Qiskit 4 - Bernstein Vazirani

A 4-bit secret bit string is held by a quantum oracle. We are to build a quantum curcuit that are able to retrieve the information of that secret string. This will be achieved by the following steps:

1. Define quantum and classical registers.
2. Construct a black-box/oracle and define the secret bitstring.
3. Perform a state-preparation and add the oracle to the circuit.
4. Add a change of basis and measurement.
5. Execute the circuit and visualize the result.
6. Run in cloud

1 - Define registers

In [78]:

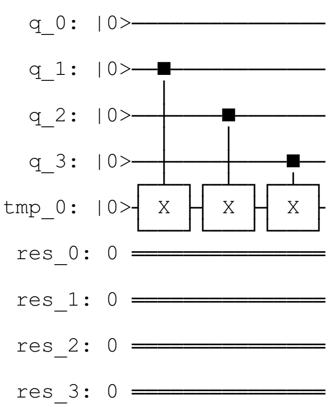
```
from qiskit import QuantumRegister, ClassicalRegister, QuantumCircuit
from qiskit import Aer, execute

from qiskit.tools.visualization import circuit_drawer, plot_histogram

q = QuantumRegister(4, 'q')
tmp = QuantumRegister(1, 'tmp')
res = ClassicalRegister(4, 'res')
```

2 - Construct the oracle

In [79]:

```
secret = 14 # 1110
oracle = QuantumCircuit(q, tmp, res)
for i in range(len(q)):
    if (secret & (1 << i)):
        oracle.cx(q[i], tmp[0])
circuit_drawer(oracle)
```

Out[79]:

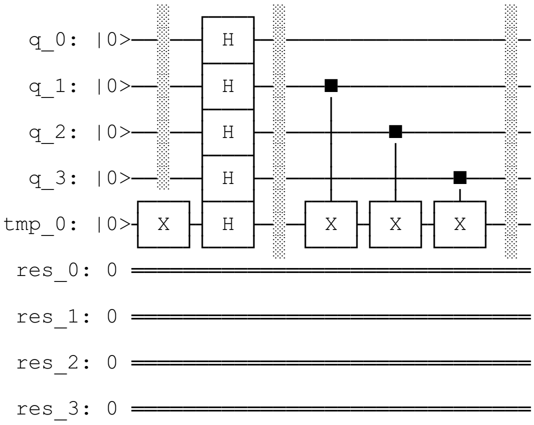


3 - State preperation

In [80]:

```
bv = QuantumCircuit(q, tmp, res)
bv.x(tmp) # flip the tmp qubit
bv.barrier(q) # for a nicer diagram
bv.h(q) # add a full layer of hadamard gates to the q qubits
bv.h(tmp) # and add a hadamard to tmp
bv.barrier()
bv += oracle # add the oracle to the bv curcuit
bv.barrier()
circuit_drawer(bv)
```

Out[80]:

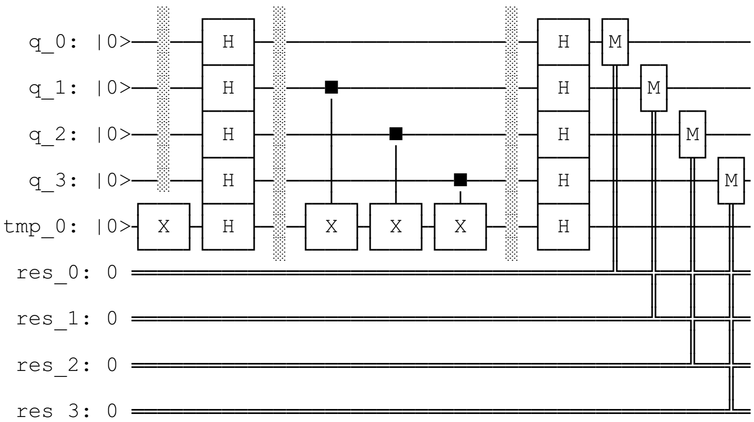


4 - Measurement

In [81]:

```
bv.h(q) # full layer of hadamard
bv.h(tmp) # hadamard on tmp qubit which is then discarded
bv.measure(q, res) # measure the q qubits
circuit_drawer(bv)
```

Out[81]:

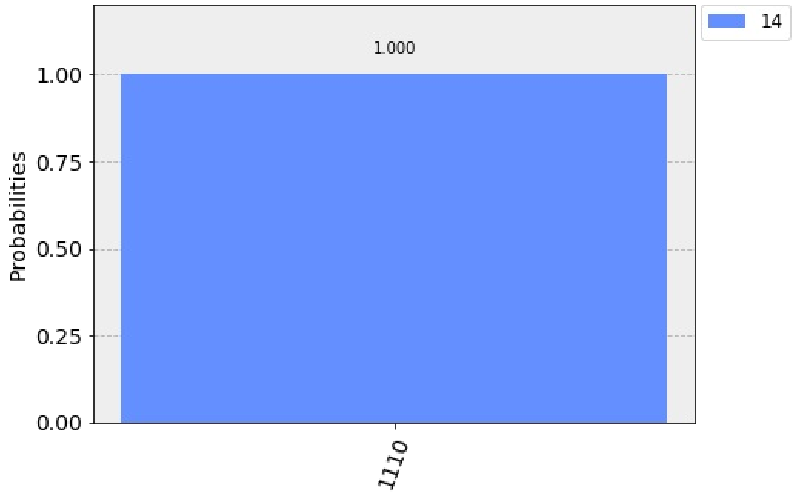


5 - Execute

In [82]:

```
sim = Aer.get_backend('qasm_simulator')
job = execute(bv, sim, shots=1000)
count = job.result().get_counts()
plot_histogram(count, legend=[str(secret)])
```

Out[82]:



We can easily change up the number of qubits and handle larger bitstrings, we also get correct results when we vary the secret string. Key parts here though is the query speed up, and the insight that if you are in a position where you can construct a quantum oracle on your problem, it is nice. Now lets have a look at Grover.

Also, keep in mind that whole mechanism with having a 'spare' qubit going in to your oracle/blackbox/unitary that you can dump information and operations on as per whatever requirements. Then, it seems, one simply discard it upon measurement. Why? It is clear that you can obtain perhaps 'enough' information by reading off the qubits corresponding to the length of the bit string that your trying to obtain...

6 - Run in cloud

In [83]:

```
from qiskit import IBMQ
IBMQ.save_account('YOUR_API_KEY')
```

In [87]:

```
IBMQ.load_account()
```

Out[87]:

```
<AccountProvider for IBMQ(hub='ibm-q', group='open', project='main')>
```

In [88]:

```
provider = IBMQ.get_provider(hub='ibm-q')
provider.backends()
```

Out[88]:

```
[<IBMQSimulator('ibmq_qasm_simulator') from IBMQ(hub='ibm-q', group='open', project='main')>,
 <IBMQBackend('ibmqx2') from IBMQ(hub='ibm-q', group='open', project='main')>,
 <IBMQBackend('ibmq_16_melbourne') from IBMQ(hub='ibm-q', group='open', project='main')>,
 <IBMQBackend('ibmq_vigo') from IBMQ(hub='ibm-q', group='open', project='main')>,
 <IBMQBackend('ibmq_ourense') from IBMQ(hub='ibm-q', group='open', project='main')>,
 <IBMQBackend('ibmq_london') from IBMQ(hub='ibm-q', group='open', project='main')>,
 <IBMQBackend('ibmq_burlington') from IBMQ(hub='ibm-q', group='open', project='main')>,
 <IBMQBackend('ibmq_essex') from IBMQ(hub='ibm-q', group='open', project='main')>]
```

In [89]:

```
backend = provider.get_backend('ibmq_essex')
```

In [90]:

```
job_cloud = execute(bv, backend, shots=1000)
```

In [91]:

```
count_cloud = job_cloud.result().get_counts()
print(count_cloud)
```

```
{'0010': 65, '1100': 55, '1101': 39, '0000': 65, '1000': 23, '1111': 166, '1010': 50, '0011': 45, '0
111': 41, '1001': 19, '0101': 25, '0100': 31, '1110': 238, '0110': 46, '1011': 34, '0001': 58}
```

In [92]:

```
plot_histogram(count_cloud, legend=['14, 1110, quantum computed'])
```

Out[92]: