HW-4.1

Using docker image UBSUNY/cp1-hw4

I am going to use the circuit that was implemented in IBM Lab. This time I am going to use the docker image mentioned above. Using the Jupyter Notebook in Docker image I m going use quiskit to to implement a circuit which can calculate 1+2=3 and than run the simulatot using the IBM Quantum Computer remotely.

We are going to use Full Adder to perform our calculation of 1+2= 3 The codes are taken from Qiskit.org.

We could just use half adder but it will not be abble to produce the carry on bit which is why we must use full adder to get both sum and carry on

To calculate , we need to use 3 qibits for our input values , 2 qibits as output qubits and 5 classical bits for measurement.

First we do our necessary imports as follows : Quantum registers, Classical register and Quantum circuit, numpy etc.

```
import numpy as np
# Importing standard Qiskit libraries
from qiskit import QuantumCircuit, transpile, Aer, IBMQ
from qiskit.tools.jupyter import *
from qiskit.visualization import *
from qiskit.providers.aer import QasmSimulator
```

Now I am going to generate the circuit (full adder) using 5 quantum registers and 2 classical registers. The codes below are taken from IBM Qiskit .

```
qc_ha = QuantumCircuit(5,2)
# encode inputs in qubits 0 and 1
qc_ha.x(0) # For a=0, remove the this line. For a=1, leave it.
qc_ha.x(1) # For b=0, remove the this line. For b=1, leave it.
qc_ha.x(2)
qc_ha.barrier()
# use cnots to write the XOR of the inputs on qubit 2
qc_ha.cx(0,3)
qc_ha.cx(1,3)
# use ccx to write the AND of the inputs on qubit 3
qc_ha.ccx(0,1,4)
qc_ha.barrier()
qc_ha.cx(2,3)
# use ccx to write the AND of the inputs on qubit 3
qc_ha.ccx(0,2,4)
qc_ha.ccx(1,2,4)
qc_ha.barrier()
# extract outputs
```

```
qc_ha.measure(3,0) # extract XOR value
qc_ha.measure(4,1) # extract AND value
```

```
<qiskit.circuit.instructionset.InstructionSet at 0xffff77271e50>
```

Lets draw the circuit :

```
qc_ha.draw()
```

```
q_0:   X

q_1:   X

q_2:   X

q_3:       X   X       X         M

q_4:           X       X   X     M

c: 2/                                                    0  1
```

Now I am going to use a real IBM quantum computer to simulate the circuit. For that I need to use my token from my IBM account to authenticate the access.

```
from qiskit import IBMQ
IBMQ.save_account('721674cf0abc1c4d6856b0e4384c3ad72a594211ba6238d49d78a6e03cdd5f4a88c2f6c8
provider = IBMQ.load_account()
```

```
configrc.store_credentials:WARNING:2021-11-28 03:11:49,360: Credentials already present. Set
ibmqfactory.load_account:WARNING:2021-11-28 03:11:49,732: Credentials are already in use. Th
```

We now choose a device with the least busy queue which can support our program

```
from qiskit.providers.ibmq import least_busy
from qiskit import execute

large_enough_devices = provider.backends(filters=lambda x: x.configuration().n_qubits > 3 an
backend = least_busy(large_enough_devices)
print("The best backend is " + backend.name())
```

```
The best backend is ibmq_belem
```

To run the circuit on the backend, we need to specify the number of shots and the number of credits we are willing to spend to run the circuit. Then, we execute the circuit on the backend using the execute function.

```
from qiskit.tools.monitor import job_monitor
# Number of shots to run the program (experiment);
```

```
# maximum is 8192 shots.
shots = 1024
# Maximum number of credits to spend on executions.
max_credits = 3
job_exp = execute(qc_ha, backend, shots=shots, max_credits=max_credits)
job_monitor(job_exp)
```

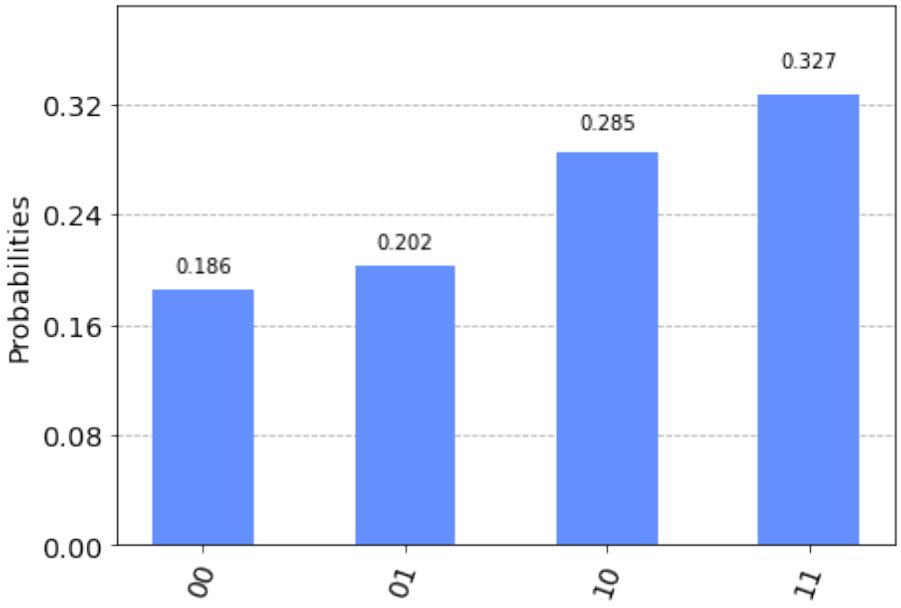
```
Job Status: job has successfully run
```

Let's get the result . When the .result() method is called, the code block will wait until the job has finished before releasing the cell. It took me almost 15 minutes to show the result.

```
result_exp = job_exp.result()
```

We can plot the result histogram as follow:

```
counts_exp = result_exp.get_counts(qc_ha)
plot_histogram(counts_exp)
```

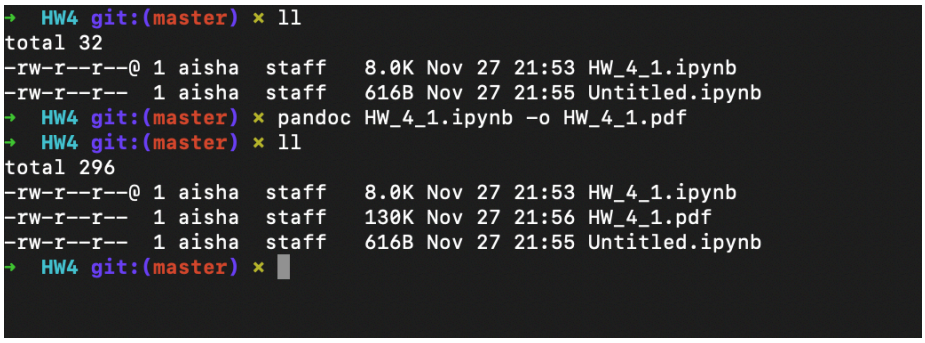


Even though I was expecting 11 (binary for 3) 100% , there are some other provabilities. But the highest provability is 32% for getting result 11.

##4.3
Using Pandoc to convert the file into .pdf

I run the following command in terminal to convert the .ipynb file to .pdf:

" pandoc hw_4_1.ipynb -o hw_4_1.pdf "



It successfully converted the jupyter notebook file to a pdf file.