Quantum Computing for Power Grid Analysis and Simulation

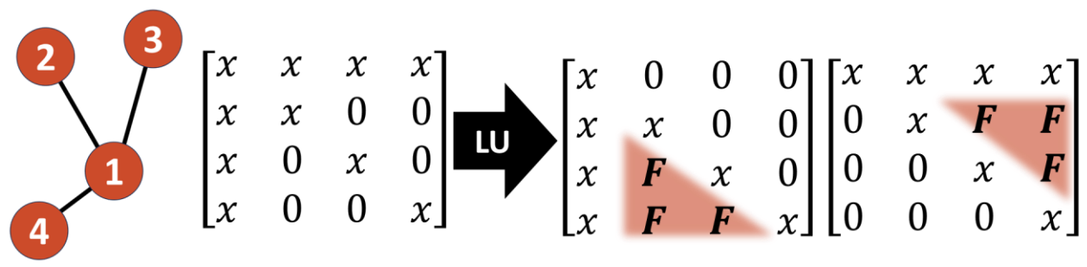
S.G. van der Linde[1], W.E. van der Schoot[1], E.P. Aguilera[1], K. Leijnse[2], T. Xiang[3], N. Jaspers[3], J. Zwetsloot[3], N. Renaud[4]

1. Netherlands Organisation for Applied Scientific Research (TNO), 2. Quantum Application Lab, 3. Alliander, 4. eScience Centre

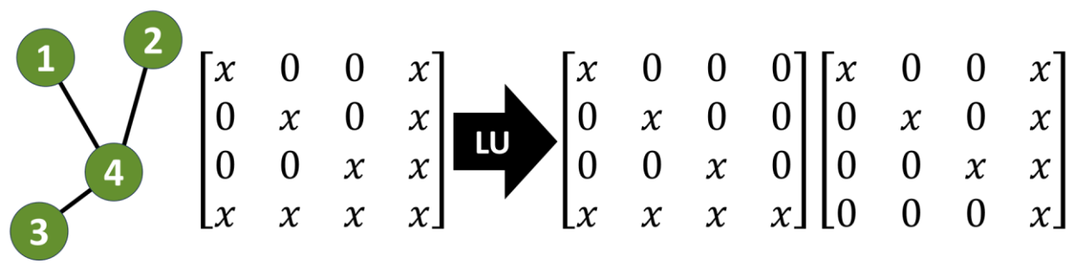
Introduction

- **Power grid analysis and simulation** is essential for distribution system operators like Alliander.
- **Bottleneck:** solving ill-conditioned sparse linear systems with **LU decomposition**, which causes **fill-in** (destruction of sparsity).
- Alliander has **30 million nodes**, with worst case fill-in, 14 000 TB of memory is needed.
- **Reordering nodes** reduces fill-in, but minimizing fill-in is **NP-hard**.
- **Goal:** develop a **quantum method** to generate **orderings that minimize fill-in**.

Fill-in Reduction

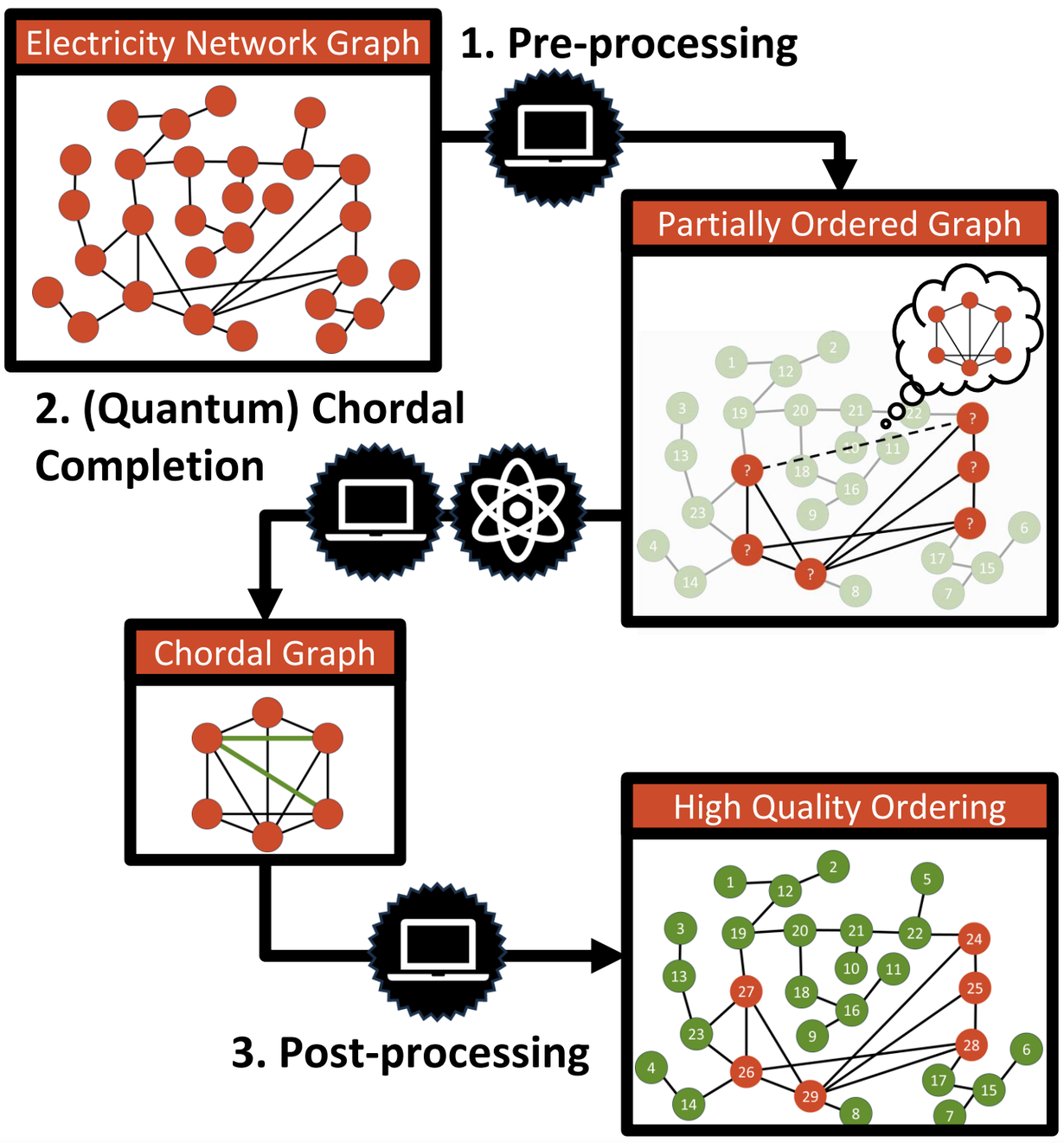


Node reordering in electricity grid changes fill-in.

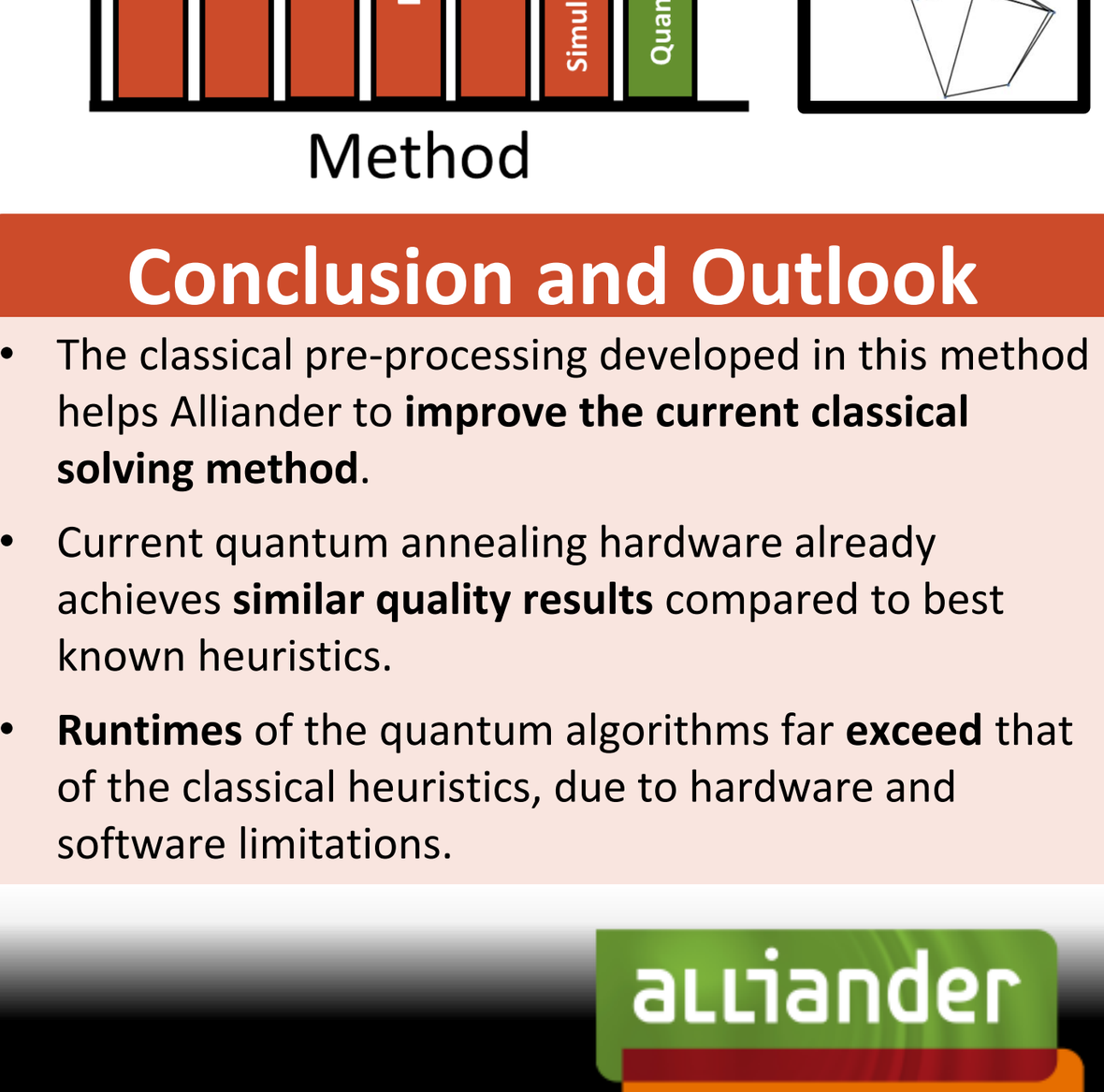


Developed Algorithm

1. Preprocessing with in-house developed **Optimal Minimum Degree Ordering** (MDO) to eliminate all ‘easy’ nodes.
2. Use in-house developed (**quantum**) **chordal completion** for remaining ‘difficult’ nodes.
3. Find order in **chordal graph** (LexicographicalBFS)**.**



Results



Conclusion and Outlook

- The classical pre-processing developed in this method helps Alliander to **improve the current classical solving method**.
- Current quantum annealing hardware already achieves **similar quality results** compared to best known heuristics.
- **Runtimes** of the quantum algorithms far **exceed** that of the classical heuristics, due to hardware and software limitations.

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