



# Software Development for a Full-stack Quantum Computer

Inho Jeon, Jieun Choi and Hoon Ryu\*

Korea Institute of Science and Technology Information (KISTI), Daejeon 34141, Republic of Korea

\* Corresponding author (E: [elec1020@kisti.re.kr](mailto:elec1020@kisti.re.kr))

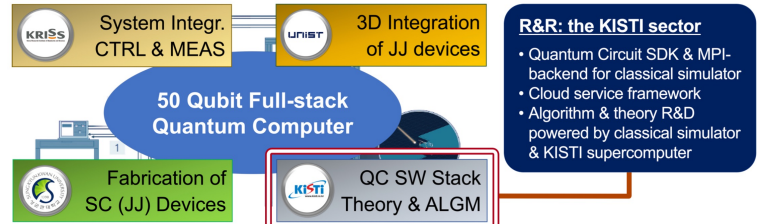
## INTRODUCTION

### A Cloud-based Quantum Computing (QC)

- Full-stack quantum computers are available and can be accessed with a cloud-based service framework.
  - IBM Q Experience** presents up to 433-qubit gate-based quantum computers based on superconductor circuits.
  - IonQ** presents up to 31-qubit programmable quantum computers based on trapped ions.
  - Xanadu Borealis** is a photonic quantum computers that presents up to 216 squeezed-state qubits.
- Each of above quantum computers has its own software-development-kit (SDK) and can be programmed with a web-embedded JupyterLab interface.

### The National Flagship Project for QC in Korea

- Develop a full-stack & circuit-based 50-qubit where qubits are encoded to electron charges in Josephson junction (JJ) arrays; Project carried by a consortium consisting of the four national research institutes

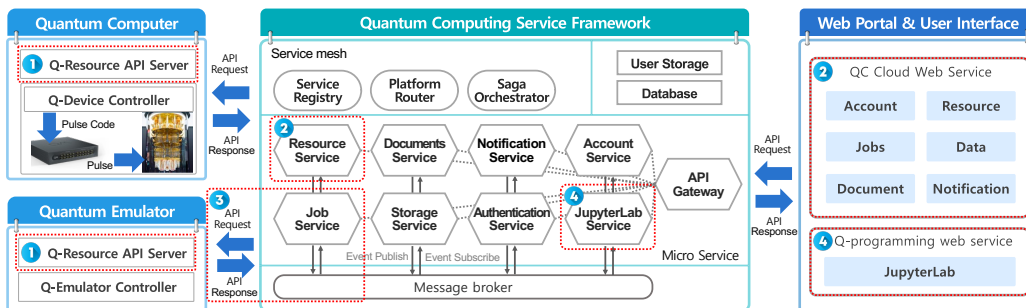


[The national research consortium working on the development of a 50-qubit full-stack QC & R&R of the KISTI sector]

## KISTI-POWERED QUANTUM COMPUTING SERVICE FRAMEWORK

### Platform-neutral Cloud-based Service Framework

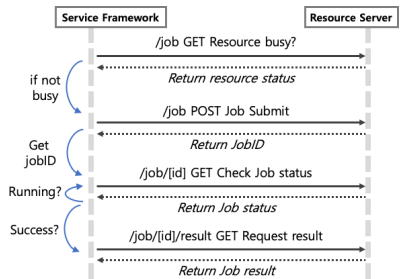
- Prototype-development has been just completed (2023 February 27<sup>th</sup>).
- Web Portal** presents interfaces for six user-level service components.
- Service Framework** has 8 "back-end" service components that process requests from users.
- Resource API server** is in charge of communication between framework & quantum resources.



[The conceptual illustration showing technical details of the KISTI-powered quantum cloud service framework]

### 1 Resource API Server

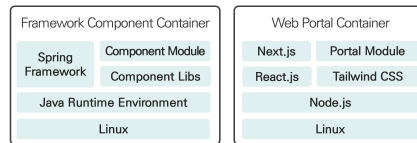
- A server that can communicate with various quantum resources using a single set of REST API's
  - Job submission & status
  - Status of quantum resources
  - Data request & transfer



[Communication between resource server & framework]

### 2 Common Component

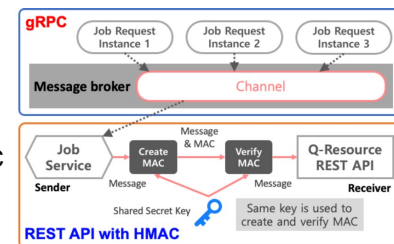
- Common service-components optimized to cloud infrastructure for efficiency in development & management
- Web portal (containers) running in separated infrastructure (web servers)



[Common components developed in our service framework]

### 3 API Communications

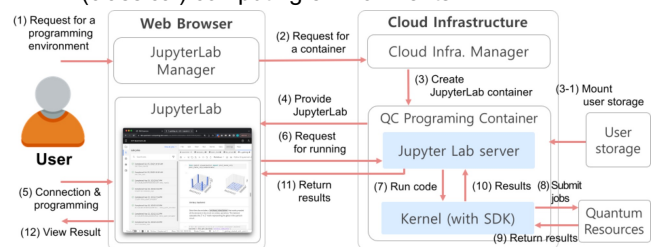
- Communications among service components in a framework: gRPC
- Communications between the framework & quantum resources: REST API with HMAC for security



[API Communications in our service framework]

### 4 Web Interface for QC Programming

- JupyterLab-based programming interface (Python)
- Virtualized programming environment for each user
- SDK for quantum circuit programming: PENNYLANE
  - We do MPI parallelization for QC emulations in huge (classical) computing environments



[End-to-end workflow of quantum circuit programming in our service framework]

## ACKNOWLEDGEMENTS

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