Limitations on feasibility of satellites for distributed quantum computer networks

S Srikara[a,1]

[a] *Centre for Quantum Software and Information, Faculty of Engineering and Information Technology, University of Technology Sydney, Ultimo, NSW - 2007*

Distributed Quantum Computing is a compelling approach towards the realization of Quantum Internet [1]. To enable distributed quantum computing, participating quantum computers (hosts) need to be connected to each other on a network. The most versatile way of enabling such a network is via quantum entanglement distribution [2]. The usage of satellites for distributing entanglement has been studied in the context of Quantum Key Distribution and Quantum Teleportation [3], but the expediency of satellite-based entanglement distribution for the purposes of Distributed Quantum Computing remains to be probed. In this work, we investigate the feasibility of satellites for distributing entanglement between two error-corrected quantum computers located at varying distances. We show that even under the most optimistic considerations, satellites require a power rating that is multiple orders of magnitude higher than that of any known satellite today for the purposes of entanglement distribution for executing a distributed quantum algorithm at continental and transcontinental distances (Fig. 1), thus imposing limitations on the feasibility of satellite-based entanglement distribution.

For our calculations, we consider the Shor's prime factorization algorithm as the standard scalable distributed quantum algorithm for reference. Since topologically encoded quantum computers provide a high level of robustness in terms of logical qubit coherence and error tolerance, we consider topological lattice-surgery-based surface-code error-corrected quantum computers [4] separated by varying distances. For entanglement generation, we consider a waveguide integrated AlGaAs-on-insulator micro-resonator [5] which is the brightest bell-pair generation source at the time of writing, fitted as a payload into the satellite. For the satellites, we consider the most powerful Indian Satellites as the satellite power data for the satellites of other space organizations is not publicly available to the best of our knowledge. Our findings indicate that for continental distances (1000-5000 km), the algorithm would take the order of a few months to execute, whereas for transcontinental distances (>5000 km), the execution would take the order of a few years, which makes satellites inapplicable for distributed quantum computing at these distances.

[1] Presenting Author, Work done in Collaboration with Hudson Leone and Simon Devitt from CQSI, FEIT, UTS

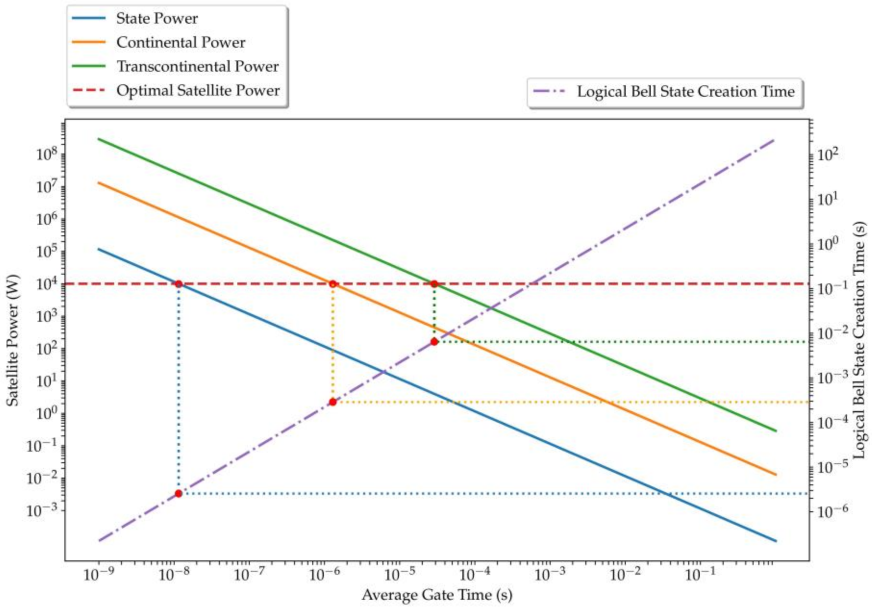

Fig.1: The required satellite power for different distance ratings overlaid with vertical lines representing average gate times for common qubit architectures and a horizontal line representing our estimate for the most powerful commercial satellites

References:

[1] Cuomo, Daniele, Marcello Caleffi, and Angela Sara Cacciapuoti. "Towards a distributed quantum computing ecosystem." *IET Quantum Communication* 1.1 (2020): 3-8.

[2] Kimble, H. Jeff. "The quantum internet." *Nature* 453.7198 (2008): 1023-1030.

[3] Yin, Juan, et al. "Satellite-based entanglement distribution over 1200 kilometers." *Science* 356.6343 (2017): 1140-1144.

[4] Horsman, Clare, et al. "Surface code quantum computing by lattice surgery." *New Journal of Physics* 14.12 (2012): 123011.

[5] Xie, Weiqiang, et al. "Ultrahigh-Q AlGaAs-on-insulator microresonators for integrated nonlinear photonics." *Optics Express* 28.22 (2020): 32894-32906.