TKET USER FEATURES

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Get started with TKET, a universal quantum SDK

TKET is available for free on GitHub (https://gitub.com/CQCL/pytket) and is installed by

```
pip install pytket
```

The extension module interfacing PyTKET with the H-series is installed by

```
pip install pytket-quantinuum
```

and for interfacing with Qiskit install

```
pip install pytket-qiskit
```

TYPICAL QUANTUM ALGORITHM WORKFLOW ON A GATE-MODEL QUANTUM COMPUTER

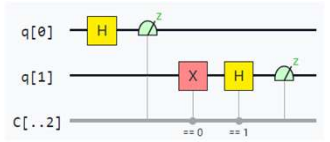
e.g. Traveling Salesman

```
circuit = QuantumCircuit(q,c)
normal = NormalDistribution(num_target_qubits = 5, mu=0, sigma=1,
low=-1, high=1)
normal.build(circuit,q)
circuit.measure(q,c)

job = execute(circuit, backend, shots=8192)
job_monitor(job)
counts = job.result().get_counts()

print(counts)
sortedcounts = []
sortedkeys = sorted(counts)

for i in sortedkeys:
    for j in counts:
        if(i == j):
            sortedcounts.append(counts.get(j))
```



e.g. TKET

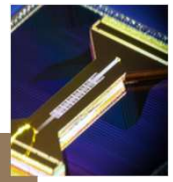
Problem Definition

Quantum Algorithm

Quantum Circuit

Quantum Compiler

Quantum Processor

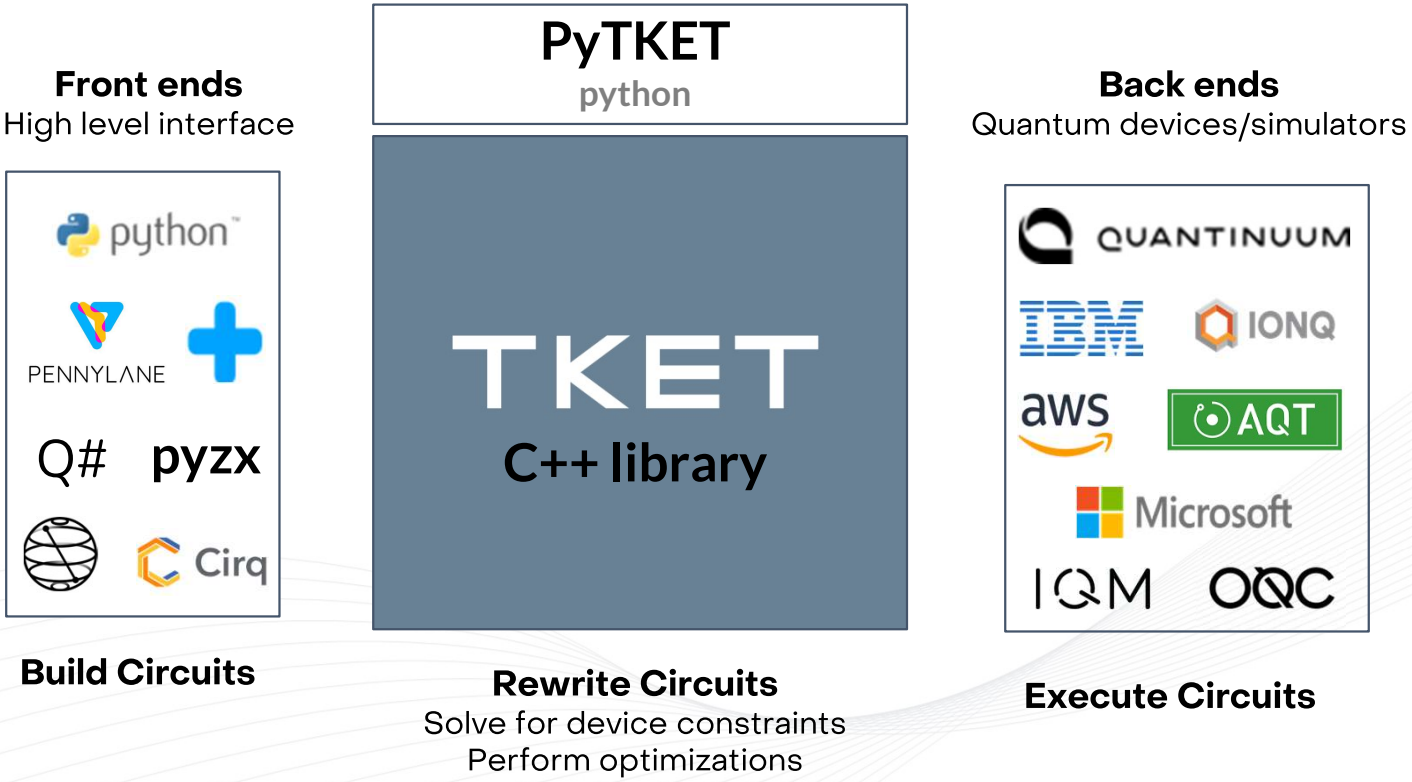


Quantum Simulator

Full-Stack

TKET as a universal SDK

TKET optimizes quantum circuits, reducing the number of required operations – essential for NISQ devices.



TKET EXTENSIONS

Device & Simulators

- pytket-quantinuum
- pytket-qiskit (IBM)
- pytket-ionq
- pytket-aqt
- pytket-braket (AWS)
- pytket-qsharp (Azure)
- pytket-pyquil (Rigetti)
- pytket-iqm

Simulators

- pytket-qujax
- pytket-project
- pytket-pysimplex
- pytket-qulacs
- pytket-stim
- pytket-cutensornet*

* Under development

Transpilers

- pytket-pennylane
- pytket-pyzx
- pytket-cirq
- pytket-qir*

* Under development

TKET SIMPLIFIES THE INTEGRATION OF DIFFERENT QUANTUM TOOLKITS.

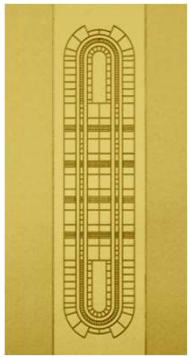
qiskit_to_tk(circuit)

Other bidirectional conversions exist: Cirq, Bracket etc.

tk_to_qiskit(circuit)

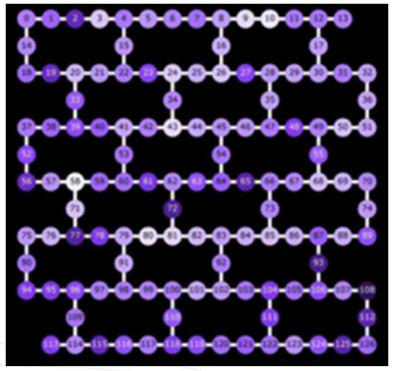
Quantum hardware architectures

H-2



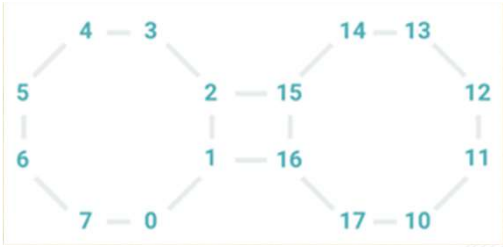
Basis Gates:
$U1q(\theta,\varphi)$, R_Z, ZZ, RZZ

EAGLE



Basis Gates:
ECR, ID, R_Z, S_X, X

ASPEN



Basis Gates:
CZ, R_X, R_Z

TKET-SPECIFIC COMPILER PASSES

- Synthesize many qubit operations to 1-, 2-qubit gates
- Local graph rewrites, pattern-replacement
- Resynthesize sub-circuits via special representations
  - ZX-terms, Clifford tableaux, Phase-polynomial / Phase gadget
- Architecture-aware synthesis
- Mapping to chosen gate basis
- Mapping and routing circuits to fixed architectures
- Symbolic expression optimization
- …. more!

TKET has a default pass manager for each backend

```
get_compiled_circuit(circuit,optimization_level)
```

Level 0	Level 1	Level 2 (default)
Solves the device constraints without optimizing.	Additionally performs some light optimizations.	Adds more intensive optimizations that can increase compilation time for large circuits.

TARGET A DIFFERENT BACKEND EASILY

```python
from pytket.extensions.quantinuum import QuantinuumBackend
# Select the H1-2 emulation device
machine = 'H1-2E'
backend_emu = QuantinuumBackend(device_name=machine)
backend_emu.login()
```

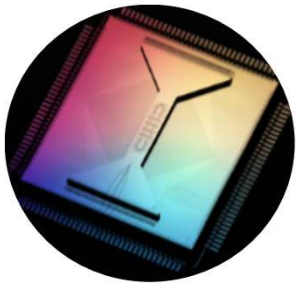
```python
from pytket.extensions.qiskit import IBMQBackend
from qiskit_ibm_provider import IBMProvider

my_instance=f"{hub}/{group}/{project}"
ibm_provider = IBMProvider(instance=my_instance)
backend = IBMQBackend("ibmq_belem") # Initialise backend for an IBM device
```

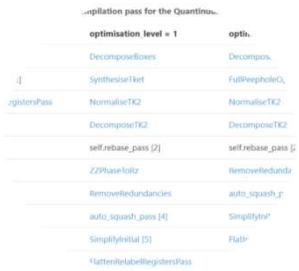
CODING EXAMPLE OF SOME TKET FEATURES

ADD TKET TO YOUR WORKFLOW IF COMPATIBLE – IT COULD HELP YOU!

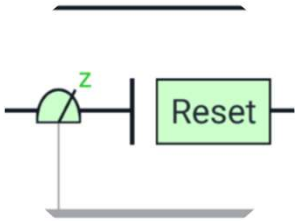
PYTKET-QUANTINUUM



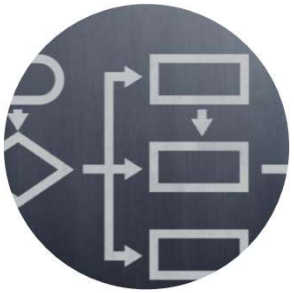
Provides access to various H-series QPUs, emulators, and syntax checkers. Emulators and syntax checkers are available for specific devices, and each device has its own specifications.



Offers a default compilation pass that optimizes circuits based on different levels of optimization. The optimization levels range from 0 to 2, with level 2 being the default, applying more intensive optimizations.



Provides predicates that circuits must satisfy to run on H-series devices. It Supports mid-circuit measurements, fast classical feedforward, cost calculation, and partial results retrieval.



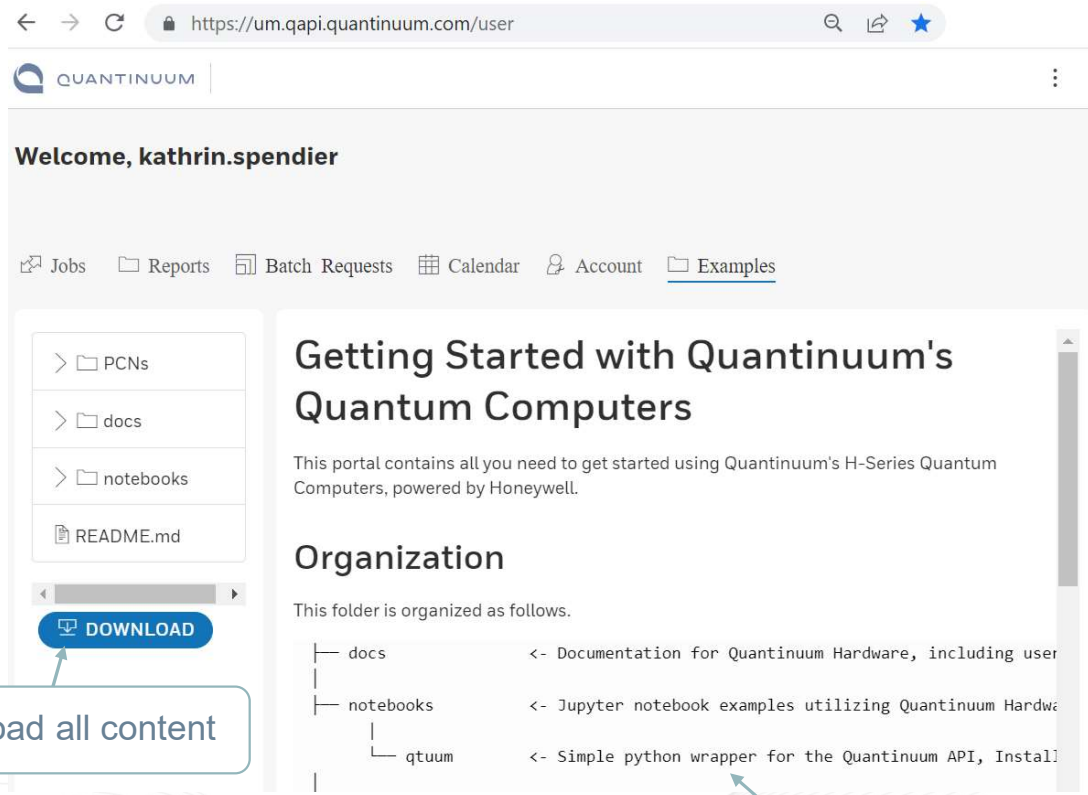
Supports batching of jobs (circuits), allowing submission of multiple circuits together as a batch, which will be executed one after another on the QPU.

Allows control of the language used for circuit submission such as QASM and QIR*.

* Under development

Getting Started with the H-series

- Web Interface: https://um.qapi.quantinuum.com
- Download the set of examples
- Set up Python Environment on your computer following the instructions
- Open Jupyter Notebook



Download all content

Follow installation instructions

JUPYTER NOTEBOOKS

Code examples include:

- Circuit Submission (conditional gates, parametrized circuits)
- Using the Emulator
- Quantinuum OpenQASM Extension
- Circuit Batching
- Mid-Circuit Measurement
- Arbitrary Angle ZZ Gates
- Using Qiskit with Quantinuum Devices
- Using the Leakage Gadget
- Qubit Reuse Compilation (see packages folder)

Quantinuum Systems

Workflow

Syntax Checker (i.e **`H1-1SC`**)

- Ensure that your quantum circuit will run on Quantinuum hardware before submitting jobs
- Checks the quantum circuit syntax against a device's compiler
- Free to use, does not require H-System Quantum Credits (HQCs)

Emulator (i.e **`H1-1E`**)

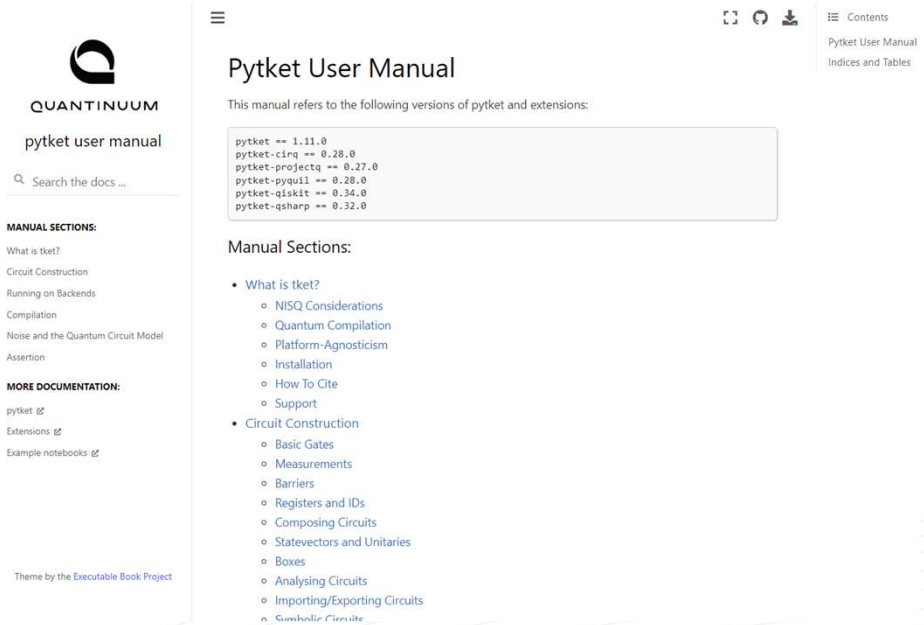
- Classical emulation of the H-Series quantum computers
- Realistic physical and noise models of the devices
- Requires HQCs

Hardware (i.e **`H1-1`**)

- Trapped ion quantum computers
- Requires HQCs

CODING EXAMPLE FOR H-SERIES WORKFLOW

PyTKET



- PyTKET User Manual: https://cqcl.github.io/pytket/manual/index.html
- PyTKET API: https://cqcl.github.io/tket/pytket/api/index.html
- Github: https://github.com/CQCL/pytket-extensions
- Slack: https://tketusers.slack.com/join/shared_invite/zt-18qmsamj9-UqQFVdkRzxnXCcKtcarLRA#/shared-invite/email