#48

Eternity II Puzzle by Beginners

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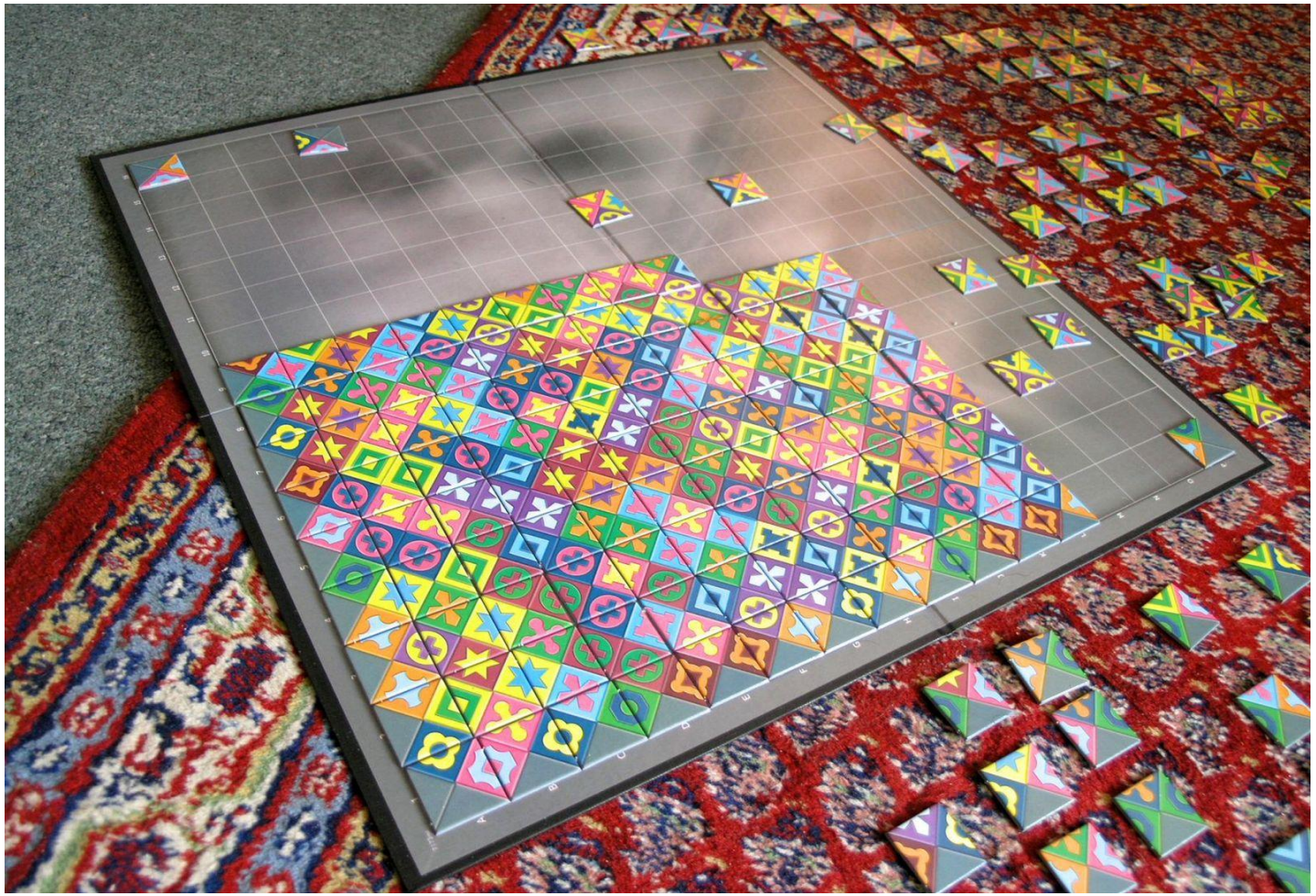
IBM Qiskit Camp Asia 2019

Eternity II



Eternity II

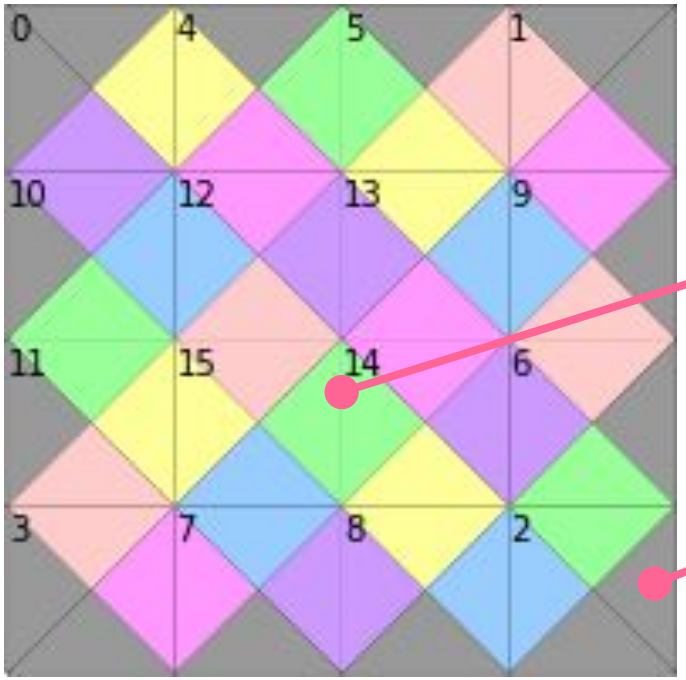
- Edge-matching puzzle
  - 256 pieces (16 by 16 grid)
- Designed to be difficult to solve by brute-force computer search

→ **Let's solve this with quantum computers!**

Problem Settings

Each piece is unique

Pieces can be used in 4 orientations

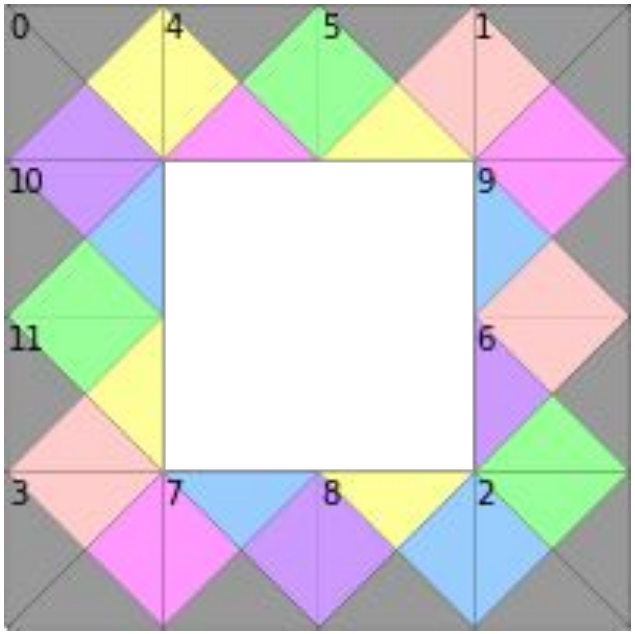


Rules

Adjacent edges must match

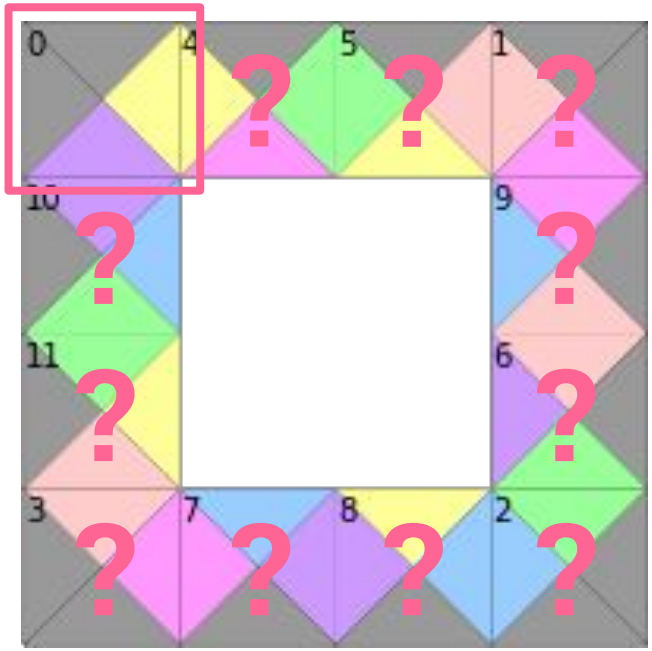
Gray = edge

Our Approach



- Start from edge
  → Proceed to inside repeatedly

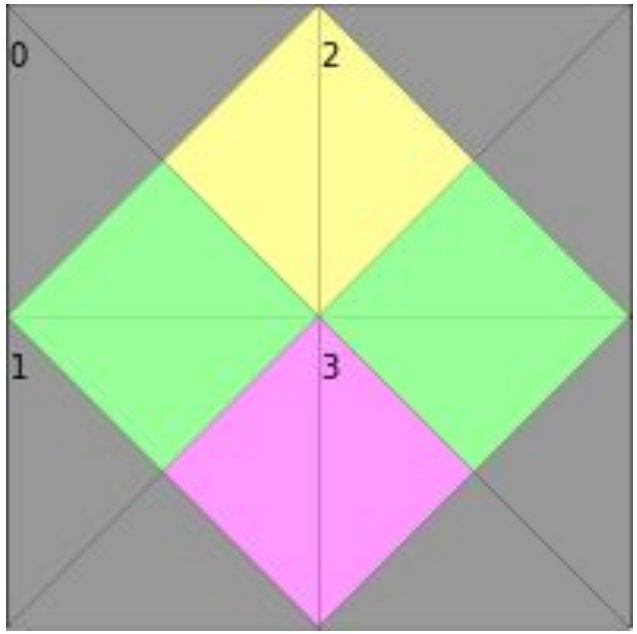
Our Approach



- Start from edge
  → Proceed to inside repeatedly

- Fix one corner
- Enumerate all possibilities for other positions
- Filter the possibilities by requirements
- Find a correct combination

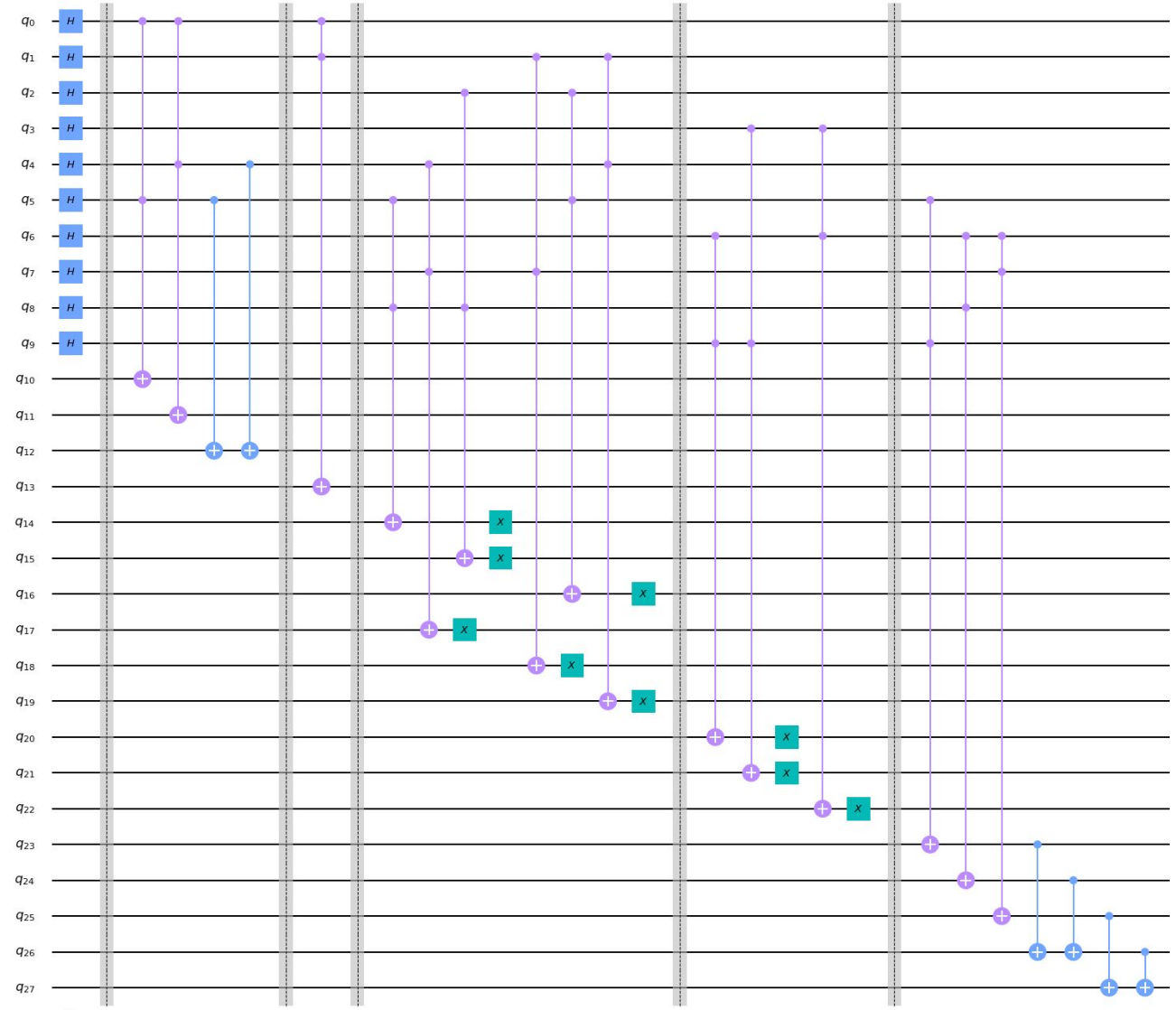
Implementation - Simplified Case



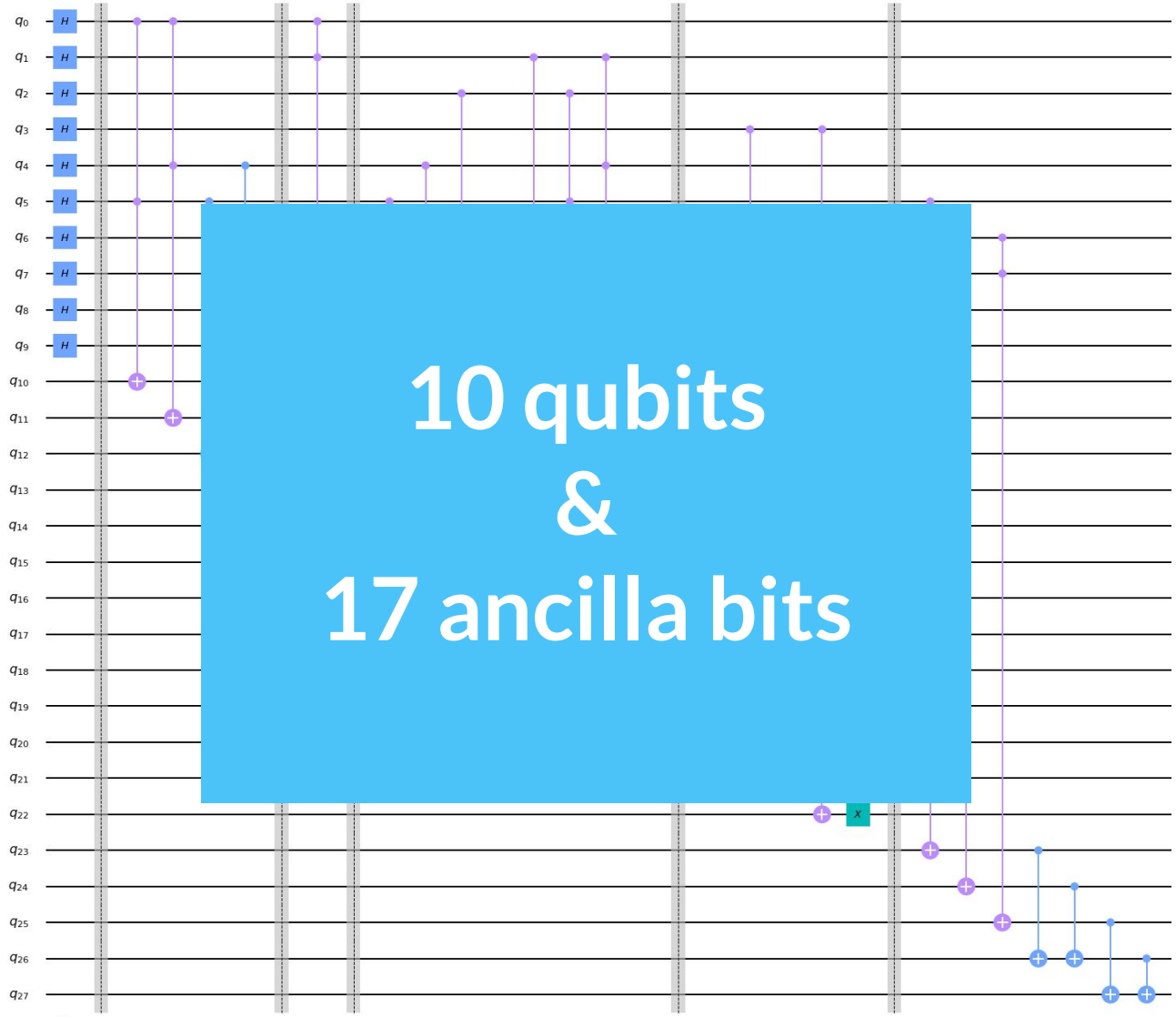
Expected output

- Find an answer for 2 by 2 grid
  - (Original: 16 by 16 grid)

Implementation - Quantum Circuit



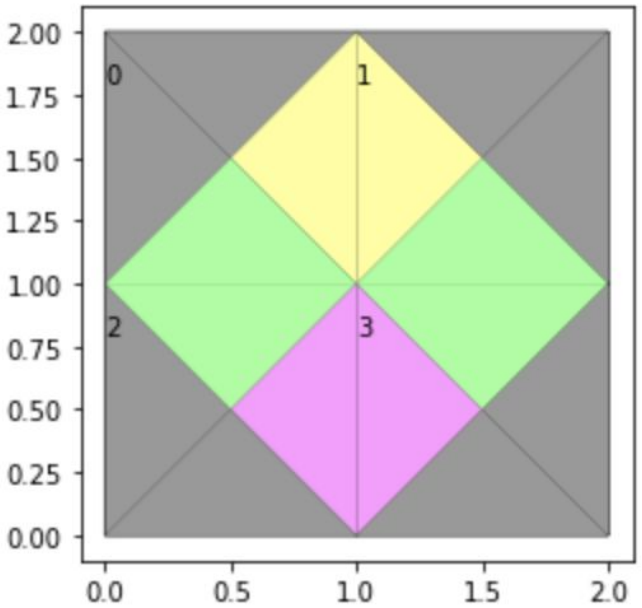
Implementation - Quantum Circuit



Experimentation Result

```
[15] for item in res_ok:
         answer = np.where(np.array(item)==1)[0]
         print(answer)
         cplot(answer, prb, qubo_prb)
```

```
[0 1 5 9]
```



We got a correct answer 🥳🎉

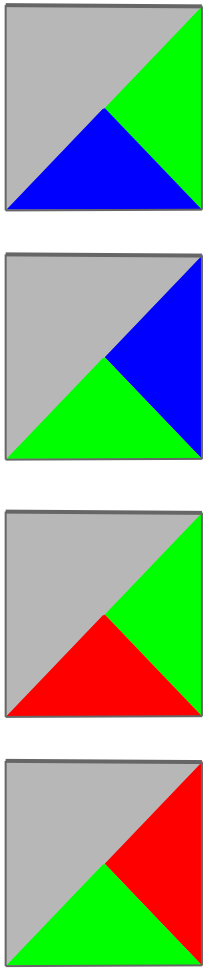
https://github.com/kumagaimasahito/Eternity/blob/master/eternity_group2.ipynb

Future Works

- Decrease the number of ancilla bits in our quantum circuit
- Try other experimentations on bigger puzzles
- Implement Grover algorithm for finding Directed Hamiltonian Cycle

Special thanks: Ken Wei (IBM), Asa Eagle!

Directed Hamiltonian Cycle



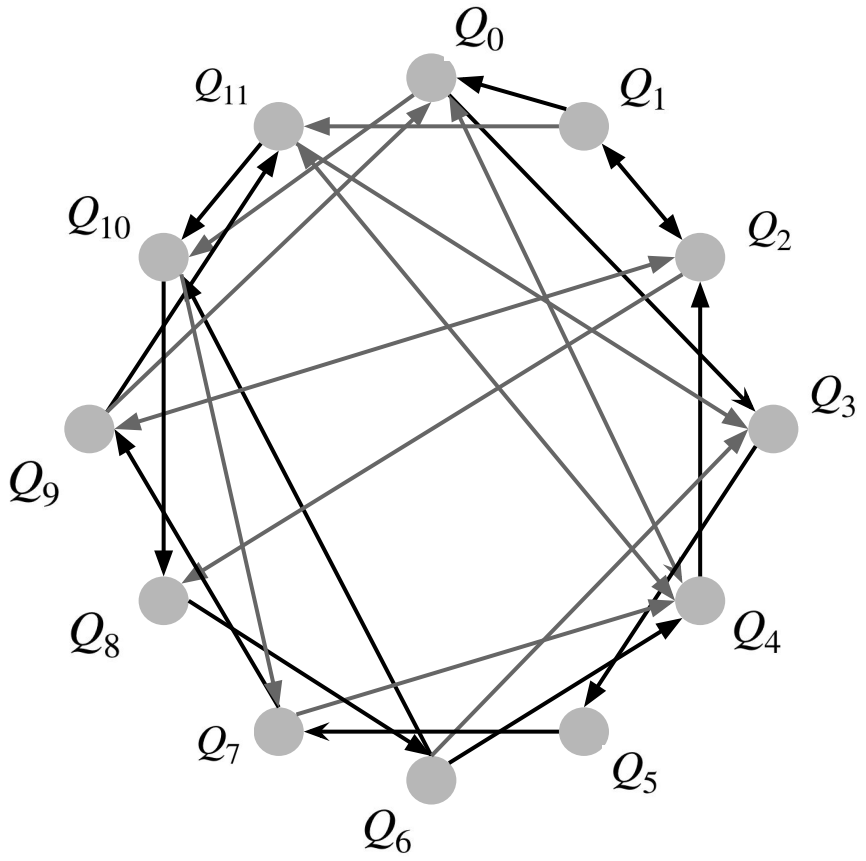
Blue: 1
Red: 2
Green: 3

$$\begin{pmatrix} 1 & 3 \\ 3 & 1 \\ 2 & 3 \\ 3 & 2 \end{pmatrix}$$

※Clockwise

Directed Hamiltonian Cycle

$$\begin{pmatrix} Q_0 \\ Q_1 \\ Q_2 \\ Q_3 \\ Q_4 \\ Q_5 \\ Q_6 \\ Q_7 \\ Q_8 \\ Q_9 \\ Q_{10} \\ Q_{11} \end{pmatrix} = \begin{pmatrix} 6 & \textcircled{4} \\ 3 & 6 \\ 6 & 3 \\ \textcircled{4} & 5 \\ \textcircled{4} & 6 \\ 5 & 2 \\ 1 & 4 \\ 2 & 3 \\ 2 & 1 \\ 3 & 6 \\ \textcircled{4} & 2 \\ 6 & 4 \end{pmatrix}$$



Directed Hamiltonian Cycle

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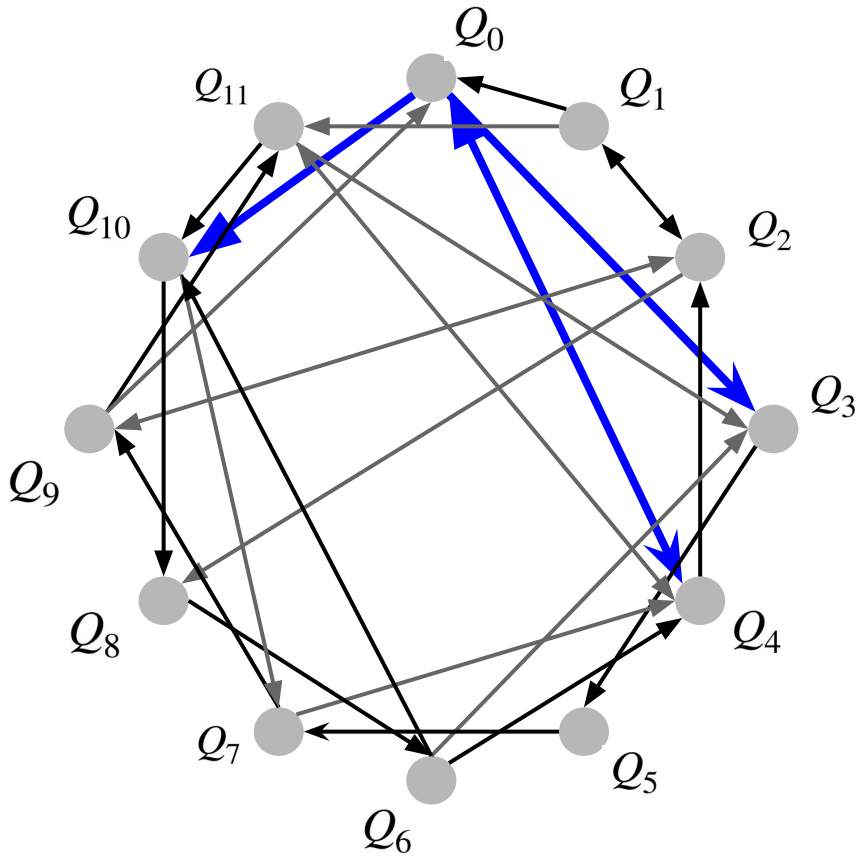

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