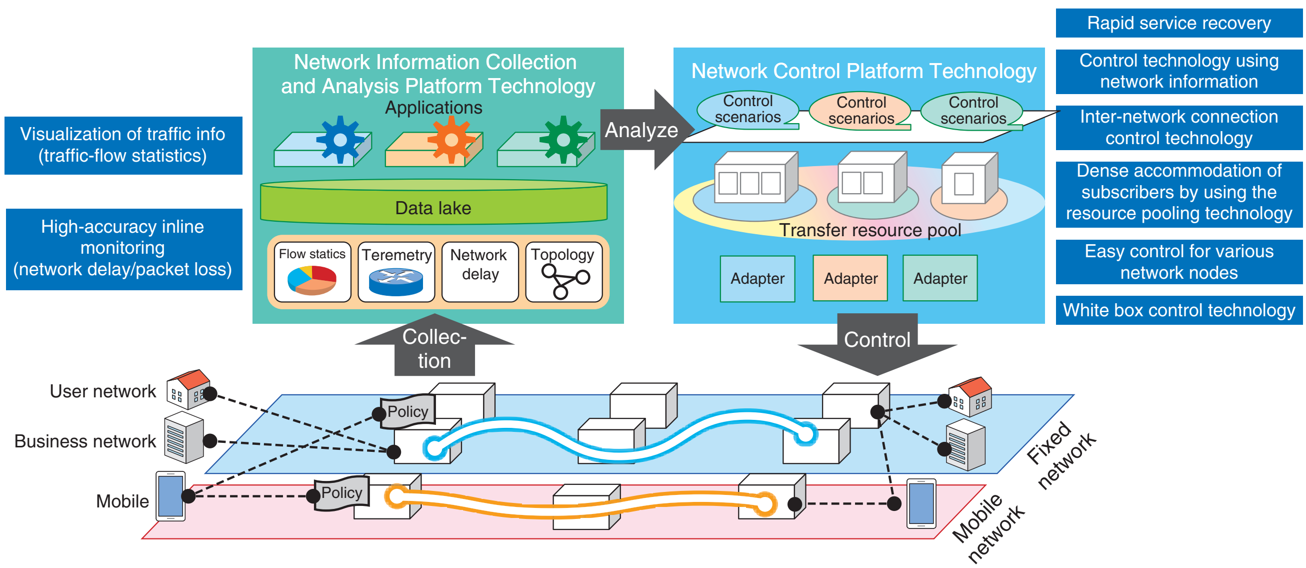


Fig. 1. Network Information Collection and Analysis Platform and Network Control Platform Technologies.

Network Control Platform Technology for automating and optimizing network operation and network control.

3. Network Information Collection and Analysis Platform Technology

To collect various types of network information in the APN, we are developing the Network Information Collection and Analysis Platform Technology shown in **Fig. 2**. This technology can be used by easily combining multiple elemental technologies that contribute to collecting and analyzing network information. For example, by installing and combining elemental technologies that support traffic-flow statistics and communication delay, it will be possible to use it for virtual private network (VPN) service monitoring or use only a part of it, such as analyzing only traffic-flow statistics. By adding elemental technologies, it will be possible to easily expand the items to be collected.

We plan to use this technology to collect various types of network information, but in this article we focus on the collection and analysis of communication delay, packet loss, and traffic-flow statistics.

3.1 Communication delay and packet loss

Communication delay for most of the services specified in 5G (5th-generation mobile communication system) is in the millisecond range, and the APN is expected to have stricter delay requirements in the microsecond range. Therefore, even higher accuracy is required in delay measurement. Scalability will also be necessary for network-quality management of carrier networks.

To solve these problems, we are researching and developing high-accuracy inline monitoring technology, which uses segment routing (SR) to generate monitoring packets. By connecting a monitoring system that is based on our technology to a carrier network, it will be able to immediately calculate all monitoring routes, generate monitoring packets, and send them. By using the Data Plane Development Kit (DPDK), delay measurement in microseconds (nanosecond precision as resolution) can be achieved. Unlike peer-to-peer probe measurement, which is a common method of measuring delay, it is possible to achieve network-carrier scale by only connecting to a single location on the network (**Fig. 3**) (without installing measurement equipment at multiple locations in the network).

The high-accuracy inline monitoring technology can be applied to monitoring VPN services because it can measure the communication delay of the desired route (e.g., user communication route).

3.2 Traffic-flow statistics

In current carrier networks, many user communications with different bandwidth requirements are transported in the network. Therefore, it is becoming

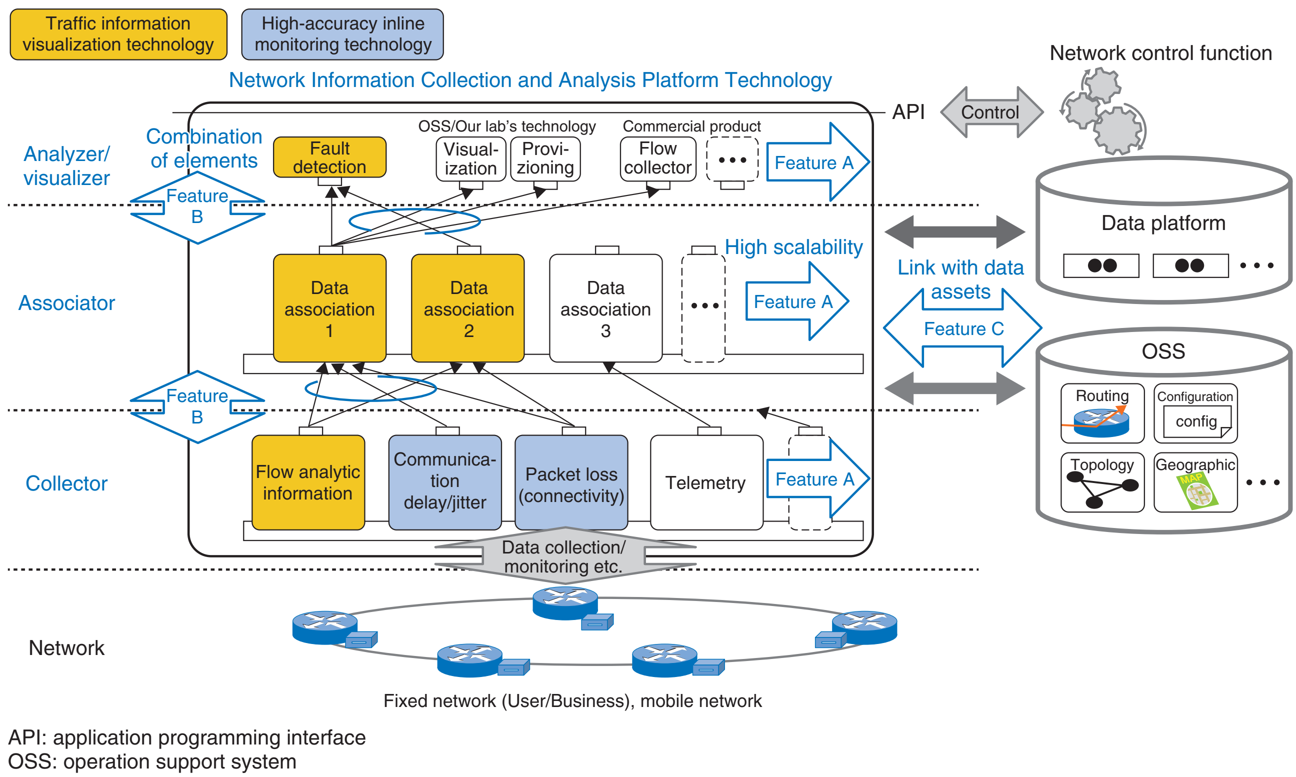


Fig. 2. Overview of Network Information Collection and Analysis Platform Technology.

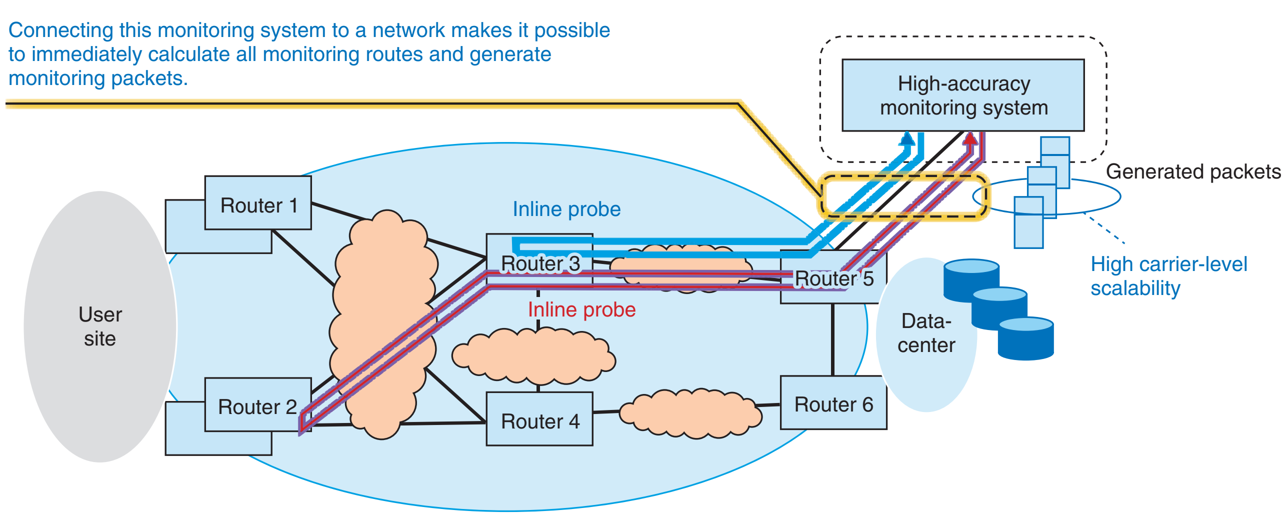
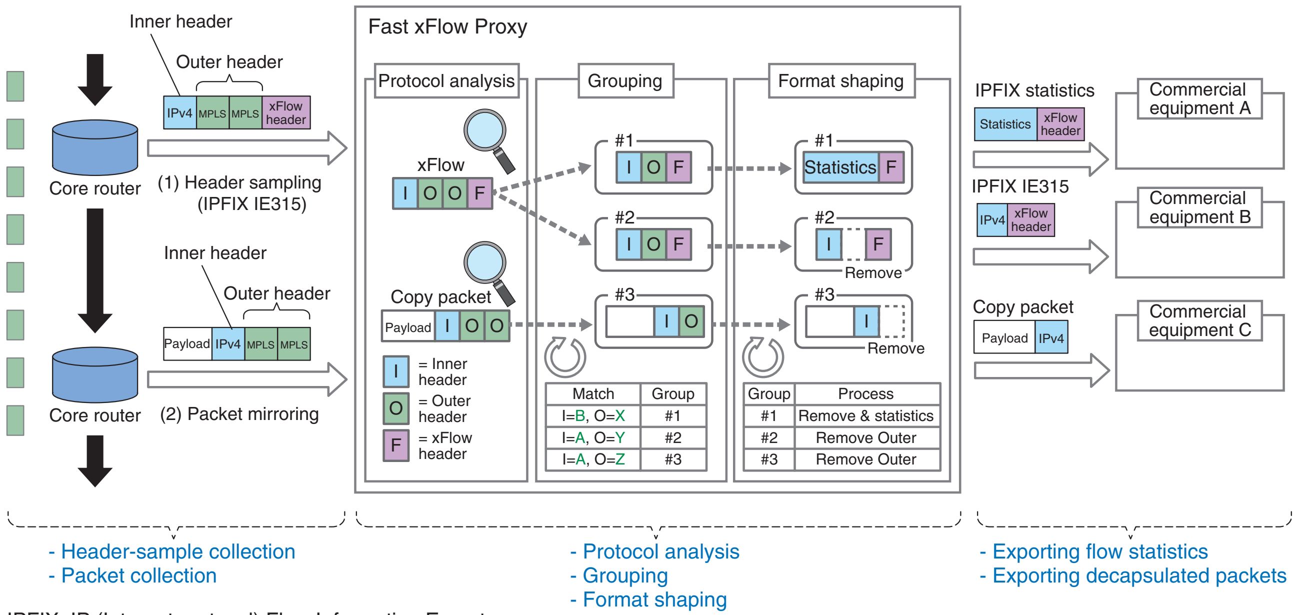


Fig. 3. Overview of high-accuracy inline monitoring technology.

increasingly important for network operation to confirm whether user communication can be transported as requested within the network.

We therefore developed a technology called Fast xFlow Proxy [2], which collects header samples and raw packets from routers and executes protocol analysis, grouping, header removal, and traffic measurement. Various flow analyses are possible by using



IPFIX: IP (Internet protocol) Flow Information Export

Fig. 4. Outline of flow-statistics collection (Fast xFlow Proxy).

the results as traffic-flow statistics as input for commercial analysis technologies (**Fig. 4**). The advantage of this technology is that these processes are accelerated using a field-programmable gate array (FPGA) and DPDK. The monitoring of carrier-level large-capacity communications will be achieved by deploying appropriate functions in both hardware and software, passing metadata from hardware to software, and providing load balancing functions to improve scalability.

By using this technology, it is possible to monitor the bandwidth of user communication and the route actually passed through, for example, in a network that provides a VPN to users on SR-MPLS (multiprotocol label switching). By comparing the current and past traffic volume of a certain user's communication and by comparing the traffic volume between users, it will be possible to identify the cause of a communication failure, i.e., the user network or carrier network.

4. Network Control Platform Technology

For practical application of the APN, NTT Network Innovation Center is researching and developing the Network Control Platform Technology. This technology controls networks efficiently in cooperation with the Network Information Collection and Analysis Platform Technology.

NTT Network Innovation Center is researching this technology on the basis of the following three requirements.

1. Dense accommodation of subscribers by using the resource pooling technology
2. Rapid service recovery
3. Easy control for various network nodes

4.1 Dense accommodation of subscribers by using the resource pooling technology

In a current commercial network, network providers consistently use the identifier of physical assignment from the subscriber-management and network-resource management systems to the network nodes. It achieves accurate accommodation with millions of subscribers. However, the consistent use of the physical identifier is a problem in that the use of the subscriber accommodation resource is not efficient, which leads to increased capital expenditure. The Network Control Platform Technology pools the resources of the network nodes and executes centralized management. The subscriber-management systems use the identifier of the virtual assignment, and this technology determines the physical assignment for efficient accommodation and translates the identifier of the virtual assignment to that of the physical assignment in accordance with the accommodation information.

4.2 Rapid service recovery

In the event of a large-scale failure such as a building-affected disaster, service provision may be suspended due to the network-node restriction in current services. The Network Control Platform Technology enables rapid service recovery by controlling network changes to other network nodes within an available resource in the pooled resources.

4.3 Easy control for various network nodes

The subscriber accommodation in the network of multi-vendor nodes has the problem that the interface implementation and configuration format of each network node differs, which requires individual configuration. The Network Control Platform Technology enables multi-vendor control by consistent configuration with a plug-in module and by flexible translation of the virtual and physical assignment identifiers.

5. Extension of control technology and target network

We are developing the following control technologies with the aim of advancing the Network Control Platform Technology and expanding its use.

5.1 Control technology using network information

Network control requires fast and appropriate recovery from sudden network failures. Therefore, we are investigating the automation of network control using real-time data from the Network Information Collection and Analysis Platform Technology. For example, when allocating traffic to optimal routes to minimize quality degradation in a real network, it is necessary to consider the reduction in route-calculation time as well as the impact on uncontrolled communications. Therefore, we implemented logic to optimize network utilization per application and minimize the communication impact of route variations. In addition to this traffic engineering, we are also considering active processing for specific traffic. This technology will automate the process from information collection and analysis to network control, which will drastically reduce operational costs.

5.2 Inter-network connection control technology

To extend the target network for control, we are investigating interconnecting different networks. Current networks are independent of fixed and mobile networks or cost-efficient networks that accommodate multiple users and quality-guaranteed networks for business, making it difficult to provide a flexible combination to meet user needs. Therefore, we are developing technology to control the connection points between networks that guarantees independence among users and technology to integrate and manage each network resource across different networks to determine the optimal interconnection point locations such as low latency routes. With these technologies, we aim to provide a secure, one-stop service for network interconnection.

5.3 White box control technology

This control technology will extend network-construction automation and network functionality for white box switches. It will enable automation of user VPN construction by managing topology information and dispatchable resource status. It will also enable the deployment of information-collection agents at arbitrary locations to extend network testing and information collection.

6. Future work

Regarding the Network Information Collection and Analysis Platform Technology, we are currently implementing the function of collecting network information, such as communication delay, packet loss, and traffic-flow statistics, for transport networks consisting of routers and switches. We will apply our elemental technologies to delay-managed transmission systems through the collection of communication delay in optical networks and integrate various types of performance-monitoring information collected from optical networks with information collected from transport networks for visualizing both network layers.

Regarding the Network Control Platform Technology, we are aiming to contribute to the actualization of IOWN by expanding the control technology of the optical layer such as cooperation with delay-managed transmission systems.

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