Distributed quantum computing

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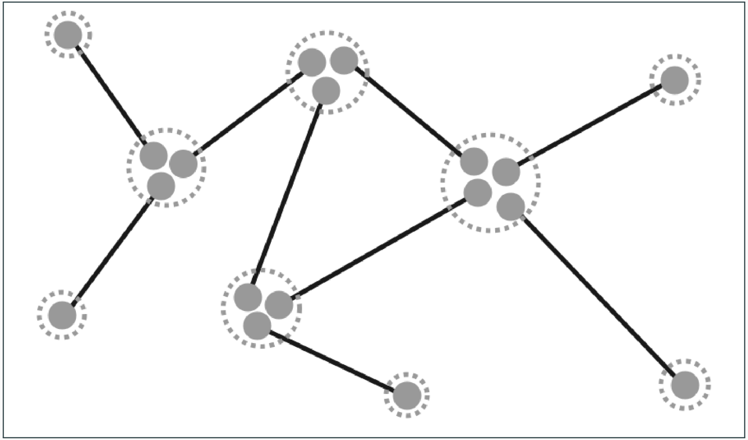
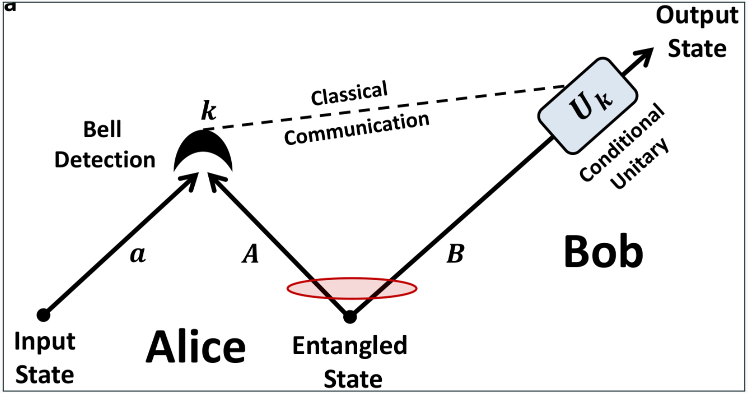


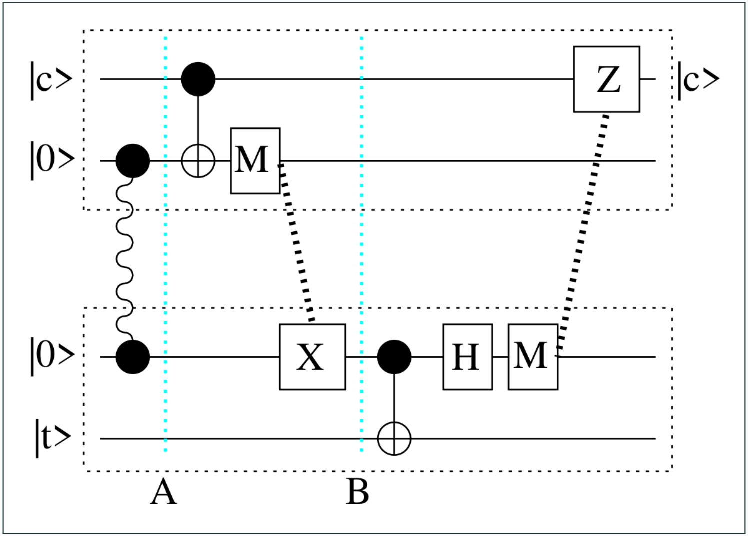
Clément Meignant, Damian Markham, and Frédéric Grosshans. **"Distributing Graph States Over Arbitrary Quantum Networks".** In: *Physical Review A* 100.5 (Nov. 27, 2019), p. 052333.
Richard Jozsa and Noah Linden. **"On the role of entanglement in quantum-computational speed-up".** In: *Proceedings of the Royal Society of London. Series A: Mathematical, Physical and Engineering Sciences* 459.2036 (Aug. 8, 2003), pp. 2011–2032.

Quantum teleportation



Stefano Pirandola et al. **"Advances in Quantum Teleportation".** In: *Nature Photonics* 9.10 (Oct. 2015), pp. 641–652.

Cat gadgets



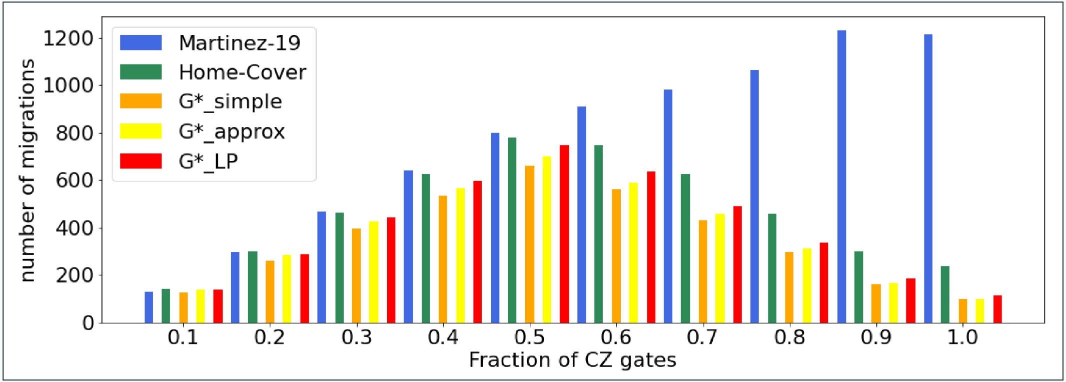
Anocha Yimsiriwattana and Samuel J. Lomonaco Jr. **“Generalized GHZ States and Distributed Quantum Computing”.** In: *arXiv:quant-ph/0402148* (Mar. 11, 2004).

Cat gadgets (cont.)

$$|c\rangle = \alpha\,|0\rangle + \beta\,|1\rangle \mapsto \alpha\,|00\rangle + \beta\,|11\rangle$$

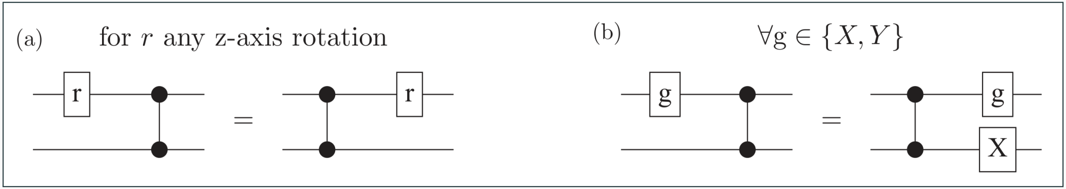
Anocha Yimsiriwattana and Samuel J. Lomonaco Jr. **"Generalized GHZ States and Distributed Quantum Computing".** In: *arXiv:quant-ph/0402148* (Mar. 11, 2004).

Previous work on the distribution problem



Ranjani G Sundaram, Himanshu Gupta, and C. R. Ramakrishnan. **"Efficient Distribution of Quantum Circuits".** In: *35th International Symposium on Distributed Computing (DISC 2021)*. Ed. by Seth Gilbert. Vol. 209. Leibniz International Proceedings in Informatics (LIPIcs). ISSN: 1868-8969. Dagstuhl, Germany: Schloss Dagstuhl – Leibniz-Zentrum für Informatik, 2021, 41:1–41:20.

Circuit optimisation before distribution



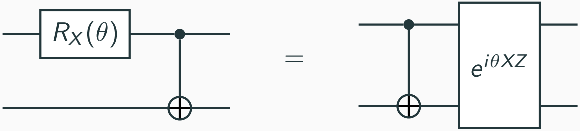
Pablo Andrés-Martínez and Chris Heunen. **"Automated distribution of quantum circuits via hypergraph partitioning".** In: *Physical Review A* 100.3 (Sept. 5, 2019), p. 032308.

Difficulties and early results

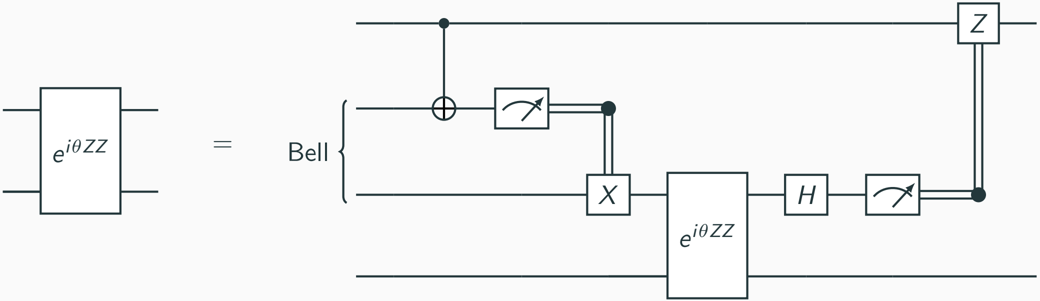
- This question has many similarities to the problem of 2-gate reduction.
- A lot of work has been done on the problem of T-count reduction, not so much for 2-gate reduction
- There is some tension between 2-gate optimisation and distributivity: sometimes gate optimisations actually increase the cost of distribution.

Pauli exponentials

- Recall: Bloch sphere rotations are exponentials of Pauli operators
  - e.g. $R_X(\theta) = \exp(i\theta X)$
- The action of the Clifford group on such exponentials is to add more terms in the exponential:

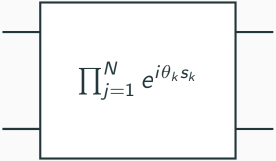


Pauli exponentials using cat gadgets



Distributing Pauli exponentials

- a natural problem to consider: distributing Pauli exponentials

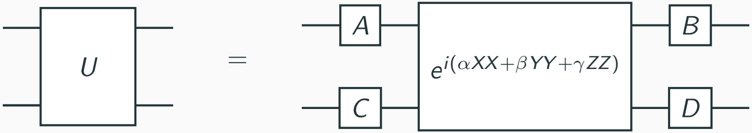


where each s_k is a generalised Pauli

- problem: there is no reason to believe that these exponentials remain small enough to run on a single processor!

Decomposing 2-gates as exponentials

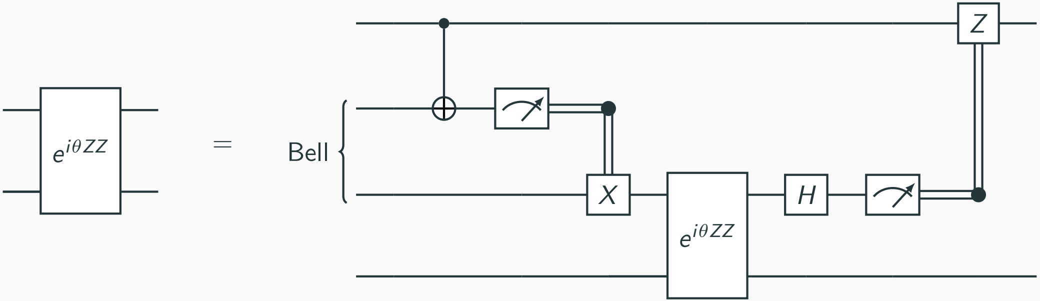
- 2-qubit unitary gates can be decomposed in terms of Pauli exponentials:



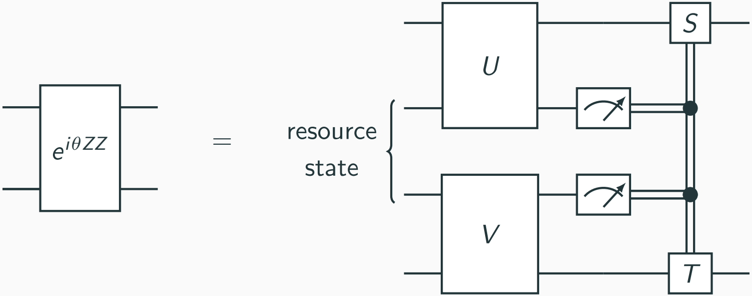
where A, B, C, D are arbitrary 1-qubit unitaries

- Can we do it with a less entangled resource state?

Pauli exponentials using cat gadgets (again)



Low entanglement protocol?



Questions?