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QC Benchmarks: A Critical Element to QC Progress

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RECENT DEVELOPMENT

Researchers at the University of Science and Technology of China (USTC), recently [published](#) a paper that outlined their efforts to execute a random circuit sampling (RCS) test on their 105 qubit *Zuchongzhi 3.0* quantum processor unit (QPU). The paper, appearing in the APS Physical Review Letters, reported that the QPU achieved 10^6 samples in just a few hundred seconds, a task cited as infeasible on the most powerful classical supercomputers today and that USTC researchers claimed would require the US DOE's Frontier HPC approximately 5.9×10^9 years to replicate. This follows a similar Google announcement [made](#) late last year that their 105 qubit *Willow* QPU performed a similar RCS test in under five minutes, which Google researchers said would have taken one of the fastest supercomputers 10^{25} years, a number that greatly exceeds the age of the universe. Other QC vendors, including US-based Infleqtion, Quantinuum, and Rigetti, also reference the RCS benchmark in their technical documentation.

ANALYST COMMENT

Random circuit sampling is one of many performance benchmarks that are currently being explored across the QC community. Advocates indicate that it appropriately highlights the potential of quantum computers to perform at a level intractable on classical counterparts, demonstrating near-term quantum superiority on NISQ systems, while being essentially QC modality and architecturally agnostic. Detractors note that the benchmark artificially emphasizes the performance strengths of quantum systems and the weakness of classical systems. Perhaps more important, they also warn of the limited potential RCS has for real world applications.

In these early days of QC system development, there are numerous benchmarks vying to become an industry standard, and RCS does incorporate a number of important QC characteristics, such as qubit count, gate fidelity, and coherence times. However, care must be taken to ensure that appropriate benchmarks come to the fore that can help potential QC end users realistically determine which QC systems offers the best performance potential for their most important workloads. More expansive QC benchmark suites, such as US-based QED-C's Application-Oriented Performance Benchmarks, can provide additional insights to help both the QC supplier sector and end user base make better informed, targeted decisions on specific QC performance potential as well as more accurately characterize QC sector-wide performance gains over time.

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