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KDDI R&D Labs., Inc.
Keio University
The University of Texas at Dallas
National Institute of Information and Communications Technology
NTT Communications Corporation
Red Hat K.K.
Fujitsu Limited
Ixia Communications K.K.
OA LABORATORY CO., LTD.
TOYO Corporation
Mitsubishi Electric Corporation

Successful Remote Control of Industrial Robot by Employing SDN-based Optical Network and Cloud/Edge Computing Technology

Toward the realization of a future, integrated network service

KDDI R&D Laboratories, Inc. ("KDDI R&D Labs.," President & CEO: Yasuyuki Nakajima), Keio University ("Keio Univ.," President: Professor Atsushi Seike), The University of Texas at Dallas ("UT Dallas," President: Dr. Hobson Wildenthal), National Institute of Information and Communications Technology ("NICT," President: Dr. Masao Sakauchi), NTT Communications Corporation ("NTTCom," President & CEO: Tetsuya Shoji), Red Hat K.K. ("Redhat," President and Representative Director: Hirokazu Mochizuki,), Fujitsu Limited ("Fujitsu," President & CEO: Tatsuya Tanaka), Ixia Communications K.K. ("Ixia," County General Manager: Hitoshi Ibuki), OA LABORATORY CO,.LTD. ("OA Lab.," President and CEO: Yoshiharu Yada), TOYO Corporation ("TOYO," President and CEO: Masaru Gomi), and Mitsubishi Electric Corporation ("Mitsubishi Electric," President & CEO: Masaki Sakuyama) succeeded in delivering a proof-of-concept for optimized remote control of an industrial robot by employing SDN-enabled optical networks and cloud/edge computing technology. This technology is expected to be applied to the construction of a future, integrated network service, which combines network/cloud services and a variety of kinds of applications.

This open demonstration is being conducted at the 12th International Conference on IP + Optical Network (iPOP2016) to be held in Yokohama during June 15th – 17th.

[Background]

Industrial robots have been widely deployed to achieve mass production and cost saving in the field of manufacturing. These solutions have been designed for repetitive and high-volume tasks. However, manufacturers are still seeking viable solutions for handling a variety of kinds of unstructured tasks. In addition, most robot systems are disconnected from operational systems and communication network systems as they are often operated and managed within individual departments. The development and adoption of new technologies such as high-speed flexible networks using software-defined networking (SDN)[*1] technology, cloud/edge computing technology, Internet of Things, and Machine-to-Machine technology offer new opportunities, but also pose new challenges for the manufacturing industry. For example, by being interconnected through high-speed and flexible networks, industrial robot systems and cloud/edge computing technologies could be effectively integrated to jointly carry out unstructured manufacturing tasks that require real-time and high-performance computing. If well-orchestrated, these resources can perform their assigned tasks while at the same time minimizing both data transfer latency and volume across the network.

[Project results and open demonstration outline]

This open demonstration at iPOP2016, the international conference held between June 15th and 17th, is meant to provide a proof-of-concept in which an industrial robot provides rough data to and receives detailed instructions from cloud/edge computing servers via SDN-enabled optical networks (see Fig. 1).

The robotic application chosen for the demonstration is the "surface blending" of a metal piece. The metal piece is securely placed on a bench, next to the robot arm. The task of the robot arm is twofold. It first scans the piece with a 3D sensor, sending the collected 3D rough data to a server at the edge. The server at the edge processes the rough data to reconstruct a digital image of the surface that needs to be blended. The digital image of the surface is then transmitted to a cloud server, which makes use of an appropriate set of algorithms to compute the blending path for the robot arm, defined as the sequence of movements that the robot arm has to execute in order to blend the surface with a grinding tool attached to the robot. Finally, the blending path is sent to the robot arm to be executed.

The system makes use of the Robot Operating System (ROS) framework[*2], which is designed to support robots from multiple vendors. The robot and edge server are located in Japan. The cloud server is located in the US. The advantage of this choice is twofold. First, the blending path computation can be performed at any desired location, which need not be close to the site hosting the robot arm. Second, the 3D rough data collected by the robot sensor is transferred only to the edge server over a high-speed network. Only the image of the detected surface is then sent to the datacenter server overseas. The latter transmission requires significantly less bandwidth compared to the former one. As a matter of fact, the network connection between the edge server in Japan and the cloud server in the US makes use of a low-rate virtual private network. For the network test-bed in Japan, the metro-core optical networks comprise an optical transport network[*3] controlled by a data center/cloud control system[*4] (supplied by NTTCom and Redhat) and an access network with wavelength division multiplexing systems (supplied by Fujitsu, Mitsubishi Electric, NICT, OA Lab. Ixia, and TOYO).

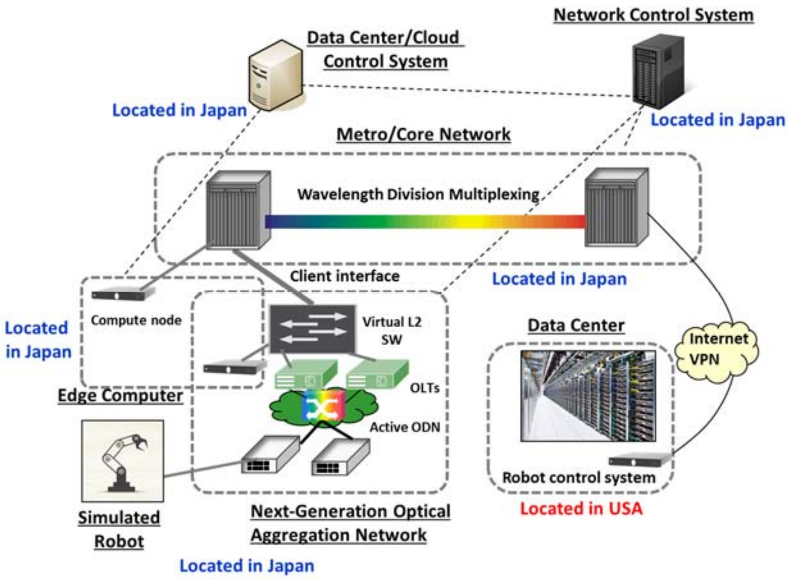

Figure 1 Demonstration configuration

The access network connecting to an industrial robot arm (a simulated version is supplied by UT Dallas), is a prototype*5 of next-generation optical aggregation network*6 (supplied by Keio Univ.). Every optical network domain in the demo is orchestrated by the network control system*7 (supplied by KDDI R&D Labs.). The network control system issues requests for provisioning paths across the three optical network domains and creating the virtual machine (VM) at the edge. More specifically, the VM creation is performed by the data center/cloud control system, while the path provisioning between the cloud, the virtual machine and the simulated robot arm is performed by each network domain controller, respectively.

This demonstration is the world's first open test*8 in which the resources required by an industrial robotic application are automatically provisioned across an SDN-based optical network and a cloud/edge computing facility.

Acknowledgments

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*1. SDN (Software Defined Networking) technology:
SDN (Software Defined Networking) technology is network technology that enables network configuration to be dynamically set and changed using software.

*2. Robot Operating System (ROS):
The Robot Operating System (ROS) is a set of software libraries and tools that help you build robot applications. http://www.ros.org/

*3. Optical Transport Network:
The Optical Transport Network is a communications network base and a network that transfers data using optical signals.

*4. Data center cloud/control system:
This system is based on OpenStack suite. OpenStack is an open source body and software that is widely used to manage and control server and cloud environments.

*5. Prototype:
The prototype supplied by Keio Univ. has been created based on the achievements of the "Research and Development of Elastic Optical Aggregation Network," a NICT-commissioned research project.

*6. Next-generation Optical Aggregation Network:
The Next-generation Optical Aggregation Network resides between the access networks for locally deployed services

and the core networks connecting communication stations. It serves as a concentrator network for all services that aggregate traffic from access networks before forwarding it to the core networks. The next-generation optical aggregation network is aimed at realizing an integrated network supporting each service using the network virtualization technology and SDN technology by extending the Fiber-to-the-Home (FTTH) technology and expanding the part where signals are converted into optical signals by integrating the aggregation network into the access network to create the active optical distribution network.

*7. Network control system:
This system has been developed based on O3 Orchestrator Suite (ODENOS). https://github.com/o3project/

*8. First open test of remote control of industrial robot by employing SDN-based optical network and cloud/edge computing technology:
This will be conducted as part of the "Research and development project on Multi-Technology Transport Network Control Technology" promoted by the Interoperability Working Group (Chair: Naoaki Yamanaka, Professor for Faculty of Science and Technology, Keio Univ.) of the Research Promotion Council of Keihanna Info-Communication Open Lab. This council has been working to contribute to the development of the economy in Kansai region by promoting research and development in the ICT field through government-industry-academia collaboration. The Interoperability Working Group consisting of 9 organizations, including KDDI R&D Labs., Mitsubishi Electric, NICT, Keio Univ. and Fujitsu, is one of the working groups of this council and has been making various proposals and performing verification on the interoperability of the next-generation optical network.

[iPOP2016 Overview]
Date: June 15–17, 2016
Venue: Fujiwara Memorial Hall, Hiyoshi Campus, Keio University Yokohama, Japan
More details: http://www.pilab.jp/ipop2016/

<Trademarks>

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