Press Release

Keio University

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Keio University

Toward Automated Quantum Network Construction
—Automatic Configuration Technology for "Plug-and-Play" Quantum Network Devices—

Associate Professor Shota Nagayama at the Graduate School of Media Design and his research team, Keio University, in collaboration with Mercari, Inc., have developed a method to automatically detect the configuration and connection status of quantum networks*1, thereby streamlining the process of automatic setup.

This research was presented at the international quantum computing conference "QCE25" on September 5, 2025, and the paper "Automatic Configuration Protocols for Optical Quantum Networks" received the Best Paper Award 2nd place in the Quantum Networking & Communications (QNET) division.

1. Main Points of Research

- Proposed an automatic configuration protocol essential for building and operating optical quantum networks.
- This protocol provides a mechanism that automatically detects and configures inter-device connection topology and performs link discovery in quantum networks. In laboratories, this work is typically performed manually.
- By automating manual tasks, the proposed technology helps enable the scaling up of quantum networks from laboratory testbeds to practical systems.
- This technology will be indispensable for the creation of large-scale distributed quantum computers that utilize a vast number of qubits, as well as the development of the quantum internet.

2. Background of Research

With the advance of quantum computers and quantum communication, the importance of "quantum networks," which connect multiple quantum computers through quantum communication channels has been steadily increasing. In a scalable quantum network, each quantum node must have its own controller; however, the management of these nodes at the control plane level is handled by the classical network. As illustrated in Figure. 1, the control plane must be aware of the connectivity of the physical quantum channels to enable proper coordination. In this context automatic configuration protocols are required to bridge the gap between the quantum physical layer and classical control plane.

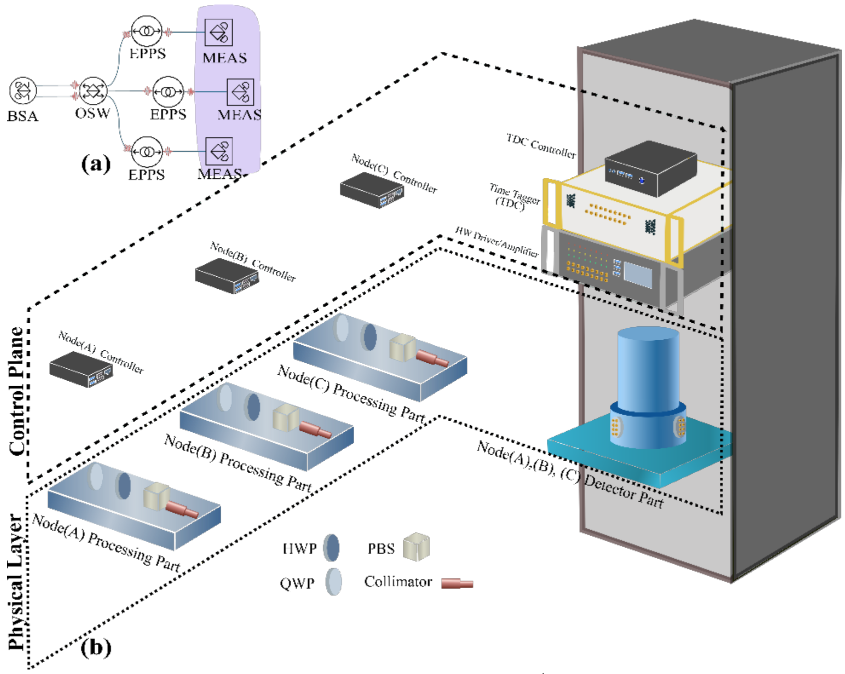

Figure 1: (a) Conceptual diagram showing three EPPS (Entangled Photon Pair Source) nodes mutually connected via an OSW (Optical Switch) node to distribute the entanglement between three quantum measurement nodes.
(b) Schematic of real implementation of the quantum measurement nodes.

3. Content of Research and Results

To address major challenges in quantum network construction, this research established the following two automatic connection verification protocols:

Challenge 1: Automatic connection verification between quantum nodes and time tagging devices (TDC*2)
・Protocols were proposed to automatically identify the connection quantum nodes and their TDC channels in the detector racks.
・Two methods were devised: a serial method (identification in sequence) and a parallel method (simultaneous identification).

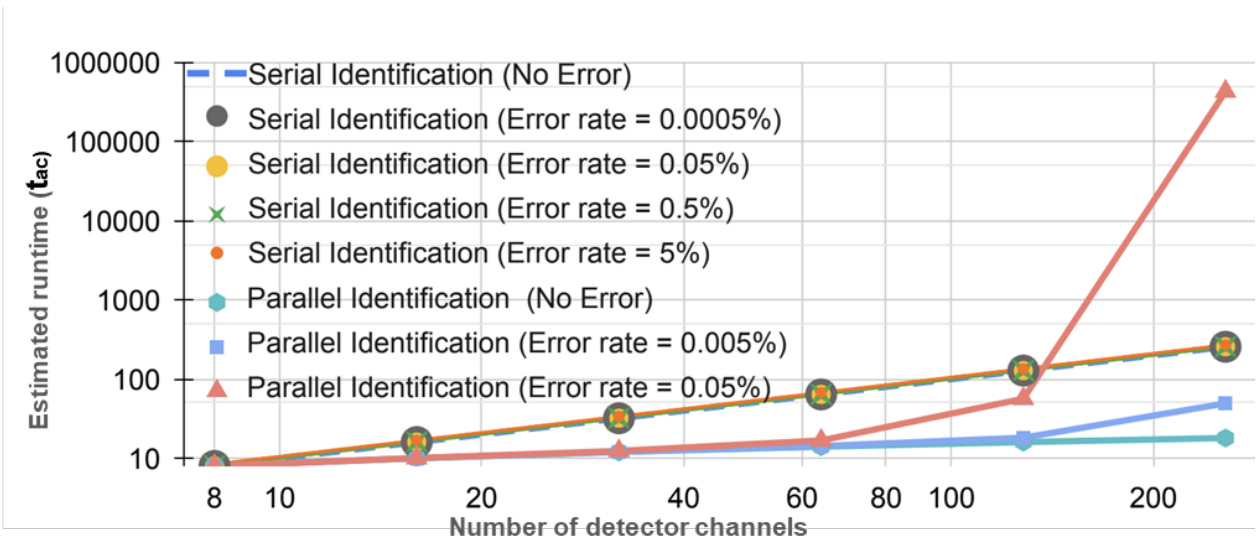

Figure 2: Performance Comparison between Serial and Parallel Methods for Automatic Connection Verification of quantum nodes and their detectors.

The parallel method is advantageous when the number of connected channels is small, but as the number increases, depending on the error rate, the serial method may become more advantageous.

Challenge 2: Automatic connection verification between quantum nodes themself, specifically optical switches[*3] and nodes

・Two protocols were proposed to automatically identify nodes connected to optical switches.

・Identification methods using optical pulses and patterns, as well as confirmation procedures via message exchange, were designed.

The first approach automates the standard procedure typically followed by experimentalists: starting from the light source, verifying the presence of light, and then sequentially checking each part of the optical setup until the light reaches the detector. Another method is a pattern-decoding approach, where each node generates a unique physical-layer pattern and uses the classical network to retrieve the associated node and port identifiers.
These technologies enable automatic detection of quantum network configurations and connection states, replacing manual work. This improves experimental efficiency and helps make large-scale quantum network systems a reality.

4. Future Developments
Moving forward, the proposed protocols will be implemented in actual quantum network experimental systems to evaluate their practicality and performance. Based on these results, further development will focus on automation technologies for quantum networks, such as topology detection, link quality monitoring, resource management, and routing, aiming for application to larger-scale quantum networks and commercial services.

5. Special notes
<Details of Journal Article>
Amin Taherkhani, Andrew Todd, Kentaro Teramoto, Rodney Van Meter, and Shota Nagayama,
"Automatic Configuration Protocols for Optical Quantum Networks" in Proc. IEEE Int. Conf. Quant. Comput. Eng. (QCE), 2025.
https://arxiv.org/abs/2504.19613

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<Glossary>
***1. Quantum Network:**
A network that connects quantum computers and quantum communication devices using entangled photon pairs to exchange quantum information.
***2. TDC (Time-to-Digital Converter):**
A time tagging device that records the occurrence time of events with high precision. In this research, it records the time when photons are detected.
***3. Optical Switch:**
A device that switches the path of optical signals. In quantum networks, it enables dynamic changes in connections between nodes.

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