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1 A Workbook for Qiskit Developer Certification

Hello everyone! This is Bartu, a fellow Qiskitter. I have recently taken the Certification exam and have followed the excellent study guide (https://slides.com/javafxpert/prep-qiskit-dev-cert-exam) by James Weaver, which also goes over the sample exam, so make sure to check it out if you haven't already!

While following the guide, I wanted to re-create examples from all specified topics on my own in an organized way to make connections easier. After completing the exam and getting my badge, I thought, hey, why not make this public? Maybe someone else will also find it useful! So this is basically what this workbook is about and I do hope that you get something out of it.

Important Notes:

1- This has been prepared in IBMQ Experience so you might want to use that instead of your local environment for avoiding conflicting versions and access to all widgets easily etc.

2-I have tried to mix up many variations of doing the same thing for demonstrating, but probably inescapably missed some things, so I do advise you also check for that in the study guide and the Qiskit documentation after you go through this Workbook if you want to expand your knowledge :)

3-Also, no info has been given on how gates work or what is a q-sphere etc. assuming the reader is already familiar with these material! This workbook was simply prepared with the intention of being exposed to all the materials covered in the exam as rapidly as possible while also remaining clear.

Rough Guidline: I intentionally didn't break this into sections explicitly to keep the feeling of flow I felt when writing these, and I think it is best to just go through all in one sitting. To avoid (en)tangling, I tried to comment on the code as much as I can, as well as creating some titles inside the code. Do let me know if you think writing a *Contents* explicitly for it would be beneficial :) You can contact me through Qiskit Slack (bartubisgin) or LinkedIn.

Here are the subjects you will be presented with, in the exam:

1 Perform Operations on Quantum Circuits	47%
1. Construct multi-qubit quantum registers	
2. Measure quantum circuits in classical registers	
3. Use single-qubit gates	
4. Use multi-qubit gates	
5. Use barrier operations	
6. Return the circuit depth	
7. Extend quantum circuits	
8. Return the OpenQASM string for a circuit	
2 Executing Experiments	**3%**
1. Execute a quantum circuit	
3 Implement BasicAer: Python-based Simulators	**3%**
1. Use the available simulators	
4 Implement Qasm	**1%**
1. Read a QASM file	
5 Compare and Contrast Quantum Information	**10%**
1. Use classical and quantum registers	
2. Use operators	
3. Measure fidelity	

6 Return the Experiment Results	7%
1. Return the histogram data of an experiment	
2. Return the statevector of an experiment	
3. Return the unitary of an experiment	
7 Use Qiskit Tools	**1%**
1. Monitor the status of a job instance	
8 Display and Use System Information	**3%**
1. Perform operations around the Qiskit version	
2. Use information gained from *quiskit_backend_overview*	
9 Construct Visualizations	**19%**
1. Draw a circuit	
2. Plot a histogram of data	
3. Plot a Bloch multivector	
4. Plot a Bloch vector	
5. Plot a QSphere	
6. Plot a density matrix	
7. Plot a gate map with error rates	
10 Access Aer Provider	**6%**
1. Assess a *statevector_simulator* backend	
2. Assess a *qasm_simulator* backend	
3. Assess a *unitary_simulator* backend	

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Credit: IBM Quantum (https://www.ibm.com/certify/exam?id=C1000-112)

1.1 The Usual Suspects: *Preliminary Imports* (Doesn't include all that will be needed for demonstration purposes later)

In [2]:
```
import numpy as np
# Importing standard Qiskit libraries
from qiskit import *
from qiskit.tools.jupyter import *
from qiskit.visualization import *
#from ibm_quantum_widgets import *

# Loading your IBM Quantum account(s)
provider = IBMQ.load_account()
```

1.2 Building the 4 Bell States and Using the Statevector Object

In [3]:
```
#bell states are very important to know in general
#here we create all 4 bell states by modifying the same circuit
#i've named them bell_0-1-2-3

#additionally, we are creating a Statevector object
#and priting out the state using LaTeX

#note that this statevector object DOES NOT require
#any kind of simulation to get the information

from qiskit.quantum_info import Statevector

bell_0 = QuantumCircuit(2)
bell_0.h(0)
bell_0.cx(0,1)

sv = Statevector.from_label('00') #we used the .from_label(), we could also
sv_ev = sv.evolve(bell_0) #we evolve this initial state through our circuit
sv_ev.draw('latex') #we print out the state via. LaTeX
```

Out[3]:

$$\begin{bmatrix} \frac{1}{\sqrt{2}} & 0 & 0 & \frac{1}{\sqrt{2}} \end{bmatrix}$$

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In [4]:
```
bell_1 = QuantumCircuit(2)
bell_1.h(0)
bell_1.z(0)
bell_1.cx(0,1)

sv_ev2 = sv.evolve(bell_1)
sv_ev2.draw('latex')
```

Out[4]:

$$\begin{bmatrix} \frac{1}{\sqrt{2}} & 0 & 0 & -\frac{1}{\sqrt{2}} \end{bmatrix}$$

In [5]:
```
bell_2 = QuantumCircuit(2)
bell_2.h(0)
bell_2.x(1)
bell_2.cx(0,1)

sv_ev_2 = sv.evolve(bell_2)
sv_ev_2.draw('latex')
```

Out[5]:

$$\begin{bmatrix} 0 & \frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} & 0 \end{bmatrix}$$

In [6]:
```
bell_3 = QuantumCircuit(2)
bell_3.h(0)
bell_3.x(1)
bell_3.cx(0,1)
bell_3.z(1)

sv_ev_3 = sv.evolve(bell_3)
sv_ev_3.draw('latex')
```

Out[6]:

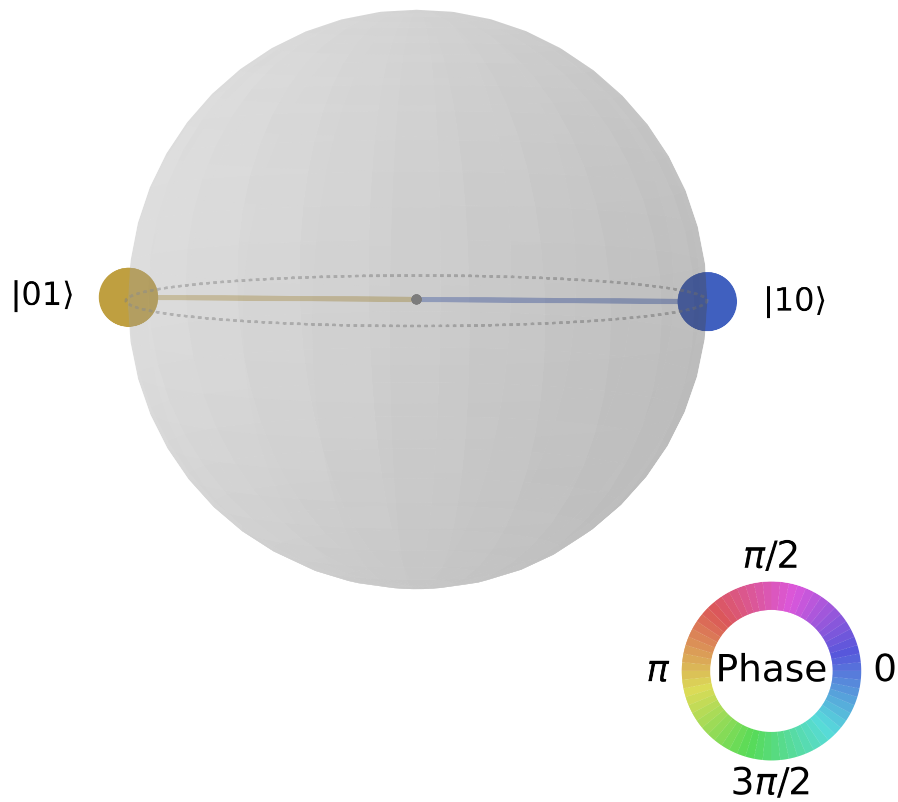
$$\begin{bmatrix} 0 & \frac{1}{\sqrt{2}} & -\frac{1}{\sqrt{2}} & 0 \end{bmatrix}$$

▸ IBMQ Jobs In [7]:

```
#the Statevector object can be directly drawn on a qsphere
#with the same .draw() method by simply changing the call from 'latex' to '
#this will NOT be the case once we move on to the statevectors from simulat

sv_ev_3.draw('qsphere')
```

Out[7]:



1.3 Build the GHZ State

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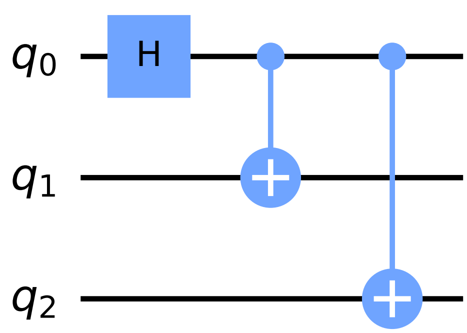
In [8]:
```python
#we have seen how to get the bell states and also get their Statevector obj
#let's move to another famous state and its circuit, the GHZ
#and let's actually see our circuits!

ghz = QuantumCircuit(3)
ghz.h(0)
ghz.cx([0,0],[1,2]) #notice we didn't need to specify 2x ghz.cx() by utiliz

ghz.draw('text') #we could also draw this with matplotlib by specifying 'mp
```

Out[8]:
```
     ┌───┐          
q_0: ┤ H ├──■────■──
     └───┘┌─┴─┐  │  
q_1: ─────┤ X ├──┼──
          └───┘┌─┴─┐
q_2: ──────────┤ X ├
               └───┘
```

In [9]:
```python
ghz.draw('mpl') #note that IBMQ resorts to this method as the default, if n
#of course, if you import it as 'plt' you will need to use it this way
```

Out[9]:



In [10]:
```python
sv = Statevector.from_int(0,2**3) #here we employed the .from_int()
sv_ev = sv.evolve(ghz)
sv_ev.draw('latex')
```

Out[10]:
$$\begin{bmatrix} \frac{1}{\sqrt{2}} & 0 & 0 & 0 & 0 & 0 & 0 & \frac{1}{\sqrt{2}} \end{bmatrix}$$

In [11]:
```python
sv = Statevector.from_label('000') #doing the same with .from_label()
sv_ev = sv.evolve(ghz)
sv_ev.draw('latex')
```

Out[11]:
$$\begin{bmatrix} \frac{1}{\sqrt{2}} & 0 & 0 & 0 & 0 & 0 & 0 & \frac{1}{\sqrt{2}} \end{bmatrix}$$

1.4 Statevector objects have method of .draw() directly as stated!

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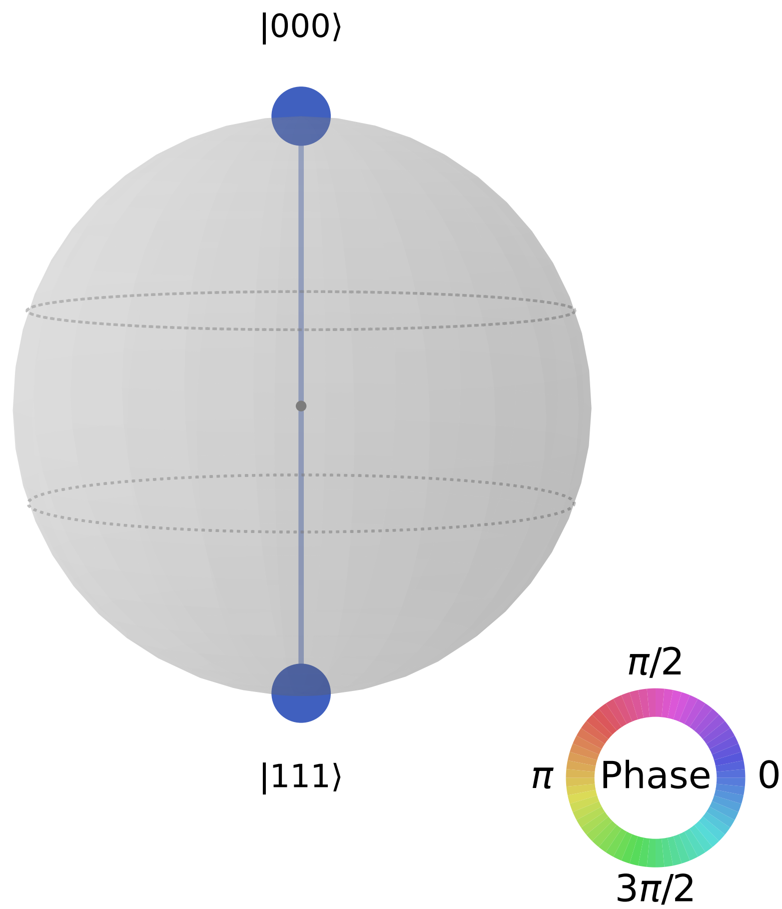
In [12]:
```
#again hitting on the home-point I specified earlier
sv_ev.draw('qsphere')
```

Out[12]:



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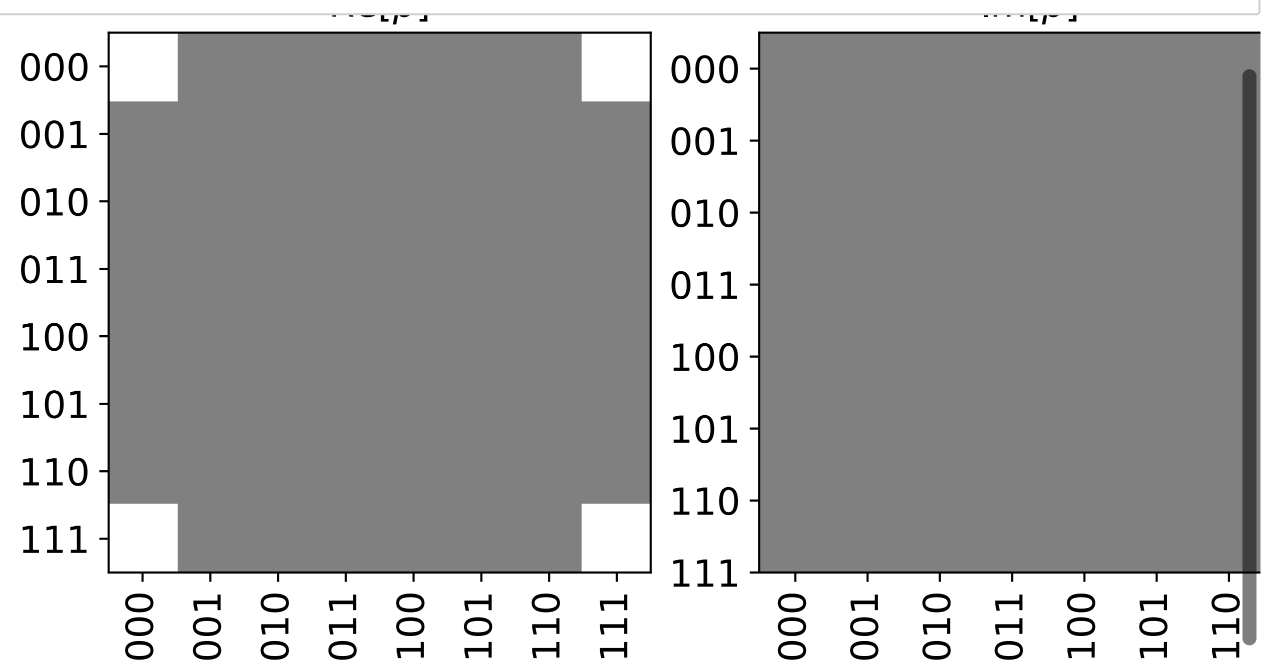
In [13]:
```python
#they also have this feature for drawing a hinton directly!
sv_ev.draw('hinton')
```



1.5 We could also have used the statevector_simulator to create a statevector instead!

In [14]:
```python
#now, calling a Statevector object is fun and all
#but what is more fun is doing the same thing via. simulation

#BasicAer is from where we get our main 3 simulators, these are:
# 1-'qasm_simulator'
# 2-'statevector_simulator'
# 3-'unitary_simulator'

BasicAer.backends()
```

Out[14]:
```
[<QasmSimulatorPy('qasm_simulator')>,
 <StatevectorSimulatorPy('statevector_simulator')>,
 <UnitarySimulatorPy('unitary_simulator')>]
```

In [15]:
```python
backend_sv = BasicAer.get_backend('statevector_simulator') #here we get the
job = execute(ghz, backend_sv, shots=1024) #we specify our job, which circu
result = job.result() #we extract the results from the job
sv_ev2 = result.get_statevector(ghz) #finally, we get the statevector from

#CAUTION: this way of getting the statevector does not have the method '.dr
#in order to visualize you need plotting functions directly

#NOTE: that we did not need any measurements for this type of operation!
#This won't be the case once we move to experimenting with the qasm_simulat
```

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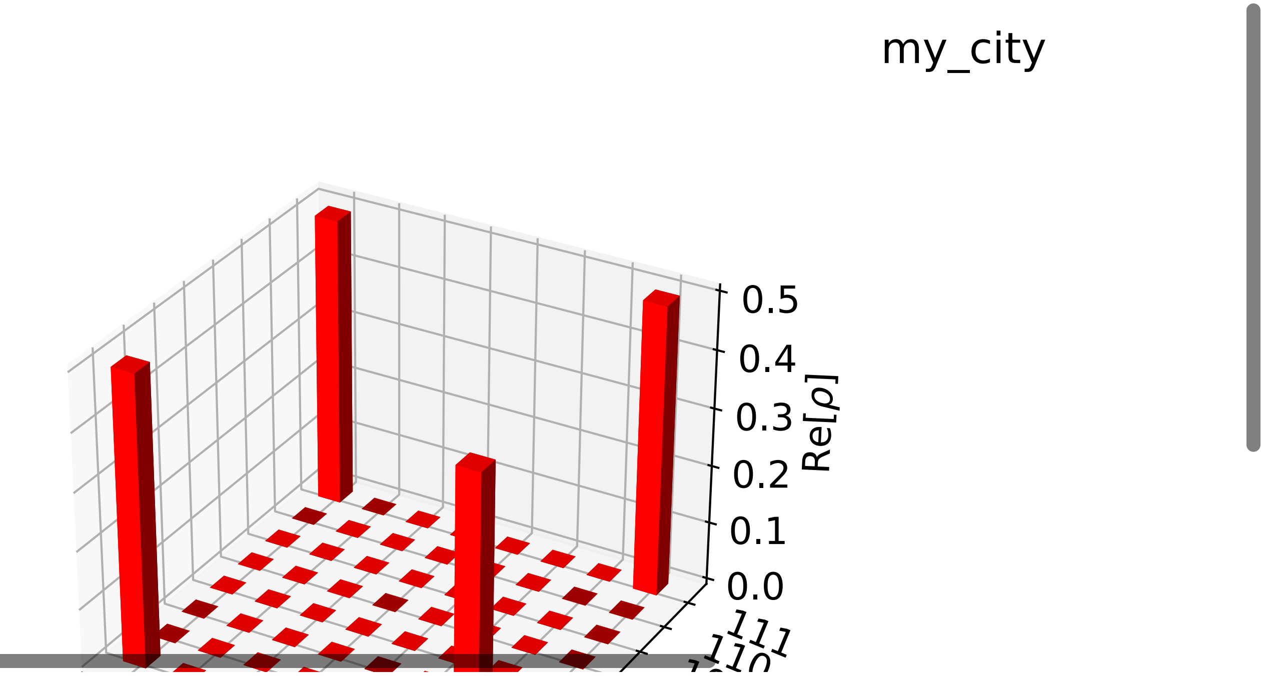
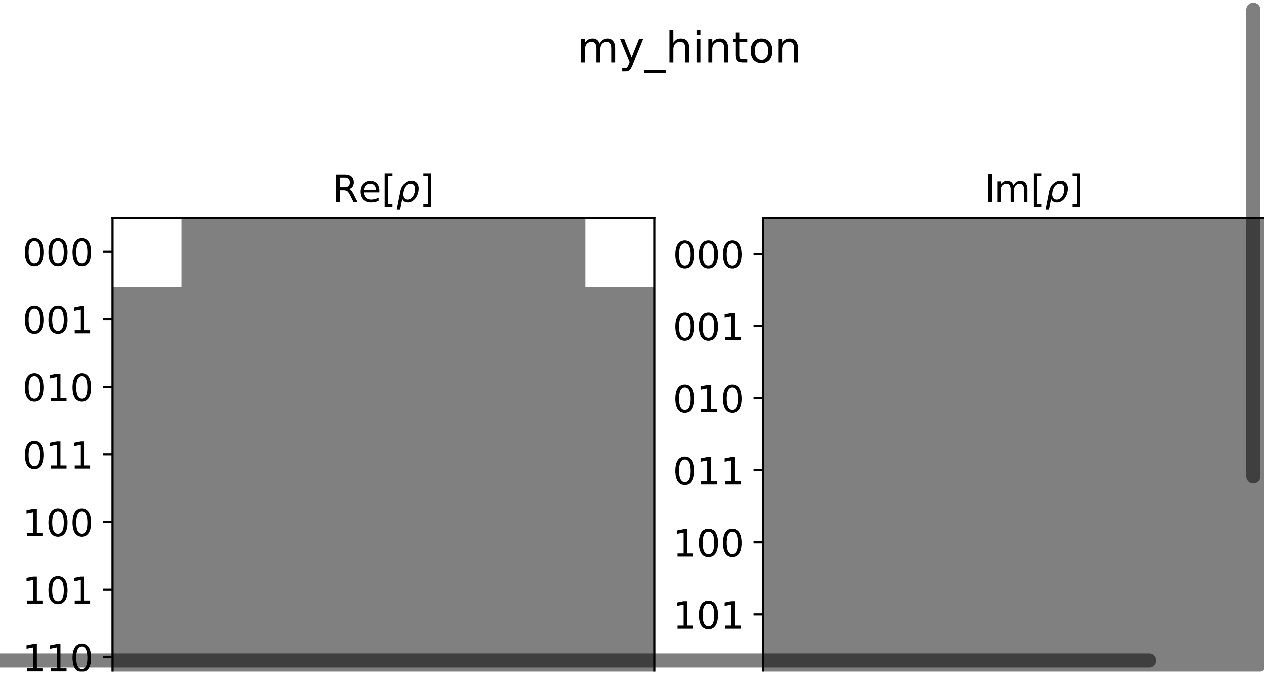
In [16]:
```
#as stated above, now, if we wanna plot our state, we need the actual plott
#there are multiple cool ways of visualizing a state

#1-Plotting the DensityMatrix aka. The state_city

plot_state_city(sv_ev2, title='my_city',color=['red','blue']) #you can set
```

Out[16]:



In [17]:
```
#2-Plot your hinton!
plot_state_hinton(sv_ev2, title='my_hinton')
```

Out[17]:



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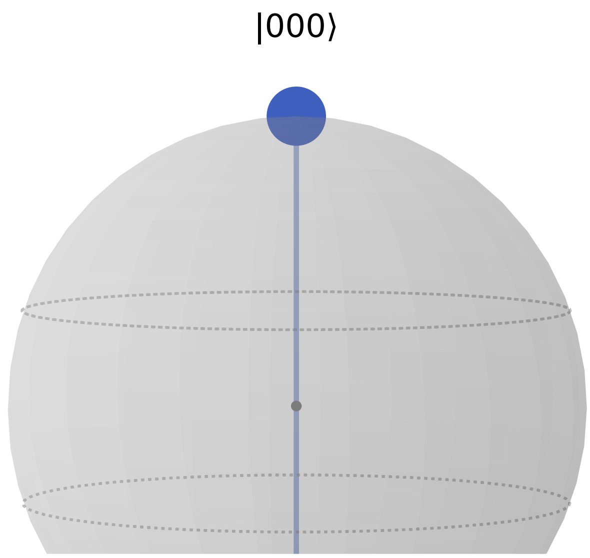
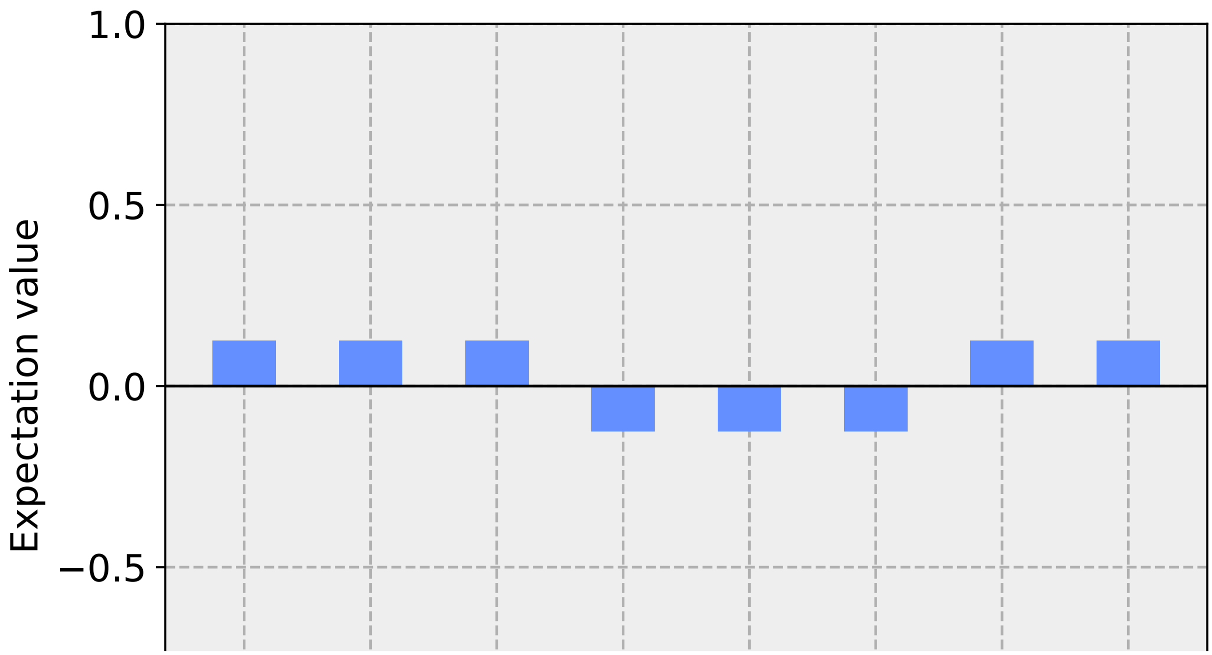
In [18]:
```
#3-Plot your good old pal QSphere, with a function directly!
plot_state_qsphere(sv_ev2) #only figsize can be specified inside
```

Out[18]:



In [19]:
```
#4-Whoa you can also plot the Pauli Expectation Values
plot_state_paulivec(sv_ev2)
```

Out[19]:



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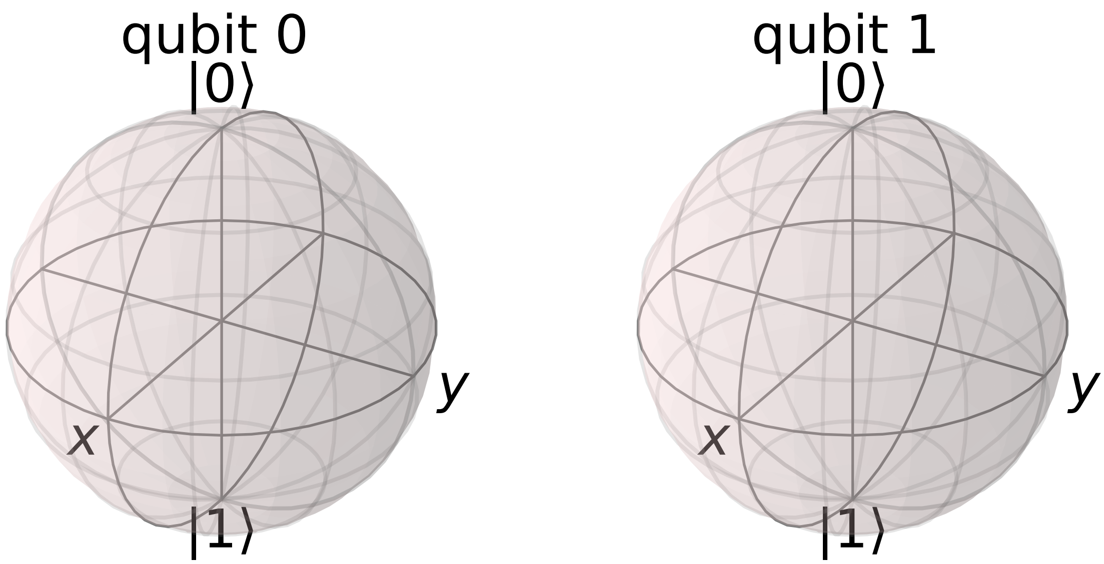
In [20]:
```
#5-And finally, you can plot the Bloch Vectors for each qubit via Bloch_MUL

#Note: This is something I haven't yet made clear for myself, but I believe
#because this is a maximally entangled state; don't pick me up on that, I'l

plot_bloch_multivector(sv_ev2)
```

Out[20]:



1.6 Know your Bloch_Vector and Bloch_Multivector

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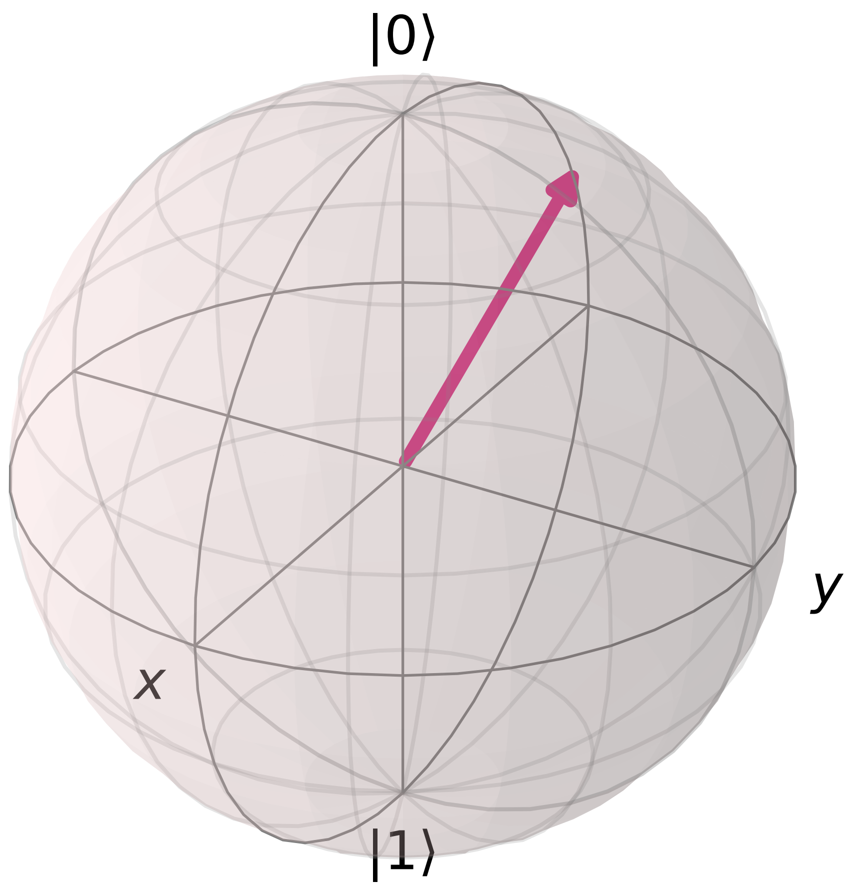
In [21]:

```
#there is an important distinction between these two, the multivector as we
#plots a state coming from a circuit
#whereas the mere bloch_vector needs coordinate specifications
#there coordinates can be cartesian, or spherical - I advise you check docs

plot_bloch_vector([0,0.5,1])
#here for [x,y,z]; x=Tr[Xϱ] and similar for y and z
```

Out[21]:



1.7 Circuits with explicit Quantum Registers??

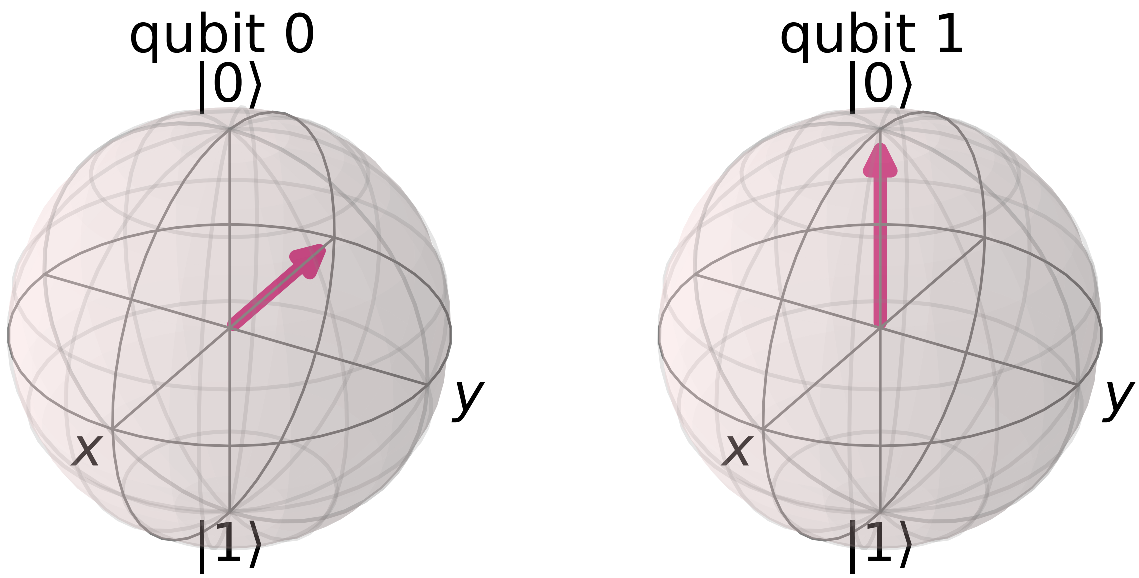
In [22]:

```
#here we create 2 registers explicitly before creating our circuit
#and we get our statevector the same way
#then we plot its bloch_multivector

q_a = QuantumRegister(1,'q_a')
q_b = QuantumRegister(1, 'q_b')
qc = QuantumCircuit(q_a, q_b)
qc.h(0)
qc.z(0)

back = BasicAer.get_backend('statevector_simulator')
result = execute(qc, back).result()
sv = result.get_statevector()
plot_bloch_multivector(sv) #voila!
```

Out[22]:



In [23]:

```
plot_state_city(sv, color=['orange','black'])
```

Out[23]:

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1.8 How about doing an actual experiment and getting Probabilities?

1.9 Enter, qasm_simulator!

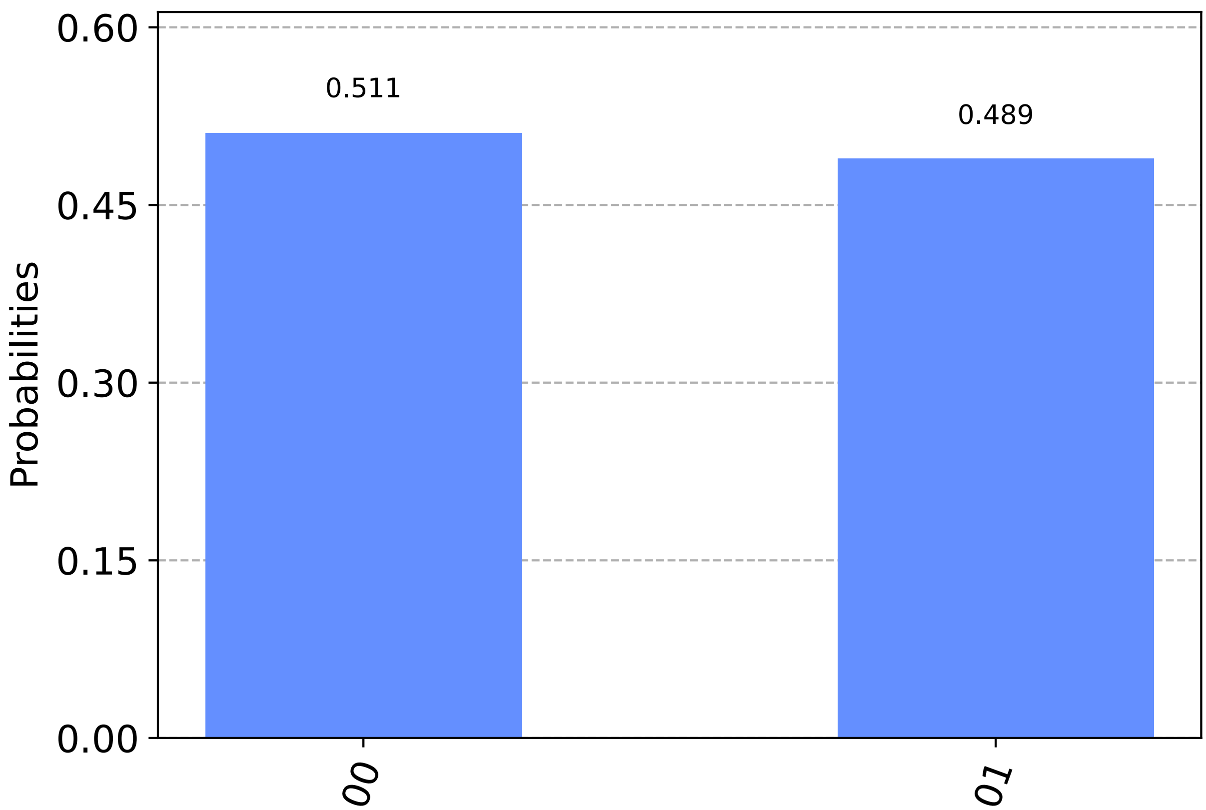
In [24]:

```
#to do this, we need to measure our circuit
#and then run the qasm simulator
#how you perform your measurements can vary quite a bit

qc.measure_all() #here we employ the measure_all() which CREATES a classica
#NOTE: this means, if your circuit already had a classical register, it wou
#so measure_all() is usually used for circuits that do not have a classical

qasm_sim = BasicAer.get_backend('qasm_simulator') #this time we call the qa
result = execute(qc, qasm_sim).result() # NOTICE: we can skip some steps by
counts = result.get_counts() #this time, we are not getting the state, but
plot_histogram(counts) #a new plotting method! this works for counts obviou
```

Out[24]:



1.10 We can extend a pre-defined circuit with 'compose'

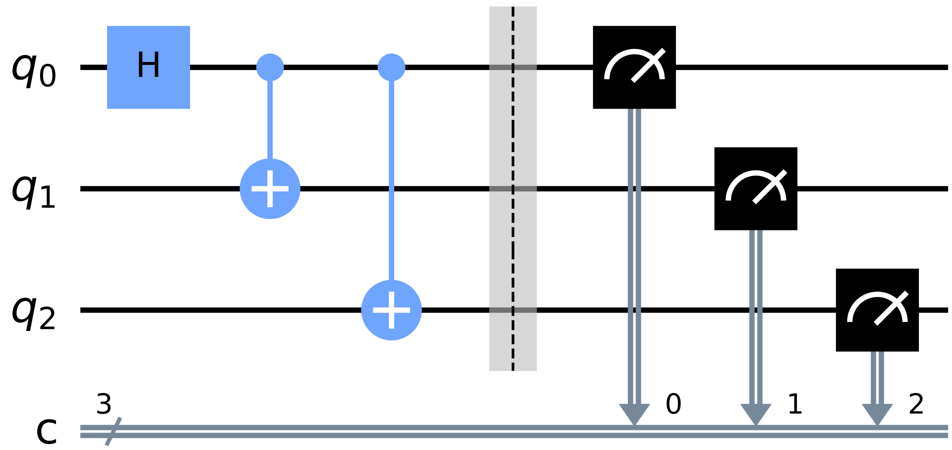
In [25]:

```
meas = QuantumCircuit(3,3) #here we create a new quantum circuit just with
meas.barrier()
meas.measure([0,1,2],[0,1,2]) #notice how again, we didn't need 3x measures
#also notice the measure here measures the respective quantum registers int
#the ordering does play a role!

circ = meas.compose(ghz,range(3),front=True) #the compose method requires w
#and the front=True ensures we get GHZ before we measure all our qubits at

circ.draw('mpl')
```

Out[25]:



In [26]:

```
backend = BasicAer.get_backend('qasm_simulator')
circ = transpile(circ, backend)
job = backend.run(circ, shots=1024) #notice here we use .run instead of exe
#most usually we employ 'execute' though because it is more flexible
result = job.result()
counts = result.get_counts()
print(counts) #now, we could also just print our counts in an un-spectacula
```

```
{'000': 506, '111': 518}
```

In [27]:

```
#let's run with execute instead of run now
job2 = execute(circ, backend, shots=1024)
result2 = job2.result()
counts2 = result2.get_counts()
print(counts2)
#here we also demonstrate the probabilistic nature of quantum measurement,
#as you can see the counts are different for 2 different experiments on the
```

```
{'111': 532, '000': 492}
```

1.11 Having 2 different results tie in well with our next demonstration!

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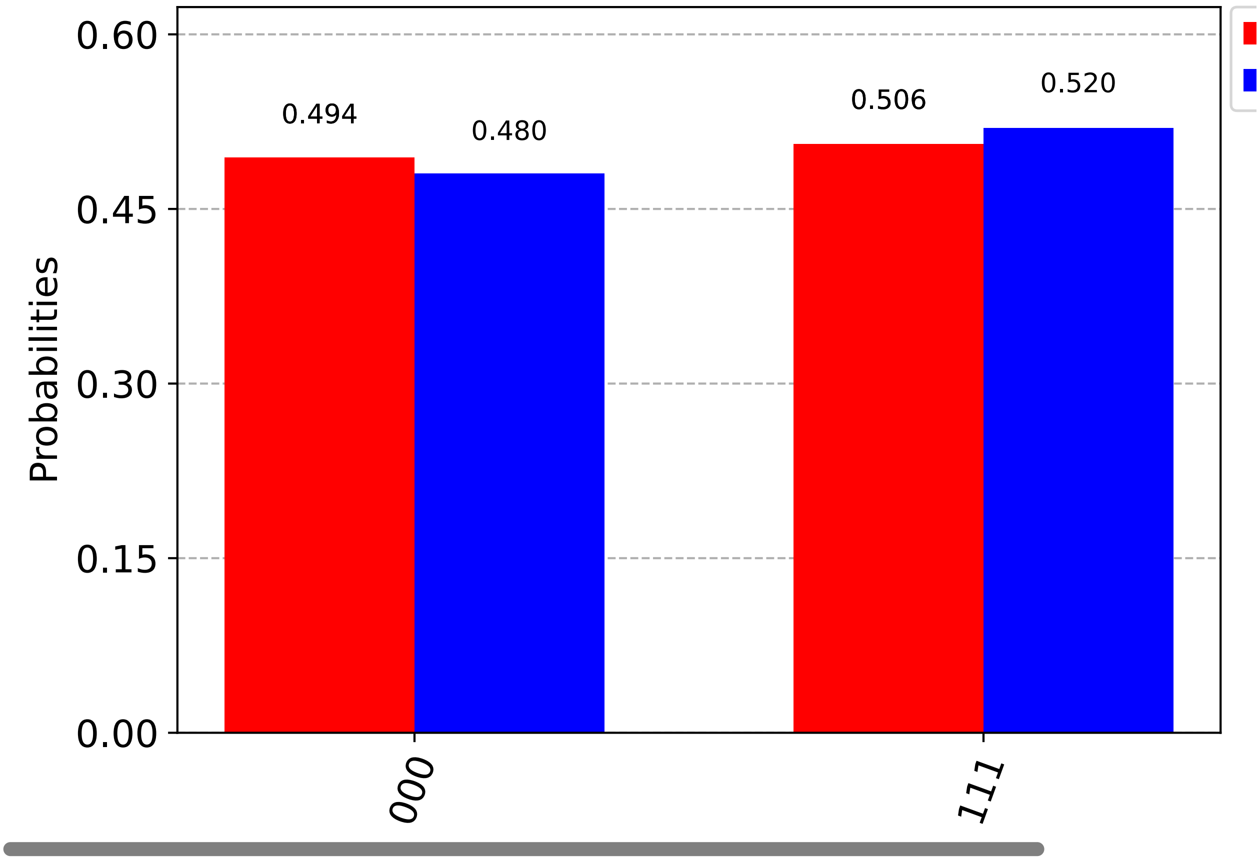
In [28]:

```
leg = ['counts-1','counts-2']
plot_histogram([counts,counts2], legend=leg, sort='asc',color=['red','blue'
#there is also a way to not show probabilities ON TOP of the bars with the
#for rest of the methods, check docs!
```

Out[28]:



1.12 We can also work on real backend by provider, and monitor the job

In [29]:

```
import qiskit.tools.jupyter
%qiskit_job_watcher #this creates a pop up of your jobs, check it out by ru
```

In [30]:

```
from qiskit.tools import job_monitor
quito = provider.get_backend('ibmq_quito') #to call a real backend, we use
#Note: you can check which backends are available for you too!
job = execute(circ, quito)
job_monitor(job)
```

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

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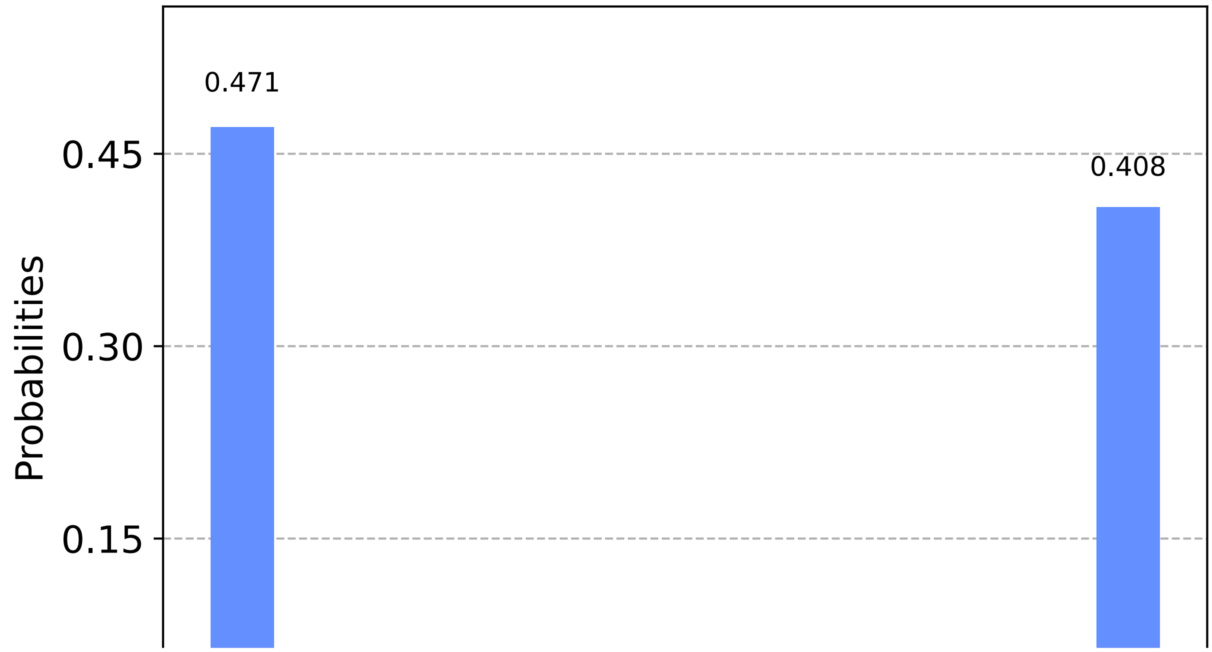
In [31]:
```
result = job.result()
counts = result.get_counts()
plot_histogram(counts)
```

Out[31]:



Until now, we've used perfect, error-prone, noisless simulators; here we see a real machine, with all its errors!

1.13 We can also create operator forms of circuits

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In [32]:

```python
from qiskit.quantum_info import Operator
U = Operator(ghz) #we can turn our ghz circuit from above into an operator!
U.data

#NOTE: this is very similar to getting the Statevector object directly,
#just this time, for getting the operator,
#we will see we can also do this via. simulation,
#just like we did for the state!
```

Out[32]:

```
array([[ 0.70710678+0.j,  0.70710678+0.j,  0.        +0.j,
         0.        +0.j,  0.        +0.j,  0.        +0.j,
         0.        +0.j,  0.        +0.j],
       [ 0.        +0.j,  0.        +0.j,  0.        +0.j,
         0.        +0.j,  0.        +0.j,  0.        +0.j,
         0.70710678+0.j, -0.70710678+0.j],
       [ 0.        +0.j,  0.        +0.j,  0.70710678+0.j,
         0.70710678+0.j,  0.        +0.j,  0.        +0.j,
         0.        +0.j,  0.        +0.j],
       [ 0.        +0.j,  0.        +0.j,  0.        +0.j,
         0.        +0.j,  0.70710678+0.j, -0.70710678+0.j,
         0.        +0.j,  0.        +0.j],
       [ 0.        +0.j,  0.        +0.j,  0.        +0.j,
         0.        +0.j,  0.70710678+0.j,  0.70710678+0.j,
         0.        +0.j,  0.        +0.j],
       [ 0.        +0.j,  0.        +0.j,  0.70710678+0.j,
        -0.70710678+0.j,  0.        +0.j,  0.        +0.j,
         0.        +0.j,  0.        +0.j],
       [ 0.        +0.j,  0.        +0.j,  0.        +0.j,
```

In [33]:

```python
#if we so want, we can round all these numbers by using np.around
#and specify how many decimals we want
np.around(U.data, 3)
```

Out[33]:

```
array([[ 0.707+0.j,  0.707+0.j,  0.   +0.j,  0.   +0.j,  0.   +0.j,
         0.   +0.j,  0.   +0.j,  0.   +0.j],
       [ 0.   +0.j,  0.   +0.j,  0.   +0.j,  0.   +0.j,  0.   +0.j,
         0.   +0.j,  0.707+0.j, -0.707+0.j],
       [ 0.   +0.j,  0.   +0.j,  0.707+0.j,  0.707+0.j,  0.   +0.j,
         0.   +0.j,  0.   +0.j,  0.   +0.j],
       [ 0.   +0.j,  0.   +0.j,  0.   +0.j,  0.   +0.j,  0.707+0.j,
        -0.707+0.j,  0.   +0.j,  0.   +0.j],
       [ 0.   +0.j,  0.   +0.j,  0.   +0.j,  0.   +0.j,  0.707+0.j,
         0.707+0.j,  0.   +0.j,  0.   +0.j],
       [ 0.   +0.j,  0.   +0.j,  0.707+0.j, -0.707+0.j,  0.   +0.j,
         0.   +0.j,  0.   +0.j,  0.   +0.j],
       [ 0.   +0.j,  0.   +0.j,  0.   +0.j,  0.   +0.j,  0.   +0.j,
         0.   +0.j,  0.707+0.j,  0.707+0.j],
       [ 0.707+0.j, -0.707+0.j,  0.   +0.j,  0.   +0.j,  0.   +0.j,
         0.   +0.j,  0.   +0.j,  0.   +0.j]])
```

1.14 We could also do it with a unitary_sim, just like we did with statevector_sim!

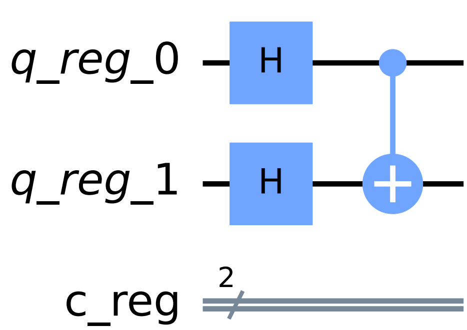
In [34]:
```
backend_uni = BasicAer.get_backend('unitary_simulator') #we get the unitary
U = execute(ghz,backend_uni).result().get_unitary(decimals=3) #we skip a wh
#instead of rounding with np.around(), you can also use 'decimals' in get_u
U
```

Out[34]:
```
array([[ 0.707+0.j,  0.707-0.j,  0.   +0.j,  0.   +0.j,  0.   +0.j,
         0.   +0.j,  0.   +0.j,  0.   +0.j],
       [ 0.   +0.j,  0.   +0.j,  0.   +0.j,  0.   +0.j,  0.   +0.j,
         0.   +0.j,  0.707+0.j, -0.707+0.j],
       [ 0.   +0.j,  0.   +0.j,  0.707+0.j,  0.707-0.j,  0.   +0.j,
         0.   +0.j,  0.   +0.j,  0.   +0.j],
       [ 0.   +0.j,  0.   +0.j,  0.   +0.j,  0.   +0.j,  0.707+0.j,
        -0.707+0.j,  0.   +0.j,  0.   +0.j],
       [ 0.   +0.j,  0.   +0.j,  0.   +0.j,  0.   +0.j,  0.707+0.j,
         0.707-0.j,  0.   +0.j,  0.   +0.j],
       [ 0.   +0.j,  0.   +0.j,  0.707+0.j, -0.707+0.j,  0.   +0.j,
         0.   +0.j,  0.   +0.j,  0.   +0.j],
       [ 0.   +0.j,  0.   +0.j,  0.   +0.j,  0.   +0.j,  0.   +0.j,
         0.   +0.j,  0.707+0.j,  0.707-0.j],
       [ 0.707+0.j, -0.707+0.j,  0.   +0.j,  0.   +0.j,  0.   +0.j,
         0.   +0.j,  0.   +0.j,  0.   +0.j]])
```

1.15 Creating a circuit with Q and C registers explicitly

In [35]:
```
#another example for getting the unitary
#but also demonstrating explicitly defining a classical register this time

q = QuantumRegister(2,'q_reg')
c = ClassicalRegister(2,'c_reg')
qc = QuantumCircuit(q,c)
qc.h(q[0:2])
qc.cx(q[0], q[1])
qc.draw('mpl')
```

Out[35]:



IBMQ Jobs

In [36]:
```python
U_bell = Operator(qc)
np.around(U_bell.data,3)
```

Out[36]:
```
array([[ 0.5+0.j,  0.5+0.j,  0.5+0.j,  0.5+0.j],
       [ 0.5+0.j, -0.5+0.j, -0.5+0.j,  0.5+0.j],
       [ 0.5+0.j,  0.5+0.j, -0.5+0.j, -0.5+0.j],
       [ 0.5+0.j, -0.5+0.j,  0.5+0.j, -0.5+0.j]])
```

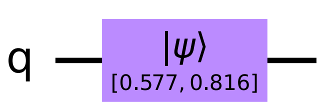
In [37]:
```python
back = BasicAer.get_backend('unitary_simulator')
result = execute(qc, back).result()
U = result.get_unitary(decimals=3)
U
```

Out[37]:
```
array([[ 0.5+0.j,  0.5-0.j,  0.5-0.j,  0.5-0.j],
       [ 0.5+0.j, -0.5+0.j, -0.5+0.j,  0.5-0.j],
       [ 0.5+0.j,  0.5-0.j, -0.5+0.j, -0.5+0.j],
       [ 0.5+0.j, -0.5+0.j,  0.5-0.j, -0.5+0.j]])
```

1.16 We can also initialize a desired_state via initialize method, as long as the desired_state is valid (the probs add up to 1) - We can also test the state_fidelity() method which checks if two states are the same!

In [38]:
```python
#Testing for fidelity with initializer
a = 1/np.sqrt(3) #we can define a state ourselves, we could also get a rand
desired_state = [a,np.sqrt(1-a**2)] #state is defined such that it is a val
q_reg = QuantumRegister(1,'q')
qc = QuantumCircuit(q_reg)
qc.initialize(desired_state,0) #as simple as this!
qc.draw('mpl')
```

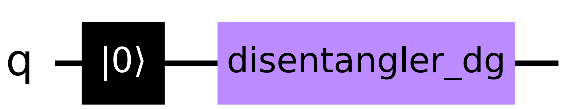
Out[38]:



1.17 There is also decomposing I heard?

In [39]:
```python
decomp = qc.decompose() #you heard right!
decomp.draw() #but what is this weird |0>? It is a reset! Meaning that init
#It is irreversible because it has a reset! This is explained very well in
#And also, how it actually works can be found in the docs too, for the curi
```

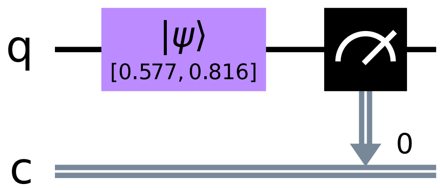
Out[39]:



IBMQ Jobs

In [40]:
```
c_reg = ClassicalRegister(1,'c')
meas = QuantumCircuit(q_reg, c_reg)
meas.measure(0,0)
circ = meas.compose(qc, range(1), front=True)
circ.draw('mpl')
```

Out[40]:



In [41]:
```
#squaring the amplitudes
alpha_squared = 0.577 **  2
beta_squared = 0.816 ** 2
print(alpha_squared, beta_squared)
```

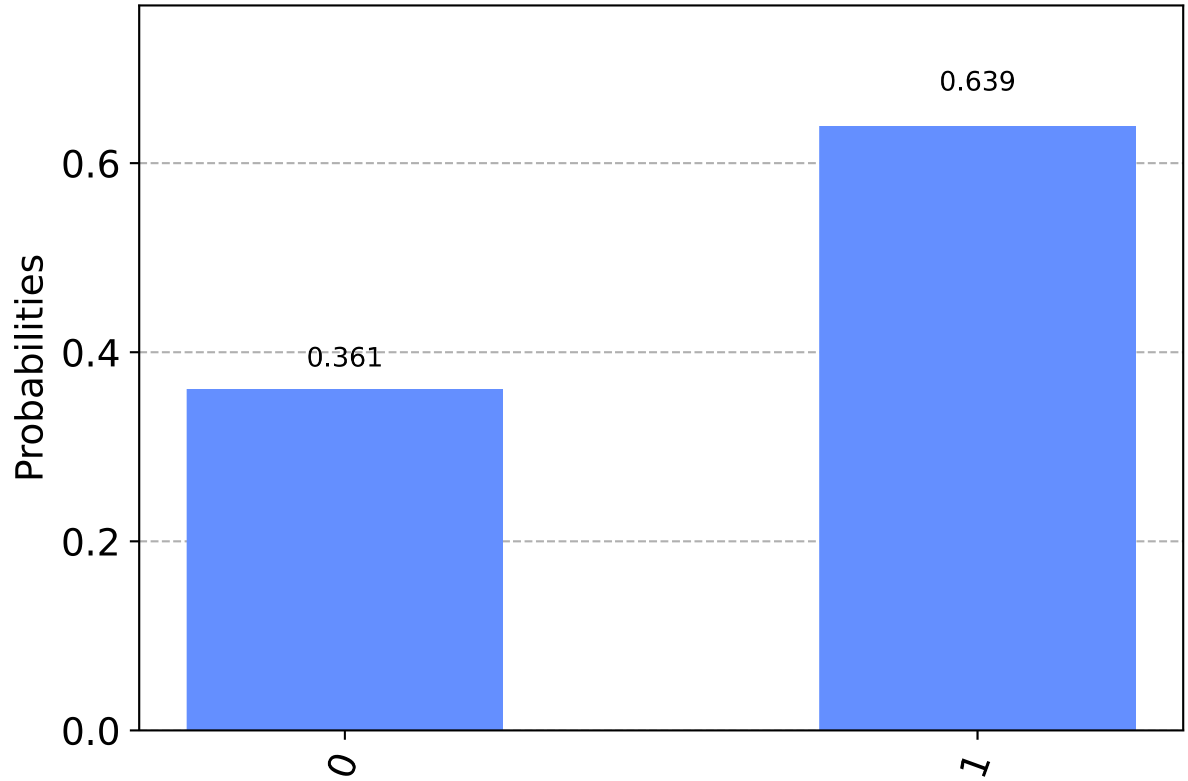
```
0.332929 0.6658559999999999
```

In [42]:
```
back = BasicAer.get_backend('qasm_simulator')
job = execute(circ, back, shots=1000)
counts = job.result().get_counts()
print(counts)
```

```
{'1': 639, '0': 361}
```

In [43]:
```
plot_histogram(counts)
```

Out[43]:



1.18 We can compare the fidelities of the state created and the state we wanted in the first place, and because we know Initialize works, we expect them to match up

In [44]:
```
#for getting the statevector from the circuit, we employ our old friend
#the .get_statevector via the state-vec sim

back_sv = BasicAer.get_backend('statevector_simulator')
result = execute(qc, back_sv).result()
qc_sv = result.get_statevector(qc)
qc_sv
```

Out[44]:
```
array([0.57735027+0.j, 0.81649658+0.j])
```

In [45]:
```
from qiskit.quantum_info import state_fidelity
state_fidelity(desired_state, qc_sv)
#this compares the statevector we got from simulation vs. the state we want
#and surprise! they match perfectly, which is expected!
```

Out[45]:
```
1.0
```

1.19 I should also be able to get fidelities for gates and processes right?

In [46]:
```python
from qiskit.circuit.library import XGate
from qiskit.quantum_info import Operator, average_gate_fidelity, process_fi
op_a = Operator(XGate())
op_b = np.exp(1j / 2) * op_a

#these differ only by a phase so the gate and process
#fidelities are expected to be 1

a = average_gate_fidelity(op_a,op_b)
a
```

Out[46]: 1.0

In [47]:
```python
b = process_fidelity(op_a, op_b)
a == b
```

Out[47]: True

1.20 We can also get the initializer in matrix form via. get_unitary()!

In [48]:
```python
#i'm just trying to mix everything up at this point, so that it becomes mem

back_uni = BasicAer.get_backend('unitary_simulator')
job = execute(qc, back_uni)
result = job.result()
U_qc = result.get_unitary(decimals=3)
U_qc
```

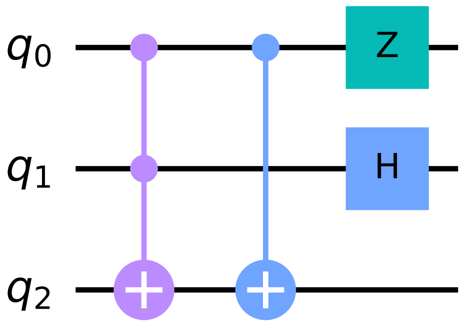
Out[48]:
```
array([[ 0.577+0.j, -0.816+0.j],
       [ 0.816+0.j,  0.577+0.j]])
```

1.21 We can wrap up circuits to gates with .to_gate() method

IBMQ Jobs

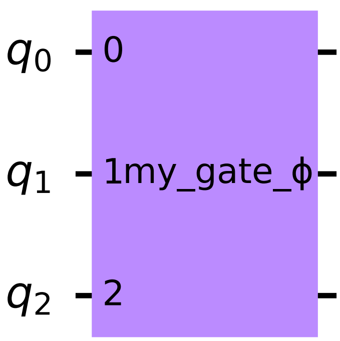
In [49]:
```python
qc = QuantumCircuit(3)
qc.mct([0,1],2)
qc.cx(0,2)
qc.h(1)
qc.z(0)
qc.draw('mpl')
```

Out[49]:



In [50]:
```python
qc_gate = qc.to_gate()
qc_gate.name = 'my_gate_ϕ' #we can even give it a name!
circ = QuantumCircuit(3)
circ.append(qc_gate, [0,1,2])
circ.draw('mpl')
```

Out[50]:

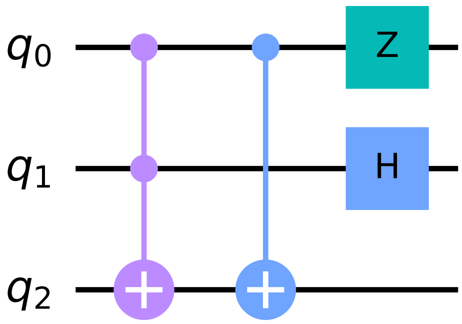


IBMQ Jobs

In [51]:

```python
circ_decomp = circ.decompose() #aaaand we can decompose it back!
circ_decomp.draw('mpl')
```

Out[51]:

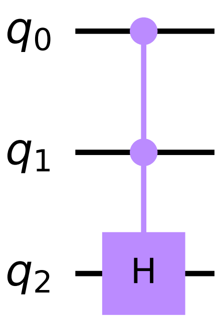


1.22 We can also actually create custom Controlled-Gates!

In [52]:

```python
from qiskit.circuit.library import HGate
ch = HGate().control(2) #here we specify how many controls we want
qc = QuantumCircuit(3)
qc.append(ch, [0,1,2]) #the [a,b,c] correspond to controls and target respe
qc.draw('mpl')
```

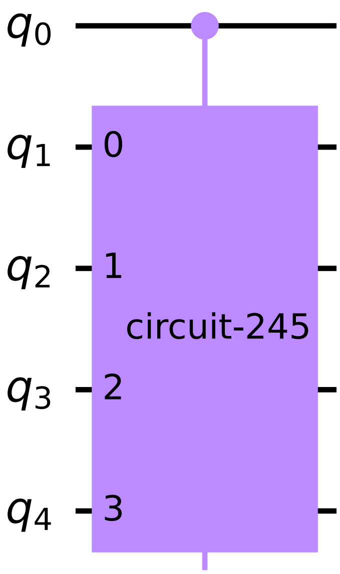
Out[52]:



IBMQ Jobs

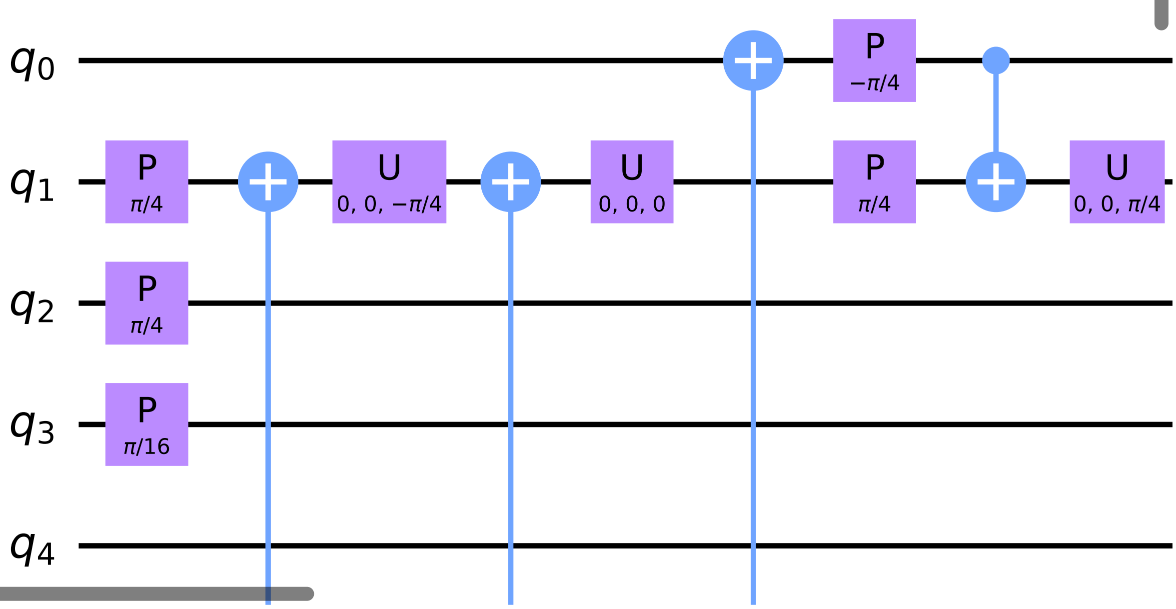
In [53]:
```
circ = QuantumCircuit(4)
circ.h(range(2))
circ.cx(0,1)
circ.cx(0,3)
circ.crz(np.pi/2,0,2)

my_gate = circ.to_gate().control(2)
qc = QuantumCircuit(6)
qc.append(my_gate, [0,5,1,2,3,4])
qc.draw()
#can also decompose this
```

Out[53]:



In [54]:
```
circ = qc.decompose()
circ.draw() #whoa this would be a nightmare to actually do manually, good t
```

Out[54]:

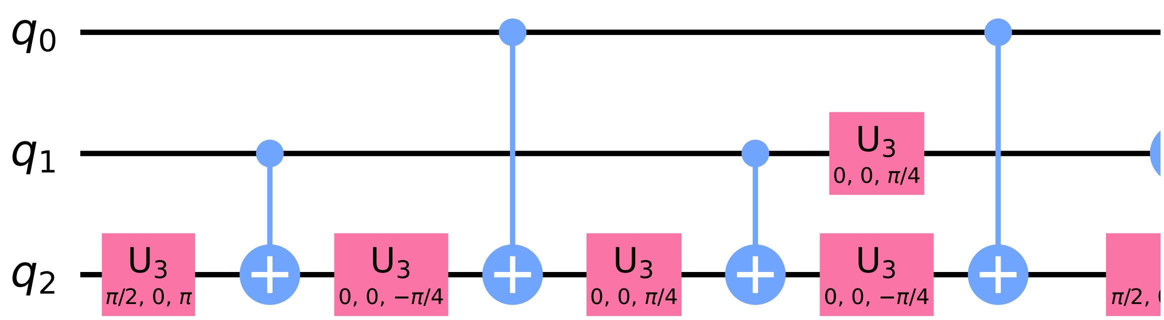


▸ IBMQ Jobs

2 After creating a circuit, we can transpile it either for the backend or for a specific set of basis gates

In [55]:
```
#going back to our simpler circuit!
qc = QuantumCircuit(3)
qc.mct([0,1],2)
qc.cx(0,2)
qc.h(1)
qc.z(0)

trans = transpile(qc, basis_gates = ['u3','cx','s'])
trans.draw('mpl')
```

Out[55]:



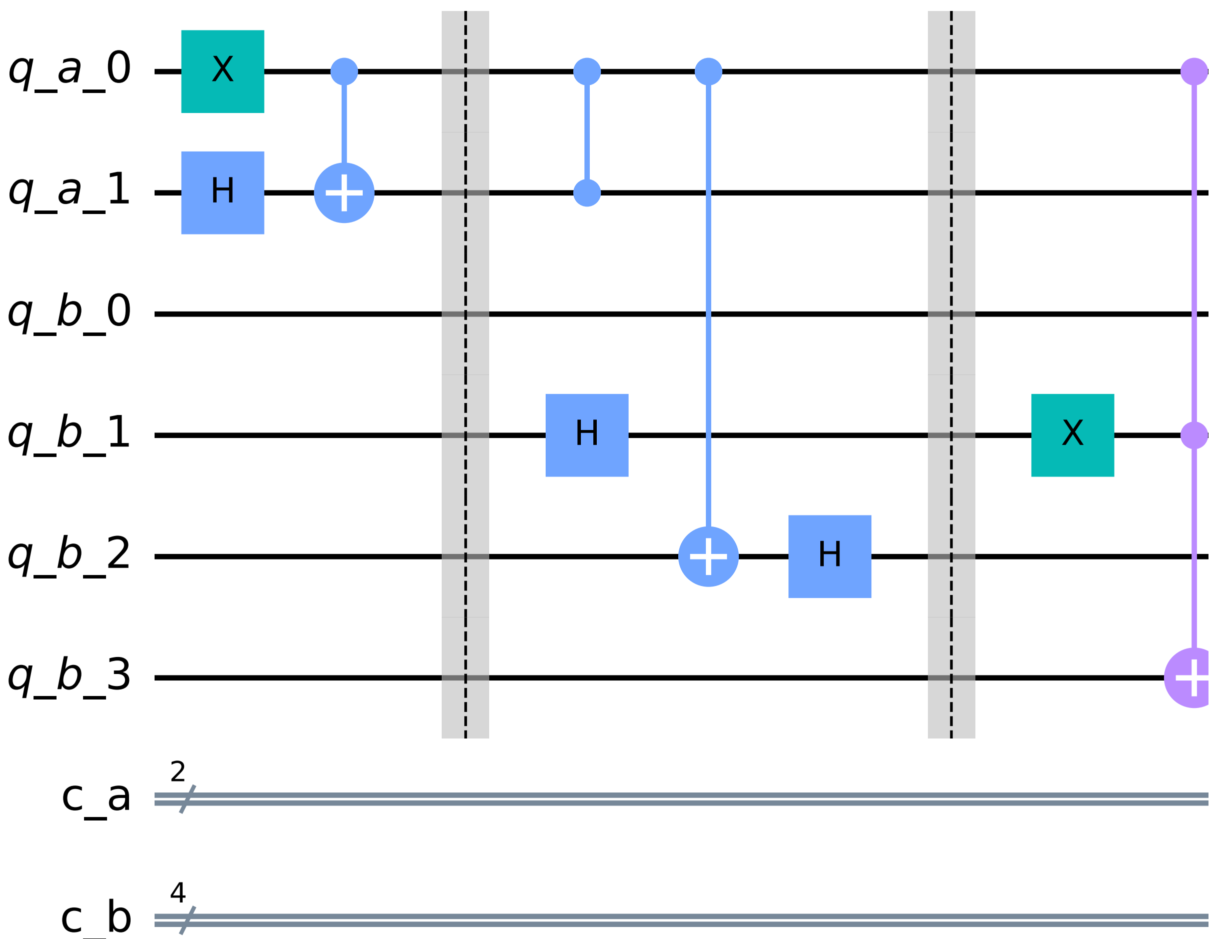
3 Advanced Circuit Visuals

IBMQ Jobs

In [56]:

```
q_a = QuantumRegister(2, 'q_a')
q_b = QuantumRegister(4, 'q_b')
c_a = ClassicalRegister(2,'c_a')
c_b = ClassicalRegister(4,'c_b')

qc = QuantumCircuit(q_a, q_b,c_a, c_b)

qc.x(0)
qc.h(1)
qc.cx(0,1)
qc.barrier()
qc.cz(0,1)
qc.cx(0,4)
qc.h(3)
qc.h(4)
qc.barrier()
qc.x(3)
qc.ccx(0,3,5)
qc.barrier()
qc.measure(q_a, c_a)
qc.measure(q_b, c_b)
qc.draw()
```

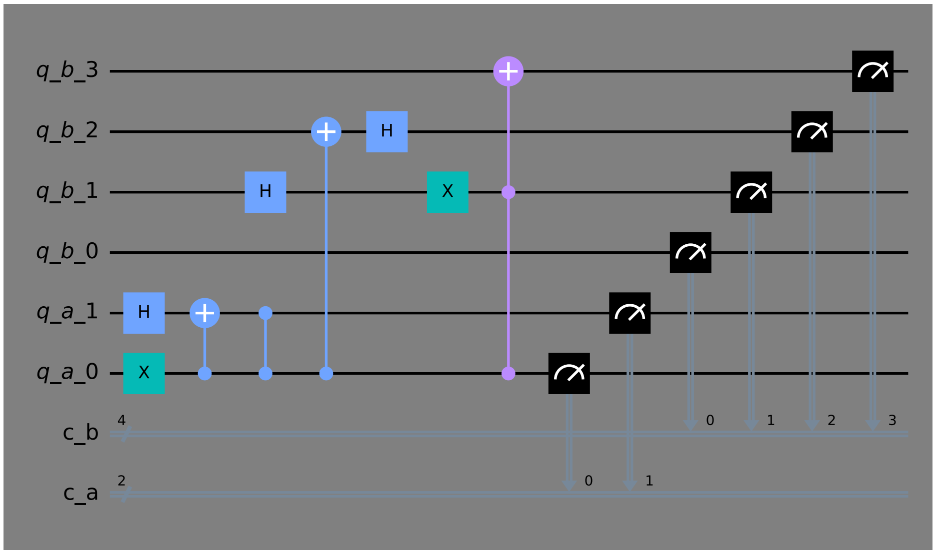
Out[56]:



IBMQ Jobs

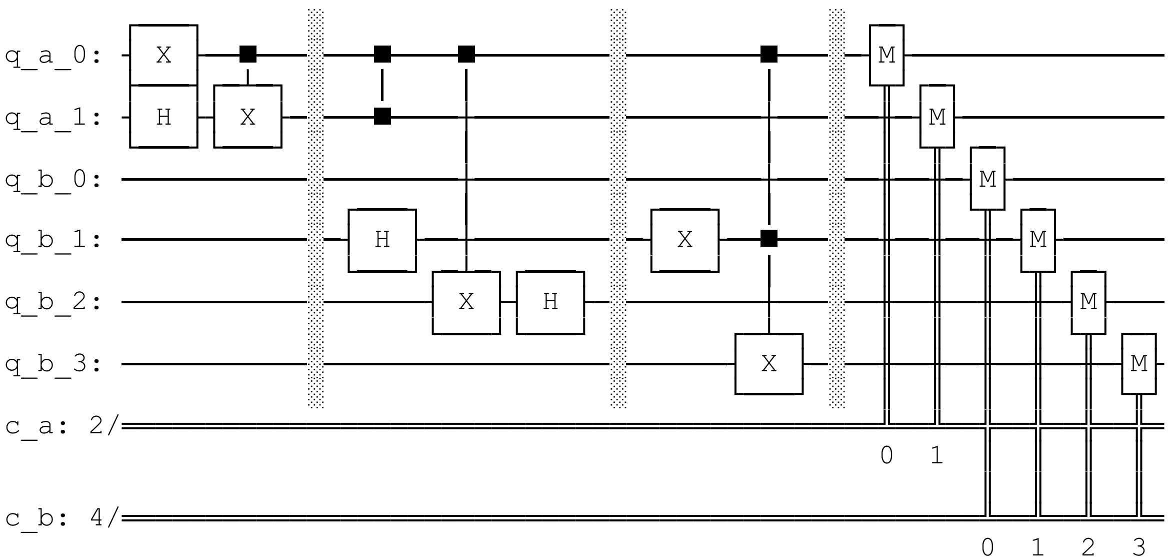
In [57]:
```
#Now look at all the crazy things we can do with the .draw() method! Who wo
qc.draw(reverse_bits=True, plot_barriers=False,scale=0.5, style = {'backgro
```

Out[57]:



In [58]:
```
from qiskit.tools.visualization import circuit_drawer
circuit_drawer(qc, output='text') #oh and yeah, there is this, circuit_draw
```

Out[58]:



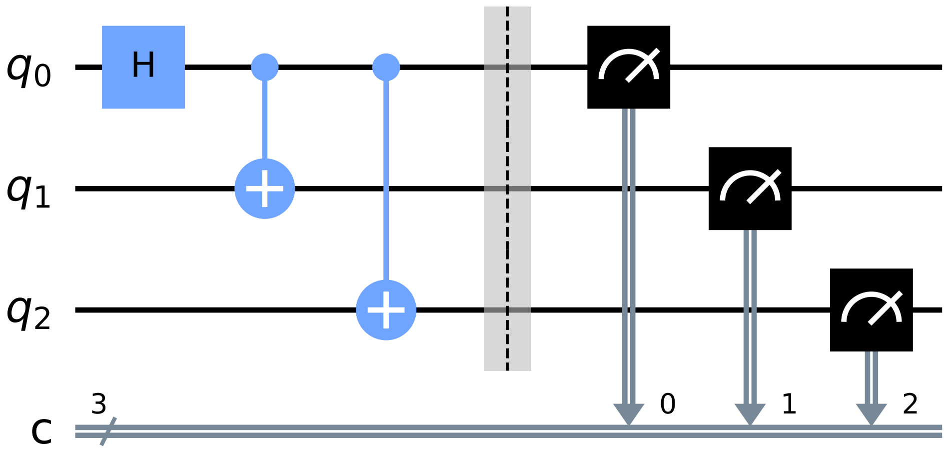
3.1 Wait, what if I want to export to QASM?

IBMQ Jobs

In [59]:

```
qc = QuantumCircuit(3,3)
qc.h(0)
qc.cx(0,1)
qc.cx(0,2)
qc.barrier()
qc.measure([0,1,2],[0,1,2])
qc.draw()
```

Out[59]:



In [60]:

```
qasm_str = qc.qasm() #returning a qasm string, THIS SIMPLE
qasm_str
```

Out[60]:

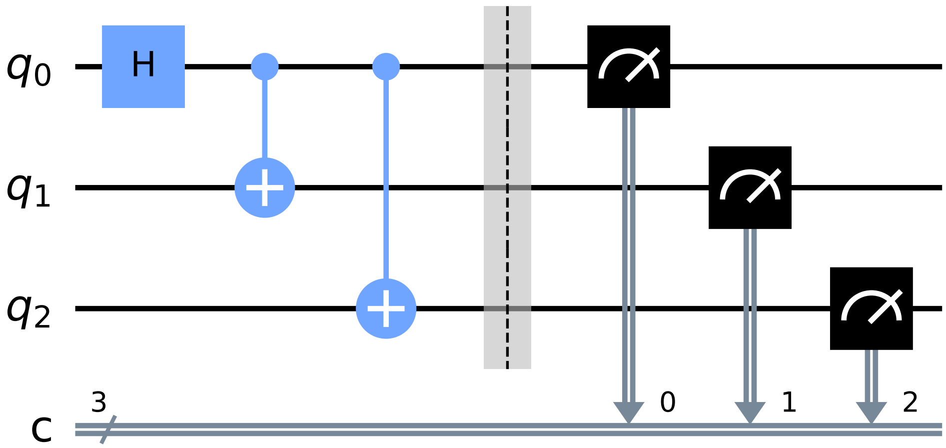
```
'OPENQASM 2.0;\ninclude "qelib1.inc";\nqreg q[3];\ncreg c[3];\nh q[0];\ncx q[0],q[1];\ncx q[0],q[2];\nbarrier q[0],q[1],q[2];\nmeasure q[0] -> c[0];\nmeasure q[1] -> c[1];\nmeasure q[2] -> c[2];\n'
```

3.2 And what if I want to import from it?

IBMQ Jobs

In [61]:
```
circ = QuantumCircuit.from_qasm_str(qasm_str) #you got to be kidding!
circ.draw() #you can also read a file directly with .from_qasm_file('path')
```

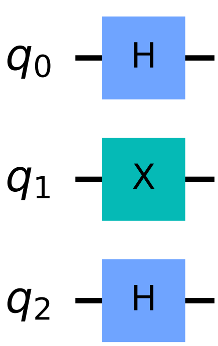
Out[61]:



3.3 Circuit depth?

In [62]:
```
#what do you think the circuit depth of this picture is?
#hint: not 2

circ = QuantumCircuit(3)
circ.h(0)
circ.x(1)
circ.h(2)
circ.draw()
```

Out[62]:



In [63]:
```
circ.depth() #one thing to watch-out here is if you have barriers whatnot,
```

Out[63]: 1

3.4 I forgot which version I'm running!!

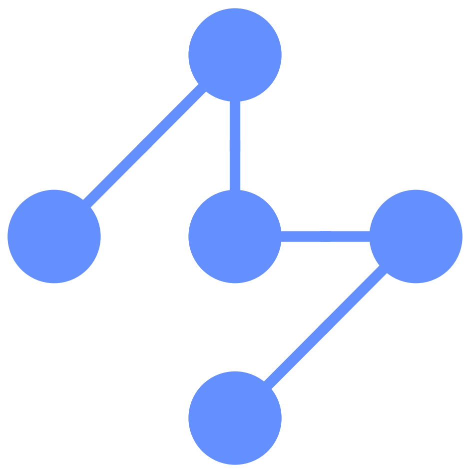
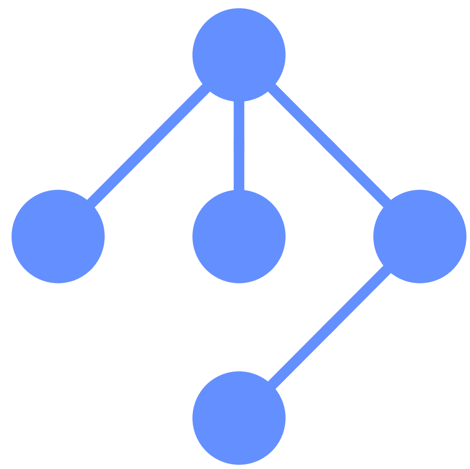
IBMQ Jobs

In [64]:
```
qiskit.__version__ #no worries...
```
Out[64]: '0.18.3'

3.5 I want to run on a real machine, but I also need some information about the connectivity? And maybe other things too?

In [65]:
```
#this is your tool to get all the information on all the hardware available
import qiskit.tools.jupyter
%qiskit_backend_overview
```

Backend Overview

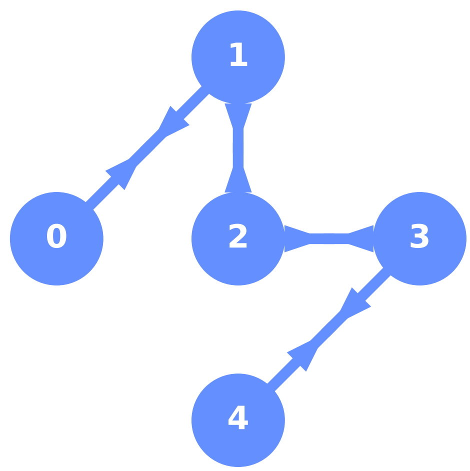
	ibmq_manila	ibmq_quito
		
Num. Qubits	5	5
Quantum Vol.	32	16
Pending Jobs	560 572	547 557
Operational	True	True
Least Busy	False	False
Avg. T1 / T2	196.6 / 60.8 us	108.7 / 126.3 us
Avg. CX Err.	0.0094	0.0089
Avg. Meas. Err.	0.0308	0.0258

3.6 I know which device I want to run on, I don't want to check all! But I do want to get the connectivity on my chip?

▸ IBMQ Jobs

In [66]:
```
#that's not a problem!

from qiskit.visualization import plot_gate_map
backend = provider.get_backend('ibmq_manila')
plot_gate_map(backend, plot_directed=True) #check other things you can do i
```

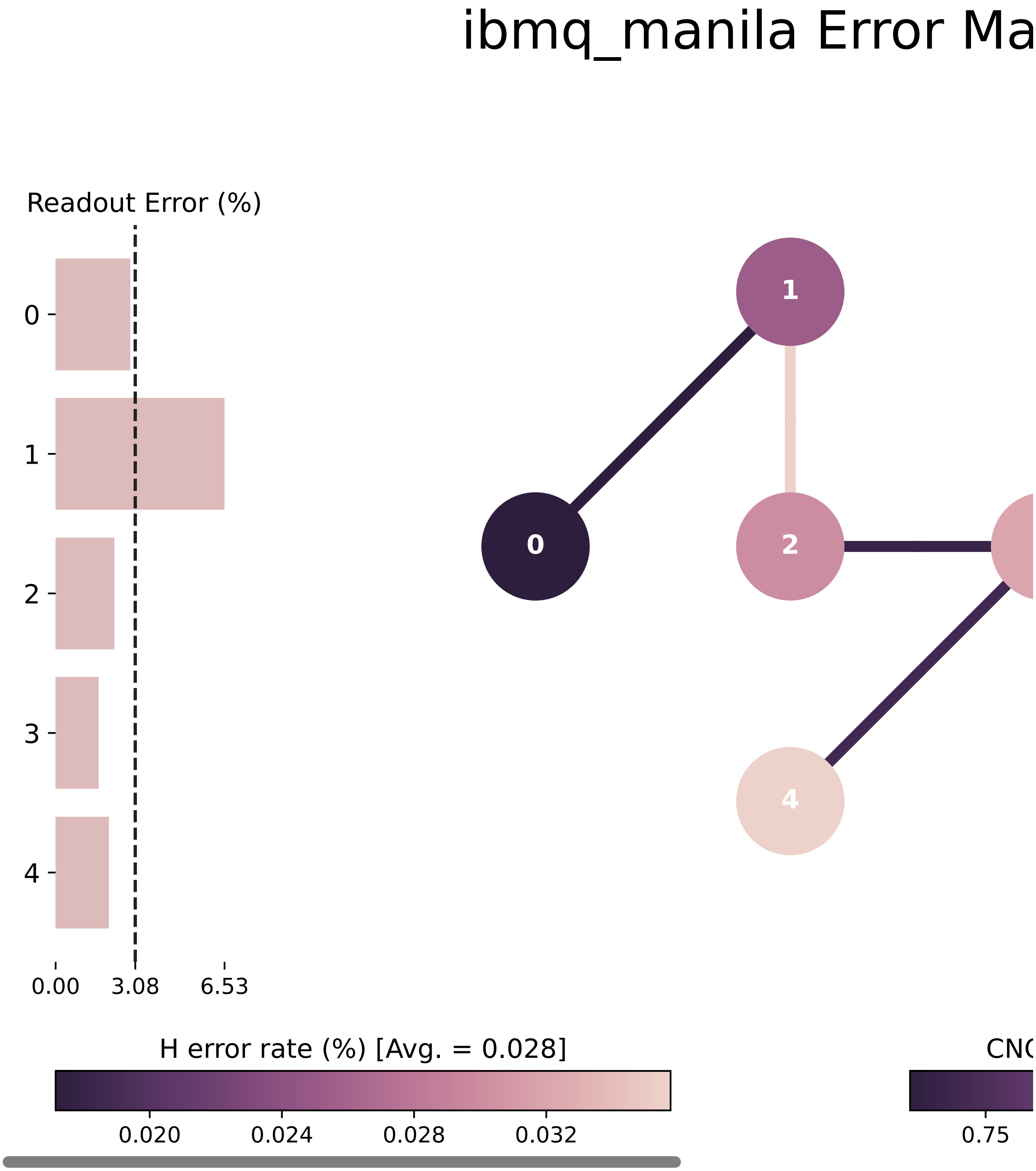
Out[66]:



In [67]:

```python
plot_error_map(backend) #I can also get my errors!
```

Out[67]:



3.7 Okay now I know my connectivity, I want to specify some couplings and run like that?

In [68]:

```
qc = QuantumCircuit(3)
qc.measure_all()
sim = BasicAer.get_backend('qasm_simulator')
couple_map = [[0,1],[1,2]] #specify some linear connection
job = execute(qc, sim, shots=1000, coupling_map=couple_map) #here is how yo
result = job.result()
counts = result.get_counts()
print(counts)
```

```
{'000': 1000}
```

3.8 Hope this has been helpful! Make sure to review the study guide, the sample questions and the documentation! Good luck on the exam!

3.9 Let me know if this has been helpful for you and don't hesitate to give feedback on it, I am planning to refine it and make better commenting :)