



## S-QGPU: Shared Quantum Gate Processing Unit for Distributed Quantum Computing

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*Coffee and snacks served before seminar*

**Zoom Link:** <https://purdue-edu.zoom.us/j/95283400606>

### **Abstract:**

Due to many physical constraints, it is extremely challenging to build a monolithic fully connected quantum computer with a very large number ( $N$ ) of qubits, in which a direct control gate operation can be performed between two arbitrary qubits. Extending from  $N$  to  $N+1$  in such a quantum computer is more than just physically adding one more qubit. For this reason, the cost of such a fully connected quantum computer increases exponentially as the number of qubits increases. On the other side, connecting two  $N$ -qubit remote quantum computers classically, the dimension of their combined Hilbert space is only  $2 \times 2^N = 2^{(N+1)}$ . If they are fully connected through quantum links, the dimension of the combined Hilbert space could reach  $2^{(2N)}$  which is much more powerful than two independent quantum computers. Consequently, there is a growing interest in exploring distributed quantum computing (DQC) systems that can interconnect many small-sized, cost-effective local quantum computers. In most conventional DQC architectures, each local quantum computer is equipped with additional communication qubits dedicated to establishing remote entanglement links. The presence of these communication qubits not only substantially increases the cost of individual local quantum computer nodes, but also renders the entanglement-communication-based scheme inherently non-deterministic. In this talk, we propose a DQC architecture in which individual small-sized quantum computers are connected through a shared quantum gate processing unit (S-QGPU). The S-QGPU comprises a collection of hybrid two-qubit gate modules for remote gate operations. In contrast to conventional entangled-communication-based DQC systems, S-QGPU effectively pools the resources together for remote gate operations, and thus significantly reduces the cost of not only the local quantum computers but also the overall distributed system. Moreover, S-QGPU's shared resources for remote gate operations enable efficient resource utilization. When not all computing qubits in the system require simultaneous remote gate operations, S-QGPU-based DQC architecture demands fewer resources, further decreasing the overall cost. Unlike conventional DQC architectures based on entanglement communication, wherein remote gate operations are accomplished via teleportation or cat-entanglers, the proposed S-QGPU approach for remote gate operations is deterministic and does not depend on any measurement-based post selection.

### **Bio:**

Dr. Shengwang Du is in the transition from The University of Texas at Dallas to Purdue University (*Elmore Family School of Electrical and Computer Engineering, and Department of Physics and Astronomy*). Dr. Du's interdisciplinary and cross-field research activities range from fundamental quantum physics to applied engineering, including AMO physics, quantum optics, atom chip and atomtronics, quantum networks, quantum computing, quantum sensing, optical neural networks for artificial intelligence, optical microscopy for solid mechanics and bioimaging. Dr. Du's PhD work on atom chips made an important contribution to the start-up of ColdQuanta (now renamed as Infleqtion), a leading company in cold atom technologies and neutral atom quantum computing. Dr. Du is a co-founder of the Light Innovation Technology USA Inc for developing and commercializing advanced optical microscopies and bioimaging techniques. Dr. Du is a Fellow of The American Physical Society (APS) and a Fellow of Optica (formerly The Optical Society of America - OSA).