Reproducibility Report for the Paper: "*A Digital Twin of Scalable Quantum Clouds*"

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ABSTRACT

All badges available in this process are awarded to the paper *A Digital Twin of Scalable Quantum Clouds*. The paper artifact is available and functional. The results claimed in the paper could be reproduced successfully. The artifact includes a brief description of how to use its classes and provides API documentation, although this documentation is not explicitly referenced. Nevertheless, it fulfills the requirements for the Reusable badge. The lack of comprehensive test coverage for the proposed framework represents a potential weakness of this artifact.

CCS CONCEPTS

• **General and reference** → Empirical studies; *Experimentation*; **Validation**; **Verification**.

KEYWORDS

Replication of Computational Results, ACM SIGSIM PADS 2025

ACM Reference Format:
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1 INTRODUCTION

The paper *A Digital Twin of Scalable Quantum Clouds* [1] presents a framework designed to model and simulate the behavior of quantum cloud systems. For doing that, the framework exposes the cloud infrastructure as digital twins. The paper then exposes two use cases as a proof-of-concept for the proposed framework.

2 EVALUATION RESULTS

2.1 Software download and installation

The companion artifact is publicly available on Zenodo[1]. The artifact is a python project, shared using GitHub, that correctly contains `.gitignore` and `LICENCE` files. The documentation on how to use and reproduce the experiment is provided in the `README.md` file.

To reproduce the experiment, the artifact was downloaded from the GitHub repository[2], according to `README.md` instructions.

Since the repository is archived on Zenodo, the *Available* badge is awarded.

The documentation specified in the *README.md* is complete.

2.2 Quality of the artifact

The documentation allows to reproduce the experiments described in the paper, thus justifying the *Artifacts Evaluated—Functional* badge.

The artifact can be executed both from the CLI and as a Docker container. For the CLI execution, the artifact specifies the dependencies required to execute and reproduce the experiment, thus increasing the confidence for future reproducibility and re-purposing of this experiment.

The artifact documentation includes a brief section explaining how the framework can be adopted for running simulations. Upon closer inspection, it is evident that the framework properly exposes its API documentation; however, this is not referenced within the main documentation. Nonetheless, the artifact meets the criteria for the *Artifacts Evaluated—Reusable* badge.

In my opinion, a notable concern with this artifact is the lack of test coverage, because the artifact does not only provides the source code for the experiment but also includes the framework implementation that enables it. To increase robustness, the framework should be thoroughly tested, which is not the case here. I was able to find only a single test covering one domain-specific element of the framework, while the remaining classes are not tested at all. Although testing alone does not guarantee the correct behavior of a code-base, their presence helps to ensure that the classes are free from implementation mistakes. This is especially important when providing a framework intended for community use.

2.3 Replicating the experiments

The artifact has no explicit requirement for computational resources to run the experiment. Thus, the experiment was reproduced using an Intel(R) Core(TM) i7-8565U CPU @ 1.80GHz with 8 physical threads. The results claimed in the paper were replicated as expected, as shown by figures. The main difference in the results obtained is a different format for figures, but they highlight the same results.

- **Table 1** does not require replication, as intended for describe comparison among the proposed framework and others preexisting in literature.

[1]https://doi.org/10.5281/zenodo.15232883

[2]https://github.com/quantumcloudsim/SigSim2025

- **Figure 1** does not require replication, as intended to describe how a quantum circuit works.
- **Figure 2** does not require replication, as intended for describing the framework layered architecture.
- **Figure 3** does not require replication, as intended for describing the framework ecosystem.
- **Figure 4** does not require replication, as intended to desribe different scheduling algorithm available in the framework.
- **Figure 5** does not require replication, as intended for describing the process of task allocation to qubit topology.
- **Table 2** does not require replication, as describes the resources available in the devices used in the simulation.
- **Figure 6** is correctly reproduced.
- **Figure 7** is correctly reproduced.
- **Figure 8** is correctly reproduced.

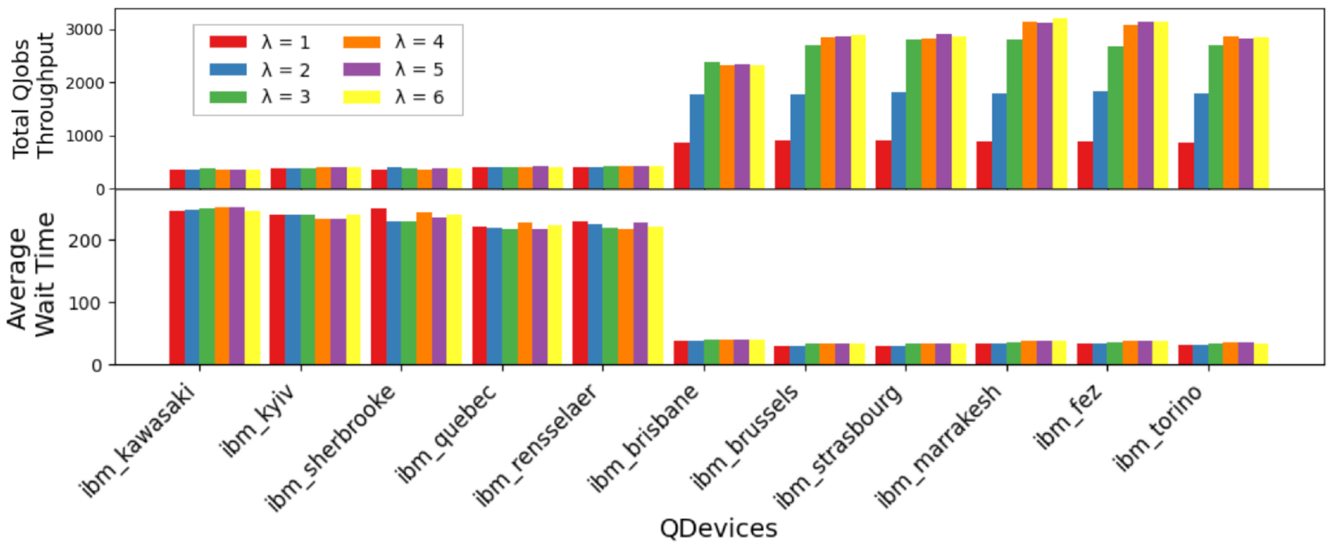
3 CONCLUSIONS

After the evaluation process, the following badges are assigned to the artifact:

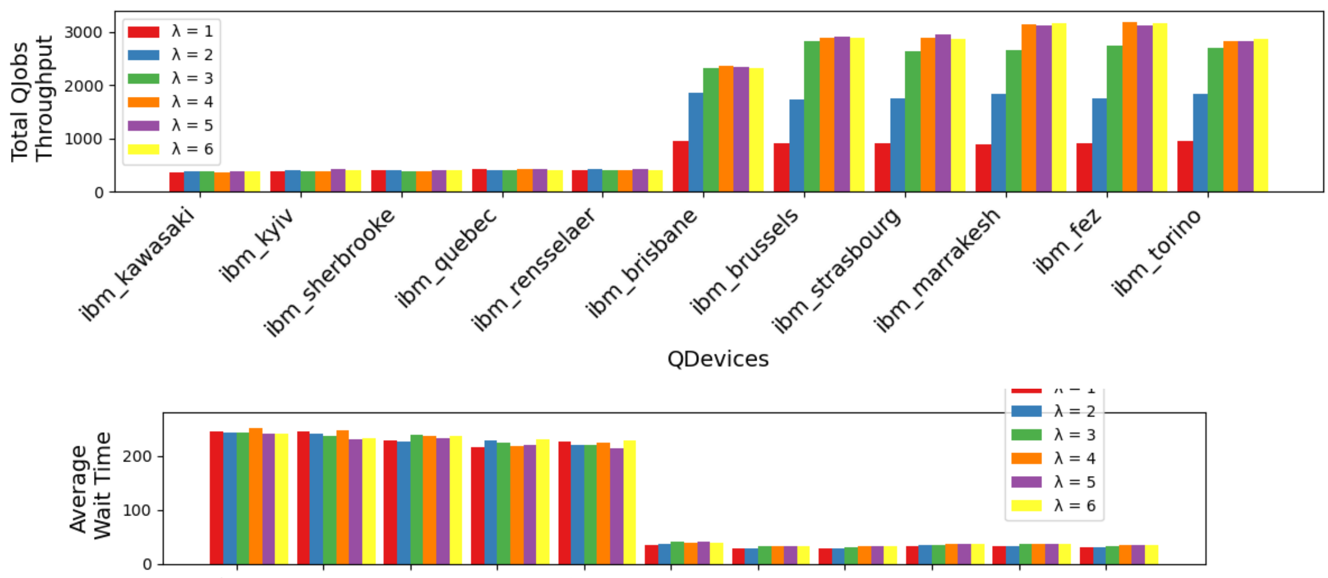
- *Artifacts Evaluated - Functional*
- *Artifacts Evaluated - Reusable*
- *Artifacts Available*
- *Results Reproduced*

REFERENCES

[1] Waylon Luo. 2025. A Digital Twin of Scalable Quantum Clouds. In *Proceedings of the 2025 ACM SIGSIM Conference on Principles of Advanced Discrete Simulation (PADS)*. ACM Press.

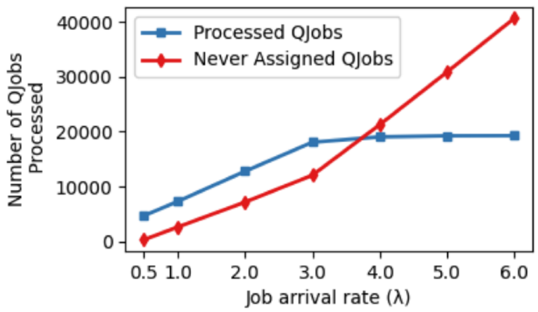


(a) Original.



(b) Reproduced.

Figure 6: Comparison of total QJob throughput (top panel) and average wait time (bottom panel) across different quantum devices (*QDevices*) for varying arrival rates ($\lambda = 1$ to $\lambda = 6$). Each bar color corresponds to a specific arrival rate, as indicated in the legend. The figure highlights the variation in device performance and queue behavior across a range of arrival intensities, with devices like *ibm_kawasaki* and *ibm_rensselaer* demonstrating lower throughput while exhibiting higher wait times.



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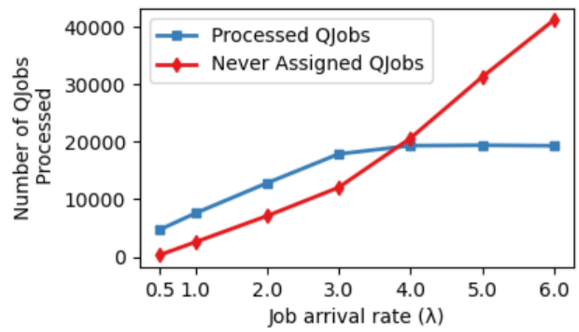
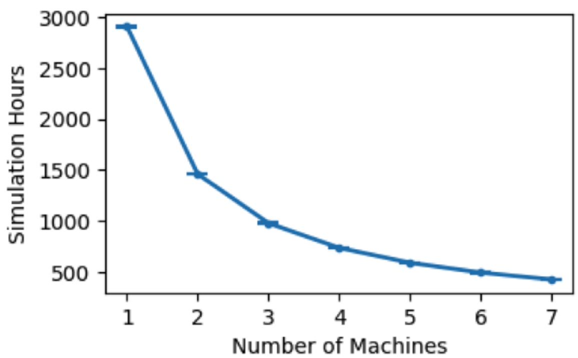
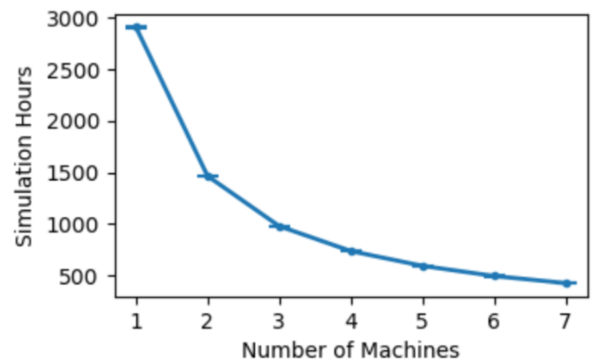


(b) Reproduced.

Figure 7: Number of QJobs processed and never assigned with varying job arrival rate (λ). The blue line with square markers represents the total number of processed QJobs, while the red line with diamond markers indicates the number of QJobs that were never assigned to a quantum device.



(a) Original.



(b) Reproduced.

Figure 8: Simulation time to process 50,000 QJobs vs. Number of IBM_strasbourg machines.