Deutsch-Jozsa Algorithm

1. Intialization

In [1]:

```
import numpy as np

from qiskit import IBMQ, Aer
from qiskit.providers.ibmq import least_busy
from qiskit import QuantumCircuit, assemble, transpile

from qiskit.visualization import plot_histogram
```

In [2]:

```
# set the length of the n-bit input string
n = 3
```

2. Constant Oracle

In [6]:

```
const_oracle = QuantumCircuit(n+1)     # need one more bit to store the output

# generate any random integer 0 or 1
output = np.random.randint(2)
if output == 1:             # if the random integer is 1 then apply an X gate
    const_oracle.x(n)

const_oracle.draw()
```

Out[6]:

```
q_0:

q_1:

q_2:

q_3:
```

3. Balanced Orcale

In [10]:

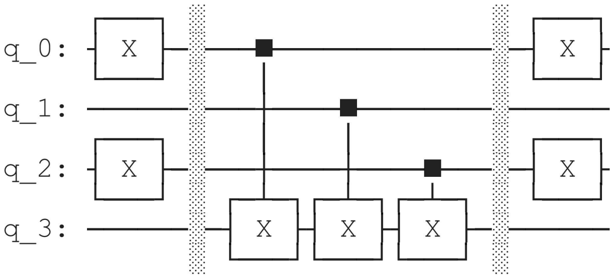
```
balanced_oracle = QuantumCircuit(n+1)    # need one more bit to store the output

# We can create a balanced oracle by performing CNOTs with each input qubit
# as control and the output bit as target. We can vary the input states that
# give 0 or 1 by wrapping some of the controls in X-gates.
```

In [11]:

```
b_str = "101"    # consider a string

# For each qubit in our circuit, we place an X-gate if the corresponding
# digit in b_str is 1, or do nothing if the digit is 0.

# place X gate
for qubit in range(len(b_str)):     # for number of qubits in the strings(Here 0, 1,
    if b_str[qubit] == '1':         # if the number is 1 then apply an X gate
```

```
        balanced_oracle.x(qubit)

balanced_oracle.barrier()

# for CNOTs
for qubit in range(n):
    balanced_oracle.cx(qubit, n)

balanced_oracle.barrier()

# Finally we repeat the code from two cells up tp finish wrapping the controls in X-
for qubit in range(len(b_str)):
    if b_str[qubit] == '1':
        balanced_oracle.x(qubit)

balanced_oracle.draw()
# here we get an extra q3, which is used to store output
```

Out[11]:

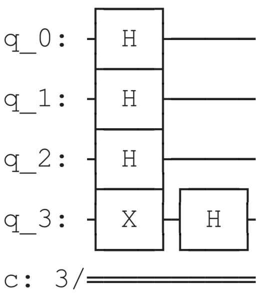


4. Algorithm

In [12]:

```
# first step is to initialize the input qubits in the state |+> and the output qubit

dj_circ = QuantumCircuit(n+1, n) #n+1 qubits and n bits

# Apply H gate till n-1
for qubit in range(n):
    dj_circ.h(qubit)

# Put output qubit in state |->, i.e the last n qubit
dj_circ.x(n)
dj_circ.h(n)

dj_circ.draw()
```

Out[12]:



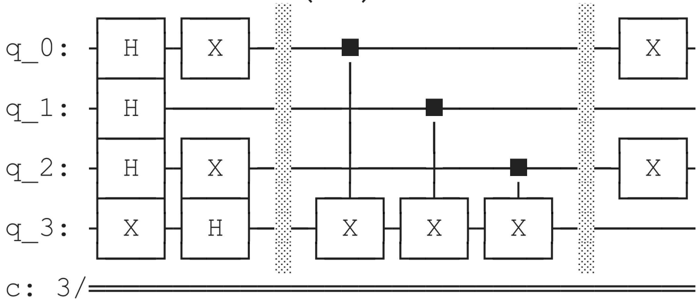
Applying the oracle

In [13]:

```
dj_circ += balanced_oracle
dj_circ.draw()
```

```
<ipython-input-13-329724047636>:1: DeprecationWarning: The QuantumCircuit.__iadd__() method is being deprecated. Use the compose() (potentially with the inplace=True argument) and tensor() methods which are more flexible w.r.t circuit register compatibility.
  dj_circ += balanced_oracle
C:\Users\hrith\anaconda3\lib\site-packages\qiskit\circuit\quantumcircuit.py:942: DeprecationWarning: The QuantumCircuit.extend() method is being deprecated. Use the compose() (potentially with the inplace=True argument) and tensor() methods which are more flexible w.r.t circuit register compatibility.
  return self.extend(rhs)
```

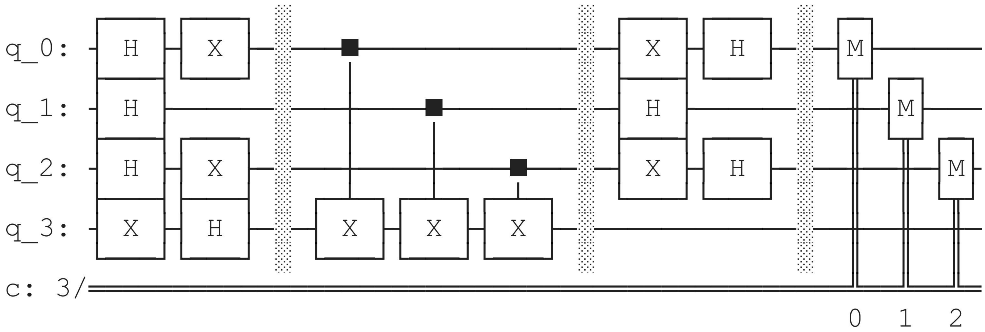
Out[13]:



In [14]:

```
# Finally, we perform H-gates on the n-input qubits, and measure our input register

# Repeat H-gates
for qubit in range(n):
    dj_circ.h(qubit)    # Applying H on n-1 qubits again

dj_circ.barrier()

# Measure
for i in range(n):
    dj_circ.measure(i, i)

dj_circ.draw()
```

Out[14]:

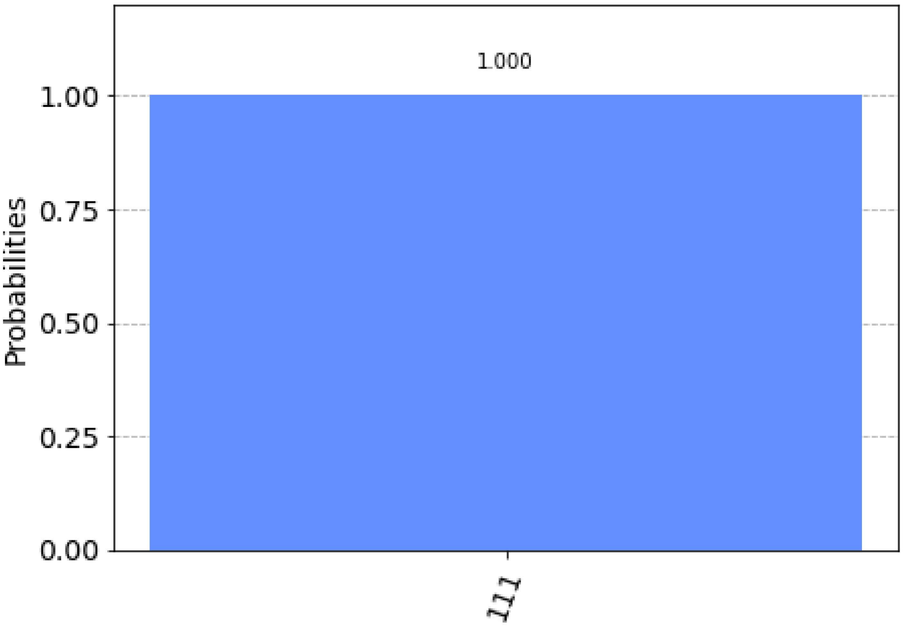


5. Output

In [15]:

```
# Local simulator

sim = Aer.get_backend('aer_simulator')
shots = 1024
qobj = assemble(dj_circ, sim)
results = sim.run(qobj).result()
answer = results.get_counts()

plot_histogram(answer)
```

Out[15]:



We can see from the results above that we have a 0% chance of measuring 000. This correctly predicts the function is balanced

6. Real Device

In [19]:

```
IBMQ.load_account()
provider = IBMQ.get_provider(hub='ibm-q')
backend = least_busy(provider.backends(filters=lambda x: x.configuration().n_qubits
                                       not x.configuration().simulator and x.status().op
print("least busy backend: ", backend)
```

```
ibmqfactory.load_account:WARNING:2021-10-25 20:03:43,685: Credentials are already in
use. The existing account in the session will be replaced.
least busy backend:  ibmq_belem
```

In [20]:

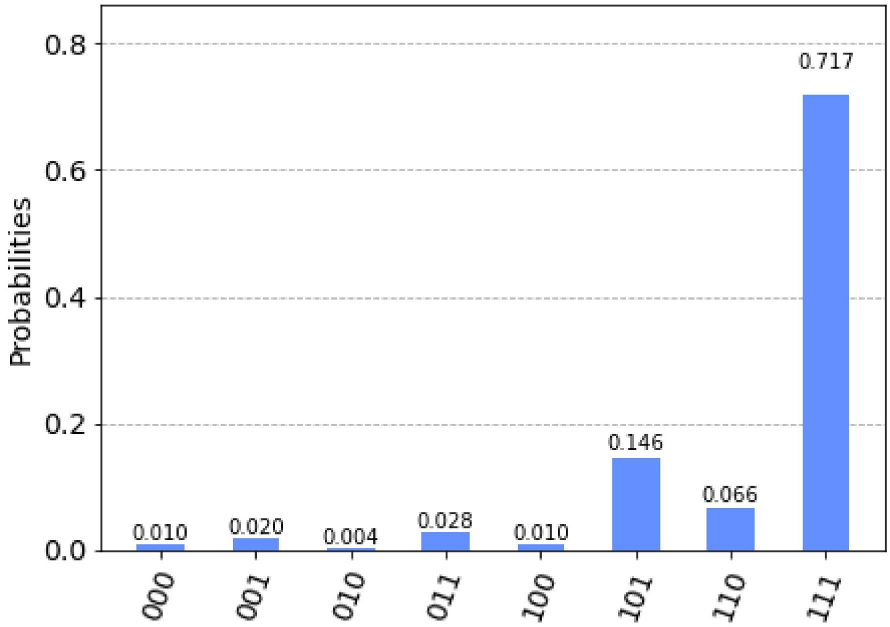
```
# Run our circuit on the least busy backend. Monitor the execution of the job in the
from qiskit.tools.monitor import job_monitor

shots = 1024
transpiled_dj_circuit = transpile(dj_circ, backend, optimization_level=3)
job = backend.run(transpiled_dj_circuit)
job_monitor(job, interval=2)
```

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

In [21]:

```
# Get the results of the computation
results = job.result()
answer = results.get_counts()

plot_histogram(answer)
```

Out[21]:



As we can see, the most likely result is 111. The other results are due to errors in the quantum computation.

In [ ]: