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A Hybrid Reference Architecture for Cloud-based Quantum Computing Microservices with an Aerial-Ground Cooperative Robot Mapping Use Case

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The increasing accessibility of quantum computing technology has opened up new avenues for exploring their potential applications in various scientific fields such as artificial intelligence, manufacturing, and finance. Many research scientists heavily depend on cloud computing infrastructures for their investigations. However, accessing actual quantum hardware resources, often located remotely, involves deploying and configuring different software components.

In this demonstration, we present our reference architecture [1,2], which combines cloud computing and quantum resources for easier initiation of experiments across diverse quantum compute resources. Our solution simplifies distributed quantum computing simulations in traditional cloud environments and provides access to remote quantum compute resources. The reference architecture is portable and adaptable to different cloud platforms, offering efficient utilization and application opportunities for research communities. It incorporates essential quantum software development kits (SDKs) with machine learning support and access to various quantum devices. Furthermore, we provide practical examples serving as references for constructing solutions to predefined problems. Our reference architecture prioritizes a user-friendly interface.

Additionally, our reference architecture enables continuous deployment of quantum applications, allowing seamless orchestration with traditional cloud-based applications. These quantum applications are deployed as microservices, accessible through standard REST APIs following open standards. This combination simplifies the design and deployment of quantum services, showcasing the effective utilization of standard methodologies from traditional service-oriented computing in this hybrid context.

The reference architecture is deployed amongst others within the National Laboratory for Autonomous Systems in Hungary [3] (abbreviated as ARNL) and within the National Research on Hydrogen-Powered, Cooperative Autonomous Remote Sensing Devices and Related Data Processing Framework project (TKP2021-NVA-01). We would like to demonstrate our reference architecture through a selected use case involving global route planning for autonomous vehicles such as unmanned ground vehicles (UGVs).

The aerial-ground cooperative mapping system aims to construct a comprehensive 3D model of an unknown environment by leveraging the perspectives of different agents. Drones enable rapid exploration, but it may result in incomplete 3D reconstructions due to limited aerial coverage. Aerial robot-collected data is used in structure from motion (SfM) pipelines to create initial 3D reconstructions. To address the aforementioned issue, we propose automatically locating unmapped regions and guiding the ground robot to complete the 3D model. Leveraging the initial aerial 3D model, we determine the shortest traversable paths between unmapped regions and utilize quantum computing to generate an optimal global route.

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[1] Quantum | HUN-REN Cloud - https://science-cloud.hu/en/reference-architectures/quantum
[2] A. Cs. Marosi, A. Farkas, T. Máray and R. Lovas, "Toward a Quantum-Science Gateway: A Hybrid Reference Architecture Facilitating Quantum Computing Capabilities for Cloud Utilization," in IEEE Access, vol. 11, pp. 143913-143924, 2023, doi: 10.1109/ACCESS.2023.3342749.
[3] National Laboratory for Autonomous Systems - https://autonom.nemzetilabor.hu/

Topic

Needs and solutions in scientific computing: Platforms and gateway

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