Higher-Level Software

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`http://aggregate.org/hankd/`

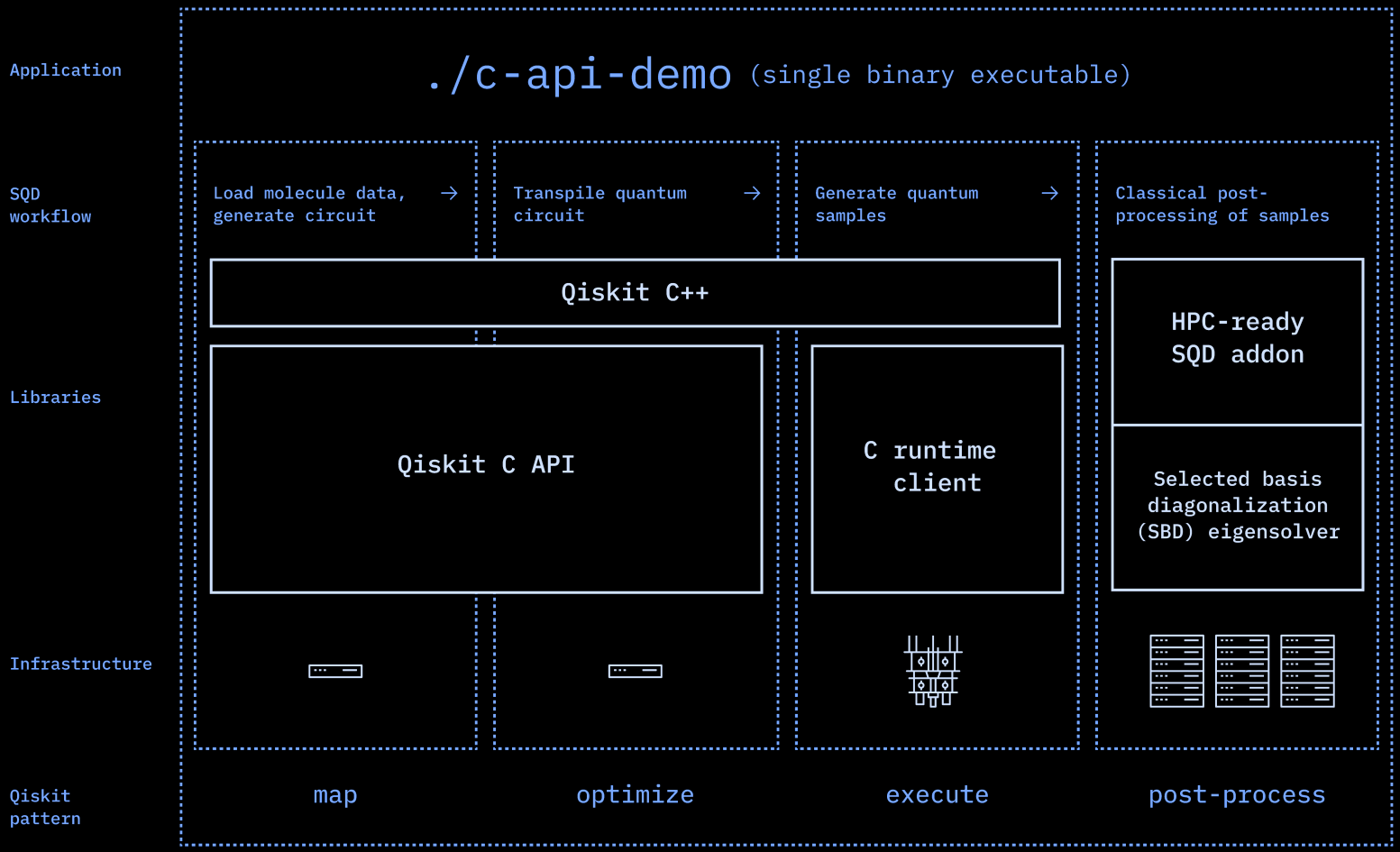
Higher Level?

- Levels we've already seen
  - Quantum circuits as gate sequences
  - Python libraries manipulating circuits
  - Higher-level libraries
  - Libraries of quantum applications
- The higher levels generally focus on integration of quantum computation with conventional HPC

HPC Integration?

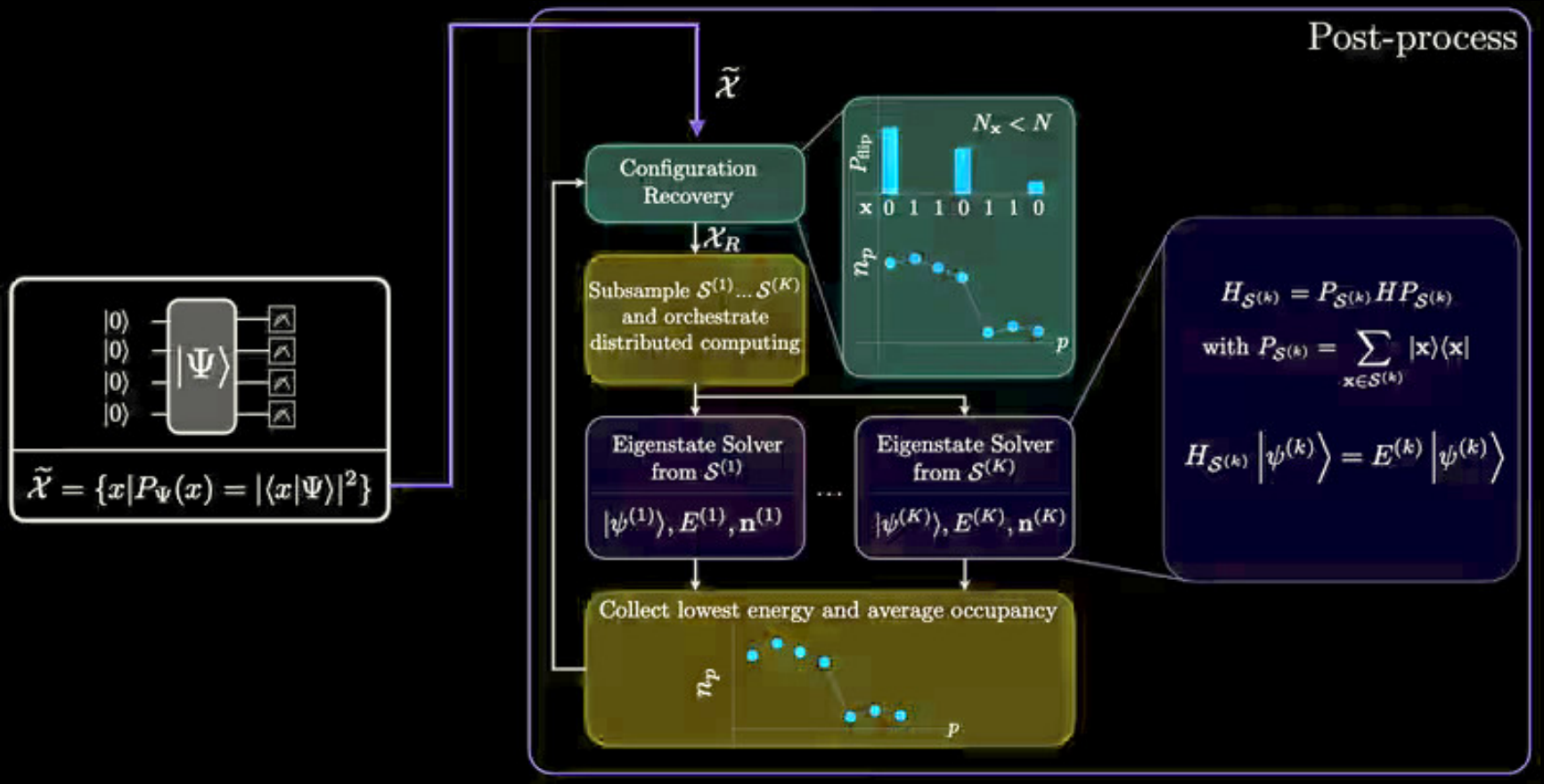
- Compile & link with existing HPC code
  - C/C++, Fortran
  - Parallel APIs like OpenMP, MPI, and CUDA
- Remove statistical nature of results
  - Provide syndrome error correction
  - Incorporate libraries for taking approximate results and refining them using conventional data types (e.g., `double`)

Qiskit C++



https://www.ibm.com/quantum/blog/c-api-enables-end-to-end-hpc-demo

Sample-Based Quantum Diagonalization (SQD)



https://quantum.cloud.ibm.com/docs/en/guides/qiskit-addons-sqd

Software Platforms

- Amazon Braket: https://aws.amazon.com/braket/
- BlueQubit: https://www.bluequbit.io/
- IBM Quantum: https://www.ibm.com/quantum
- Intel Quantum SDK: https://www.intel.com/content/www/us/en/developer/tools/quantum-sdk/overview.html
- Strangeworks: https://strangeworks.com/
- Q#: https://learn.microsoft.com/en-us/azure/quantum/qsharp-overview
- qBraid: https://www.qbraid.com/
- QC Ware: https://www.qcware.com/
- QuTech Quantum Inspire: https://www.quantum-inspire.com/

Quantum Applications

- Quantum Simulation – Chemistry, Quantum Physics, and Materials; drug discovery, battery technologies, differential equations (e.g., CFD)
- Optimization Problems – mostly annealing
- AI Training – LLMs, classifiers
- Cryptography and Cybersecurity – attacks and alternatives (Quantum Key Distribution: QKD)
- Financial Models – risk analysis, option pricing

- *Quantum excells where all values must be tried and you need one result or one property*