QAMP Spring 23

TKET Transpilation Pass Wrapper

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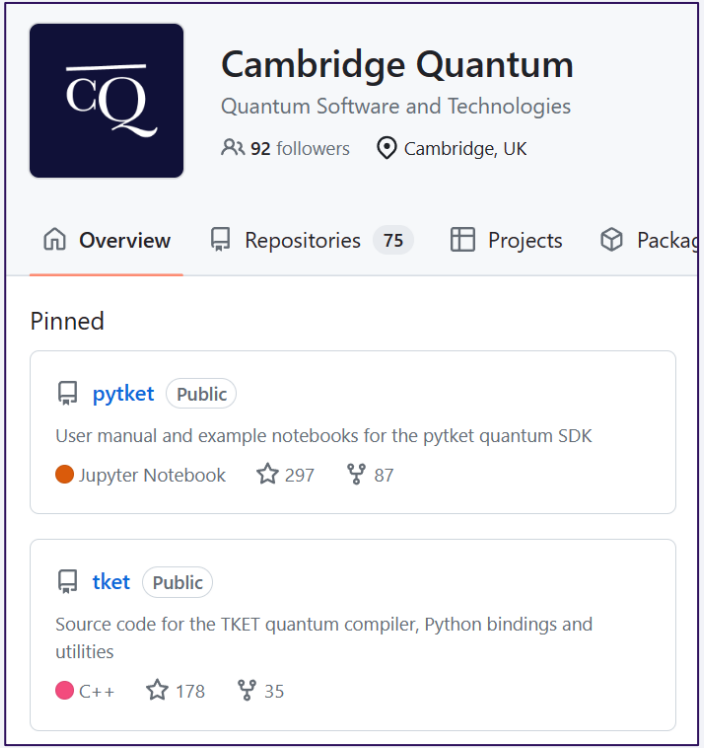
What is TKET

- TKET is an advanced software development kit for the creation and execution of programs for gate-based quantum computers.
- It is platform-inclusive, and its state-of-the-art circuit optimization routines allow users to extract as much power as possible from any of today's Noisy Intermediate-Scale Quantum (NISQ) devices.
- TKET is open source and easily accessible through the PyTKET Python package, with extension modules providing compatibility with many quantum computers, classical simulators, and popular quantum software libraries.



Project Description

- TKET has a lot of nice transpilation passes that cover the different transpilation stages (decomposition, routing, optimization, ...)
- We have also pytket-qiskit, an extension to pytket that supports the conversion to and from Qiskit representations. And allows pytket circuits to be run on IBM backends and simulators.
- Can we write a wrapper on TKET transpilation passes so that we could use them in Qiskit?

- CXMappingPass
- CliffordSimp
- CnXPairwiseDecomposition
- CommuteThroughMultis
- ComposePhasePolyBoxes
- ContextSimp
- CustomRoutingPass
- DecomposeArbitrarilyControlledGates
- DecomposeBoxes
- DecomposeClassicalExp
- DecomposeMultiQubitsCX
- DecomposeSingleQubitsTK1
- DecomposeSwapsToCXs
- DecomposeSwapsToCircuit
- DecomposeTK2
- DefaultMappingPass
- DelayMeasures
- EulerAngleReduction
- FlattenRegisters
- FlattenRelabelRegistersPass
- FullMappingPass
- FullPeepholeOptimise
- GlobalisePhasedX
- GuidedPauliSimp
- KAKDecomposition
- NaivePlacementPass
- NormaliseTK2
- OptimisePhaseGadgets
- PauliSimp
- PauliSquash
- PeepholeOptimise2Q
- PlacementPass
- RebaseTket
- RemoveBarriers
- RemoveDiscarded
- RemoveImplicitQubitPermutation
- RemoveRedundancies
- RenameQubitsPass

TKET Passes Performance

Qiskit

- When transpiling the same circuit using both Qiskit and TKET with the default transpiler parameters, and the highest optimization level:
  - TKET provides a lower circuit depth and less number of CNOTs.
  - However, it takes much longer time.

	Depth	CNOTs	Time
qiskit	308	148	1.9
pytket	281	140	5.5
qiskit	299	142	2.1
pytket	243	119	5.8
qiskit	266	120	1.7
pytket	237	119	5.6
qiskit	299	161	2
pytket	261	135	6.6
qiskit	243	132	1.8
pytket	211	119	5.5

Ideas

- Idea #1 – Custom transpiler pass that works as a wrapper.

```
from pytket.passes import CnXPairwiseDecomposition
from foo.bar import ToQiskitPass
new_pass = ToQiskitPass(CnXPairwiseDecomposition)
```

- Idea #2 – A transpiler stage plugin.

```
transpile(circuit, routing_method='tket_routing')
transpile(circuit,
unitary_synthesis_method='tket_synthesis')
```

- Idea #3 – A pass manager.

```
from egretta import TketPassManager
pm = TketPassManager()
pm.run(quantumcircuit)
```

Progress

- ✓ Kickoff meeting
  - Project scope.
  - The proposed ideas have been discussed.
  - Agreed on how and when the progress meetings will be conducted.
- ✓ Learning the basics of pytket.
- ✓ POC for first idea.
- ✓ POC for second idea (WIP)

Idea #1

Qiskit

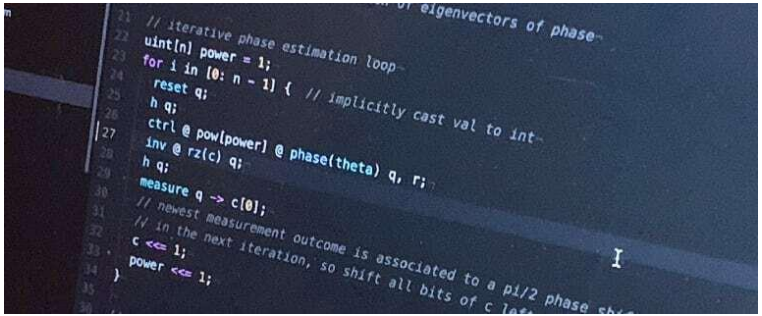
POC for first idea has been conducted successfully

```
from foo.bar import ToQiskitPass
import pytket.passes as tkps

pm = PassManager([
    UnrollCustomDefinitions(std_eqlib, basis),
    BasisTranslator(std_eqlib, basis),
    ToQiskitPass(tkps.SynthesiseTket),
    ToQiskitPass(tkps.CliffordSimp, allow_swaps=True),
])

transpiled_circ = pm.run(circ)
```

Challenges

- Both Qiskit and TKET use DAG representation, but node types are not compatible. How to convert back-and-forth between them in the most efficient way?
- Device constraints are represented differently. In Qiskit, Target class is used. In TKET they are represented as a collection of predicates.
- Transpilation parameters are of different types e.g., basis gateset.

```
# Qiskit
basis_gates = ['cx', 'id', 'rz', 'sx', 'x’]
# pytket
basis_gates ={OpType.CX, OpType.Rz, OpType.SX, OpType.X}
```



Resources

- pytket Documentation
- Qiskit Transpiler Passes and Pass Manager
- Qiskit Transpiler Stage Plugin Interface

Qiskit

Thank You!