Tic Tac Toe Machine - Using Quantum Computation

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A qiskit implementation of the classic game of Tic Tac Toe using quantum simulators which can be migrated to run on quantum computers.

In [131…

```
# importing Qiskit
from qiskit import Aer, execute
from qiskit import QuantumCircuit

#importing the Oracle circuit builder
from qiskit.circuit.library import PhaseOracle

# import basic plot tools
from qiskit.visualization import plot_histogram
```

Initialization

We start with initializing the qubits with all states having equal amplitudes using Hadamard Gates.

In [132…

```
def initialize_s(qc, n):
    for q in list(range(n)):
        qc.h(q)
```

Diffuser

Grovers algorithm works by applying an Oracle reflection and a diffuser amplitude amplification around $\sqrt{n}$ times to search for a particular state.

We define the diffuser function here which amplifies the negated state that the Oracle has prepared.

In [133…

```
# Multicontrolled z-gate subroutine that applies the gate to the circuit based on the control and target qubits
def multicontrolled_z(qc, control, target):
    qc.h(target)
    qc.mct(control, target)
    qc.h(target)

# Actual diffuser function that applies the diffuser to the circuit
def diffuser(qc):
    for qubit in range(10):
        qc.h(qubit)
        qc.x(qubit)

    multicontrolled_z(qc, list(range(9)), 9)

    for qubit in range(10):
        qc.x(qubit)
        qc.h(qubit)
```

Oracle and the completed circuit

We continue to build the Oracle using the PhaseOracle method, using the winning clause expressions to determine the winning state.

All these pieces are finally put together to run the Grover's algorithm 3 times(since we use 9 qubits, 1 for each space on the board)

In [134…

```
circuit = QuantumCircuit(10, 9)

# Expression defining all the winning states
expression = '(x1 & x2 & x3) ^ (y1 & y2 & y3) ^ (z1 & z2 & z3) ^ (x1 & y1 & z1) ^ (x2 & y2 & z2) ^ (x3 & y3 & z

initialize_s(circuit, 10)

for i in range(3):
    circuit.barrier(list(range(10)))

    circuit.append(PhaseOracle(expression), list(range(9)))

    circuit.barrier(list(range(10)))

    diffuser(circuit)


# Output
circuit.measure(list(range(9)), list(range(9)))
#circuit.measure([9], [8])
```

Out[134…

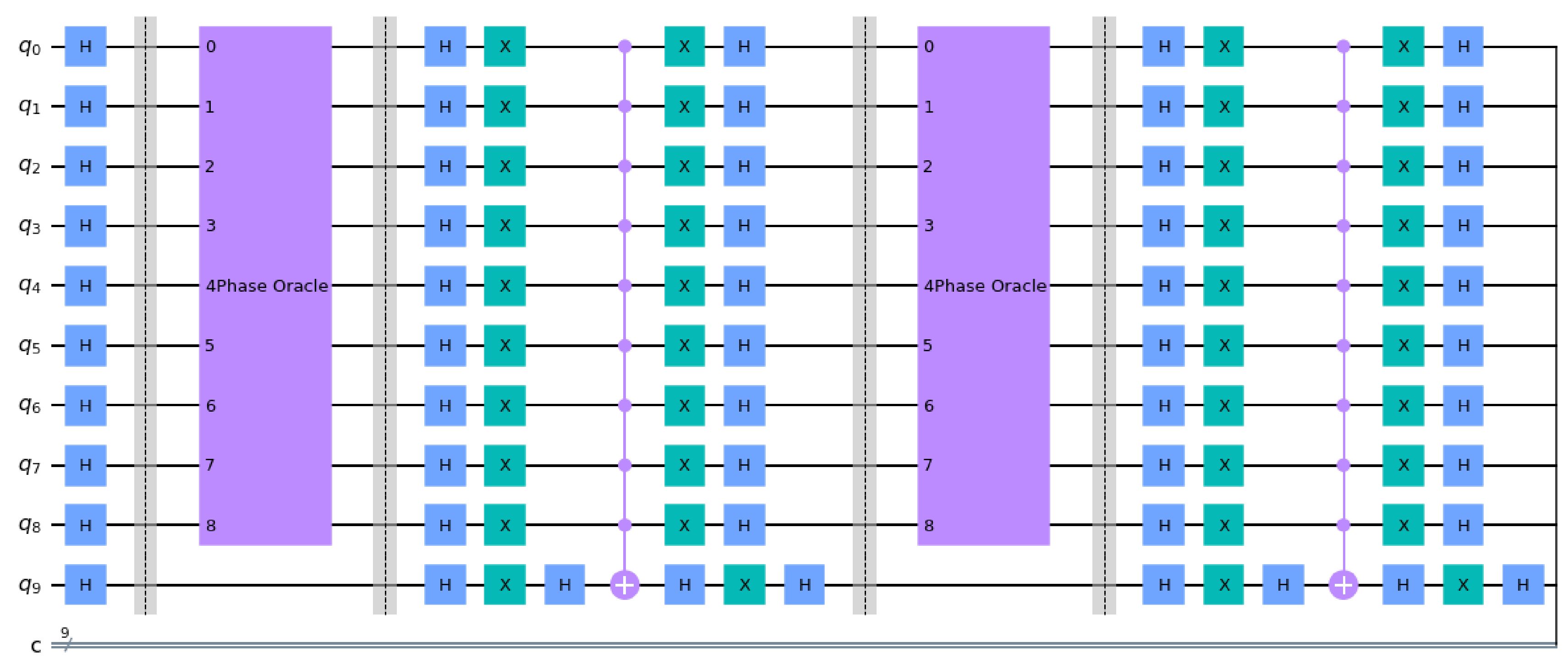
```
<qiskit.circuit.instructionset.InstructionSet at 0x170dfc5d2b0>
```

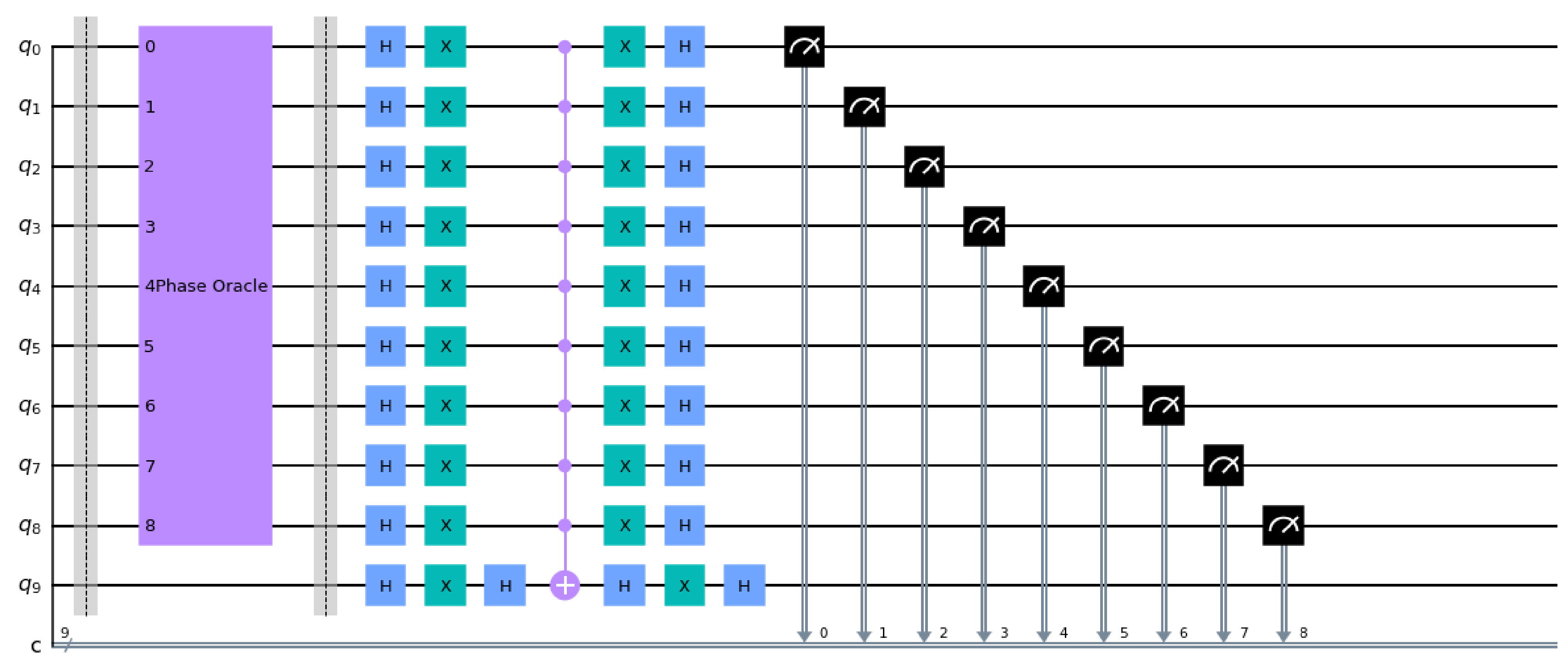
The circuit used for this algorithm is drawn below.

In [135…

```
circuit.draw(output='mpl')
```

Out[135…





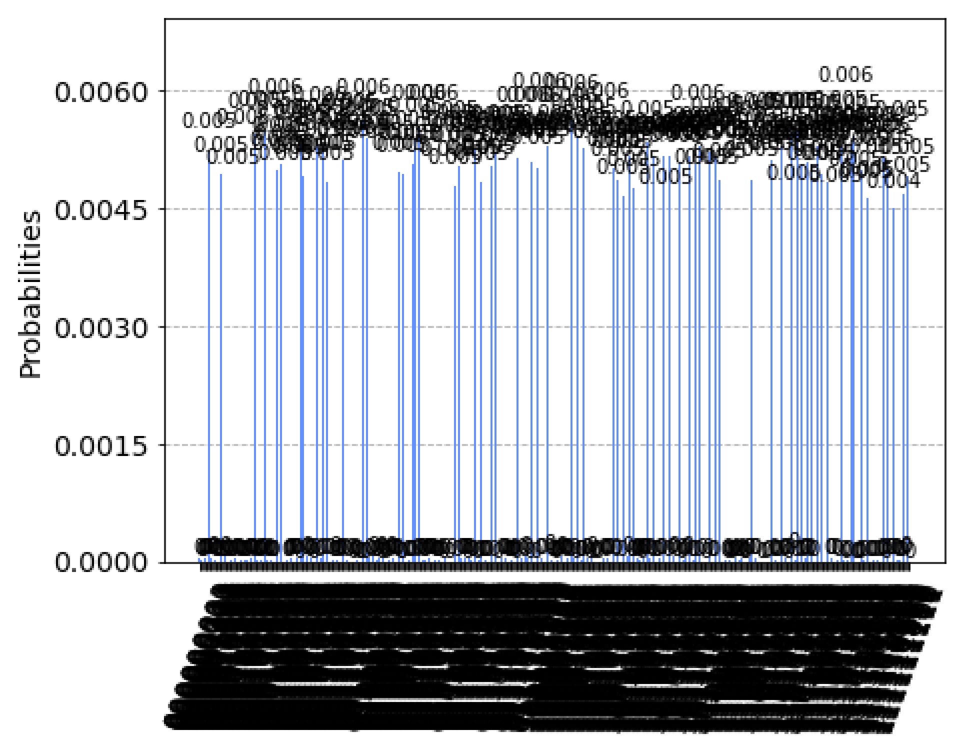
Output

We finally run the quantum circuit on the "aer_simulator" provided by qiskit to simulate a quantum circuit and observe the output using histograms.

In [136…

```
N = 100000  #Since we encounter random outputs due to the nature of the algorithm, we average the outcomes of N
simulator = Aer.get_backend('aer_simulator')
results = execute(circuit, backend=simulator, shots=N).result()
counts = results.get_counts()
plot_histogram(counts)
```

Out[136…



To further analyse the output we received, we plot the histogram as a bar graph.

The results containing the higher outcomes represent the winning states while the ones having lower/zero outcomes represent the losing/tied states.

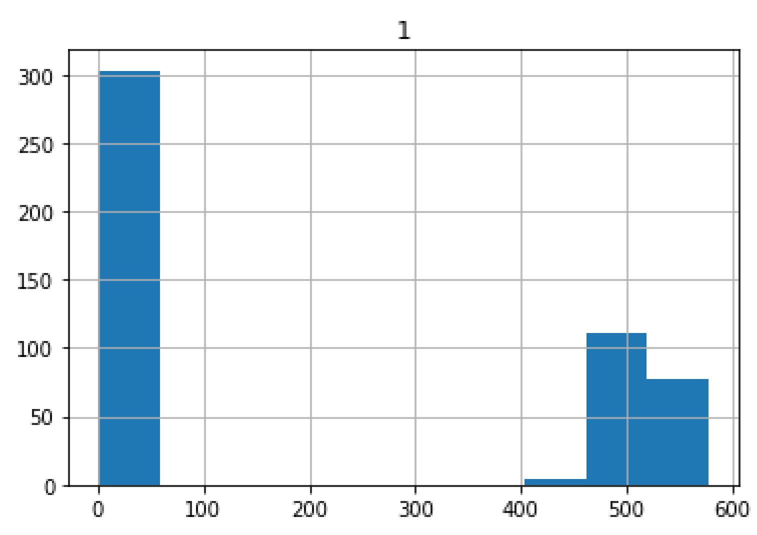
In [137…

```
import pandas as pd
df = pd.DataFrame(counts.items())
df = df.sort_values(by=1, ascending=False)

df.hist()
```

Out[137…

```
array([[<AxesSubplot:title={'center':'1'}>]], dtype=object)
```



In [138…

```
print(df)
```

```
             0    1
8    111010011  577
114  011111000  571
165  100010001  567
239  001110101  563
208  000110111  563
..         ...  ...
352  100000100    1
318  011001010    1
158  011100110    1
391  110000011    1
494  101000011    1

[495 rows x 2 columns]
```

In [139…

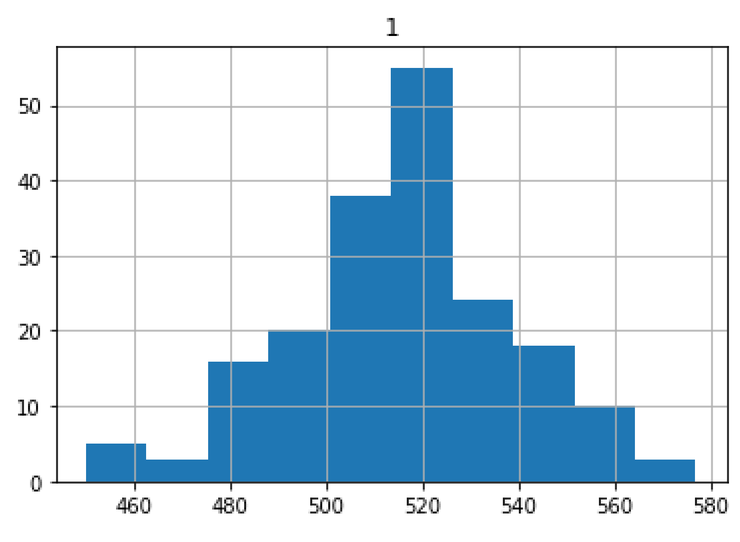
```
df1 = df.copy(deep = True)
df1 = df1[df1[1] > N/1000]
print(df1)
df1.hist()
```

```
             0    1
8    111010011  577
114  011111000  571
165  100010001  567
239  001110101  563
208  000110111  563
..         ...  ...
3    111100000  462
260  110101110  458
202  111001100  456
105  101010100  454
194  111110100  450

[192 rows x 2 columns]
```

Out[139…

```
array([[<AxesSubplot:title={'center':'1'}>]], dtype=object)
```



Hence, the problem is solved