Team Name - Double Epsilons

Leader Name – Nitanshu Tak

Member Name- Daksh Mehrotra

College – UPES, Dehradun

Quantum-Enhanced Cloud Resource Optimization

Abstract

By being the infrastructure of digital services in the modern world, cloud computing platforms such as AWS are used by applications ranging from e-commerce to AI. With increasing adoption of clouds, providers are faced with the challenge of efficient allocation of compute, storage, networking resources, and workload variety. Resource allocation in the cloud is an NP-hard optimization problem balancing cost-efficiency, energy usage, and service-level agreements (SLAs) at large demand levels. They are constrained to bottlenecks caused by traditional solvers, such as linear programming, or heuristics that do not scale well with real-life workloads, giving inferior allocations on larger problems. And this impacts performance and costs for the customers.

Quantum computing offers a potentially promising approach to tackle such high-complexity optimization problems. Algorithms such as Quantum Approximate Optimization Algorithm (QAOA) and Variational Quantum Eigensolver (VQE) are of special interest for situations where large search spaces are efficiently explored. Quantum algorithms make use of superposition and entanglement to evaluate multiple possibilities simultaneously rather than exhaustive testing of configurations, thus identifying better allocation strategies much faster than classical methods. In this respect, being hybrid quantum-classical methods enable us to profit from the best that both paradigms offer, with classical pre-processing cutting down the problem size and quantum solvers dealing with the toughest optimization levels.

We design a Quantum-Cloud Resource Scheduler (QCRS) hybrid framework embedded in the AWS cloud ecosystem. The solution treats resource allocation as an optimization problem, encoding workload requirements, resource availability, and cost/latency constraints into a Hamiltonian. QAOA processes this assignment through quantum simulation backends or real quantum backends via Qiskit Runtime to determine near-optimal allocations. To make the solution practical, QCRS operates as a hybrid pipeline: AWS-autoscaling plus classical solvers carry out baseline scheduling, leaving the quantum layer to tackle complicated, large-scale optimization problems.

This is the core design principle. QCRS interfaces with Amazon Elastic Kubernetes Service (EKS) or AWS Batch, thereby promoting autoscaling and job placement decisions. And the use of AWS Braket that provides managed access to quantum hardware and simulators ensures smooth deployment of QAOA in the AWS universe of services, thus creating a cloud-native quantum resource scheduling pipeline, which fits into AWS's innovation and customer-centric effectiveness.

That basically means it works like a charm. QCRS improves infrastructure utilization, lowers energy consumption, and reduces operational costs for cloud providers. For customers, it cuts down on job completion times, lowers the bills for services, and enhances the overall user experience. More broadly speaking, this project represents the very first industrial application of hybrid quantum-classical algorithms encountered in real-world cloud challenges, thus building the bridge between academic quantum R&D and enterprise-level quantum adoption.

What distinguishes this proposal is the idea of novelty and scalability. While quantum optimization has been utilized in the finance and logistics sectors, applying quantum optimization to cloud resource scheduling represents an under-explored yet highly important frontier. The project can begin from simulated workloads (e.g., AWS public datasets or traces from real-world job logs) and evolve into live integration with cloud orchestration tools. It is such an iterative development approach that ensures viability within a hackathon timeframe while laying the foundations for longer-term applications.

In summary, Quantum-Enhanced Cloud Resource Optimization offers a futureready solution that combines AWS cloud infrastructure with quantum optimization techniques. By reimagining classical scheduling bottlenecks through quantum innovation, this proposal delivers a unique, impactful, and technically grounded contribution to the hackathon's vision of learning and experimentation.
