"Encoding" here refers to how an object is represented/considered not error correction encodings.

Global vs Local encodings for DQC

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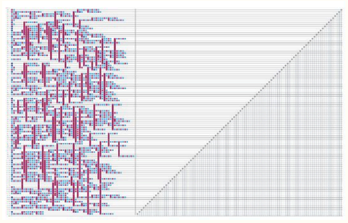
Distributed Quantum Computing

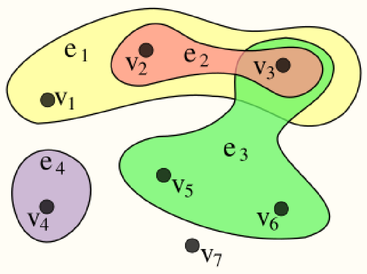
Refers to the collaboration of multiple interconnected quantum devices working to complete a computation larger than their individual capacities.

What does Distribution entail?

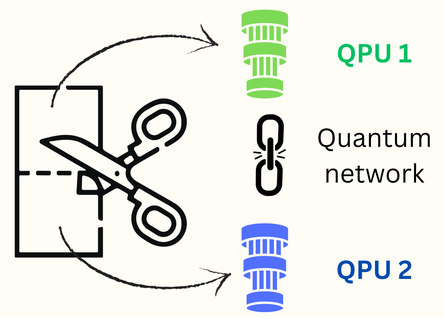
Large Computation



Abstracted to a Hypergraph



Partitioned and assigned



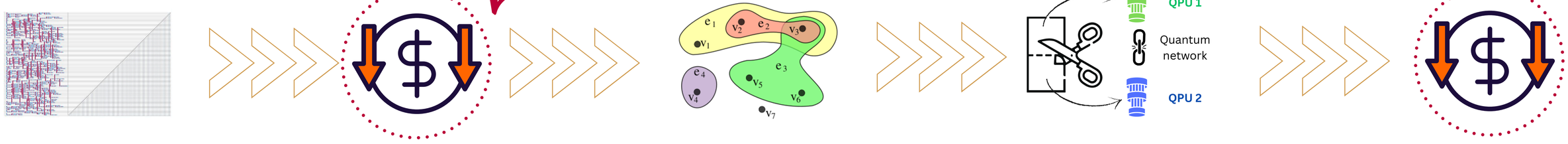
To **reduce costs**, large computations will require:

- Circuit optimisation
- Error mitigation
- Error correction

How do these fit in the pipeline?

Where?

- Before partitioning?
- After partitioning?



Before partitioning

Global encoding: the optimisation/error correction is performed on the entire computation **prior to** partitioning.

After partitioning

Local encoding: the optimisation/error correction is performed on the sub-computations **post** partitioning.

VS

- ✓ Enables globally-aware optimisations and error correction, capturing reductions that local, partition-level approaches cannot exploit.
- ✗ The solution space is large and optimisations can become intractable.
- ✗ Does not accommodate for hardware specific optimisations in heterogeneous QPU settings.

- ✗ Misses global optimisations.
- ✓ Working with smaller sub-computations can enable much faster, parallelisable, and tractable optimisations.
- ✓ Naturally accommodates for heterogeneous QPUs, enabling hardware specific optimisations.

GOALS:

- **Fast** compilation
- **Minimal** resource usage (network and devices)
  - compute time
  - number of qubits/gates
  - entanglement consumed
- Yields the **intended** result (if the pass is too large it may return unchanged)

Progress so far

- Distributed Quantum Error Mitigation: Global and Local ZNE encodings, Maria Gragera Garces, INFOCOM QUNAP 2026
- On the Interplay Between Optimisation and Partitioning in Distributed Quantum Circuit Compilation, Maria Gragera Garces & Majid Haghparast, In review
- Open collaboration between UoE QEC team and Heriot Watt on how the question of Global vs Local translates to the Error Correction

Optimisation

In review

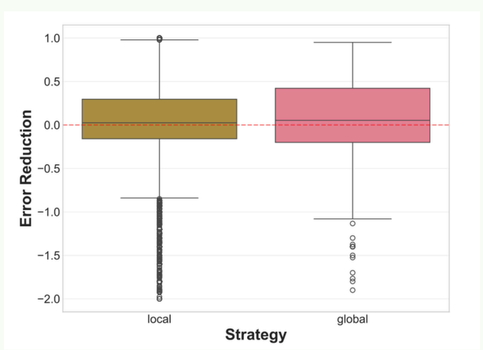
- **Local** encoding reduces total **computation** (number of gates) **and** offers higher **speed** (shorter circuits)**.**
- **Global** achieves lower **communication** requirements (aka non-local gates), an important resource consuming network entanglement.
- **Hybrid** encodings (optimising before and after) achieve both, at a high compilation time **cost.**

Collaborators: Majid Haghparast (University of Jyväskylä)

Error mitigation

Peer reviewed results, pertaining to empirical tests with one technique (ZNE) on a sub-set of algorithms. More to be explored.

Global ZNE **outperforms** Local,
but counterintuitively leads to l**ess stable** results.



arXiv

Error correction

Ongoing work

The question here of global vs local can take a few shapes:

1. Are logical **qubits** local?
2. Are logical **operators** local?
3. Do we encode the full computation in one code or have **separate codes** for each device?

Collaborators: Liam Veeder-Sweeney (UoE) & Kenny Campbell (Heriot Watt)