

T3 - Exercise Bernstein-Vazirani

December 11, 2024

1 Bernstein-Vazirani Algorithm

```
[10]: %pip install qiskit[visualization]
```

```
Requirement already satisfied: qiskit[visualization] in
/opt/.qbraided/environments/qbraided_000000/pyenv/lib/python3.11/site-packages
(1.3.0)
Requirement already satisfied: rustworkx>=0.15.0 in
/opt/.qbraided/environments/qbraided_000000/pyenv/lib/python3.11/site-packages (from
qiskit[visualization]) (0.15.1)
Requirement already satisfied: numpy<3,>=1.17 in /opt/conda/lib/python3.11/site-
packages (from qiskit[visualization]) (1.26.4)
Requirement already satisfied: scipy>=1.5 in
/opt/.qbraided/environments/qbraided_000000/pyenv/lib/python3.11/site-packages (from
qiskit[visualization]) (1.14.1)
Requirement already satisfied: sympy>=1.3 in
/opt/.qbraided/environments/qbraided_000000/pyenv/lib/python3.11/site-packages (from
qiskit[visualization]) (1.13.3)
Requirement already satisfied: dill>=0.3 in
/opt/.qbraided/environments/qbraided_000000/pyenv/lib/python3.11/site-packages (from
qiskit[visualization]) (0.3.9)
Requirement already satisfied: python-dateutil>=2.8.0 in
/opt/conda/lib/python3.11/site-packages (from qiskit[visualization]) (2.9.0)
Requirement already satisfied: stevedore>=3.0.0 in
/opt/.qbraided/environments/qbraided_000000/pyenv/lib/python3.11/site-packages (from
qiskit[visualization]) (5.4.0)
Requirement already satisfied: typing-extensions in
/opt/conda/lib/python3.11/site-packages (from qiskit[visualization]) (4.12.2)
Requirement already satisfied: symengine<0.14,>=0.11 in
/opt/.qbraided/environments/qbraided_000000/pyenv/lib/python3.11/site-packages (from
qiskit[visualization]) (0.13.0)
Requirement already satisfied: matplotlib>=3.3 in
/opt/conda/lib/python3.11/site-packages (from qiskit[visualization]) (3.9.3)
Requirement already satisfied: pydot in
/opt/.qbraided/environments/qbraided_000000/pyenv/lib/python3.11/site-packages (from
qiskit[visualization]) (3.0.3)
Requirement already satisfied: Pillow>=4.2.1 in /opt/conda/lib/python3.11/site-
packages (from qiskit[visualization]) (11.0.0)
```

Requirement already satisfied: pylatexenc>=1.4 in
/opt/.qbraid/environments/qbraid_000000/pyenv/lib/python3.11/site-packages (from
qiskit[visualization]) (2.10)

Requirement already satisfied: seaborn>=0.9.0 in
/opt/.qbraid/environments/qbraid_000000/pyenv/lib/python3.11/site-packages (from
qiskit[visualization]) (0.13.2)

Requirement already satisfied: contourpy>=1.0.1 in
/opt/conda/lib/python3.11/site-packages (from
matplotlib>=3.3->qiskit[visualization]) (1.3.1)

Requirement already satisfied: cycycler>=0.10 in /opt/conda/lib/python3.11/site-
packages (from matplotlib>=3.3->qiskit[visualization]) (0.12.1)

Requirement already satisfied: fonttools>=4.22.0 in
/opt/conda/lib/python3.11/site-packages (from
matplotlib>=3.3->qiskit[visualization]) (4.55.2)

Requirement already satisfied: kiwisolver>=1.3.1 in
/opt/conda/lib/python3.11/site-packages (from
matplotlib>=3.3->qiskit[visualization]) (1.4.7)

Requirement already satisfied: packaging>=20.0 in
/opt/conda/lib/python3.11/site-packages (from
matplotlib>=3.3->qiskit[visualization]) (24.0)

Requirement already satisfied: pyparsing>=2.3.1 in
/opt/conda/lib/python3.11/site-packages (from
matplotlib>=3.3->qiskit[visualization]) (3.2.0)

Requirement already satisfied: six>=1.5 in /opt/conda/lib/python3.11/site-
packages (from python-dateutil>=2.8.0->qiskit[visualization]) (1.16.0)

Requirement already satisfied: pandas>=1.2 in /opt/conda/lib/python3.11/site-
packages (from seaborn>=0.9.0->qiskit[visualization]) (2.2.3)

Requirement already satisfied: pbr>=2.0.0 in
/opt/.qbraid/environments/qbraid_000000/pyenv/lib/python3.11/site-packages (from
stevedore>=3.0.0->qiskit[visualization]) (6.1.0)

Requirement already satisfied: mpmath<1.4,>=1.1.0 in
/opt/.qbraid/environments/qbraid_000000/pyenv/lib/python3.11/site-packages (from
sympy>=1.3->qiskit[visualization]) (1.3.0)

Requirement already satisfied: pytz>=2020.1 in /opt/conda/lib/python3.11/site-
packages (from pandas>=1.2->seaborn>=0.9.0->qiskit[visualization]) (2024.1)

Requirement already satisfied: tzdata>=2022.7 in /opt/conda/lib/python3.11/site-
packages (from pandas>=1.2->seaborn>=0.9.0->qiskit[visualization]) (2024.2)

Note: you may need to restart the kernel to use updated packages.

```
[11]: %pip install qiskit_aer
```

Requirement already satisfied: qiskit_aer in
/opt/.qbraid/environments/qbraid_000000/pyenv/lib/python3.11/site-packages
(0.15.1)

Requirement already satisfied: qiskit>=1.1.0 in
/opt/.qbraid/environments/qbraid_000000/pyenv/lib/python3.11/site-packages (from
qiskit_aer) (1.3.0)

Requirement already satisfied: numpy>=1.16.3 in /opt/conda/lib/python3.11/site-

```

packages (from qiskit_aer) (1.26.4)
Requirement already satisfied: scipy>=1.0 in
/opt/.qbraided/environments/qbraided_000000/pyenv/lib/python3.11/site-packages (from
qiskit_aer) (1.14.1)
Requirement already satisfied: psutil>=5 in /opt/conda/lib/python3.11/site-
packages (from qiskit_aer) (5.9.8)
Requirement already satisfied: rustworkx>=0.15.0 in
/opt/.qbraided/environments/qbraided_000000/pyenv/lib/python3.11/site-packages (from
qiskit>=1.1.0->qiskit_aer) (0.15.1)
Requirement already satisfied: sympy>=1.3 in
/opt/.qbraided/environments/qbraided_000000/pyenv/lib/python3.11/site-packages (from
qiskit>=1.1.0->qiskit_aer) (1.13.3)
Requirement already satisfied: dill>=0.3 in
/opt/.qbraided/environments/qbraided_000000/pyenv/lib/python3.11/site-packages (from
qiskit>=1.1.0->qiskit_aer) (0.3.9)
Requirement already satisfied: python-dateutil>=2.8.0 in
/opt/conda/lib/python3.11/site-packages (from qiskit>=1.1.0->qiskit_aer) (2.9.0)
Requirement already satisfied: stevedore>=3.0.0 in
/opt/.qbraided/environments/qbraided_000000/pyenv/lib/python3.11/site-packages (from
qiskit>=1.1.0->qiskit_aer) (5.4.0)
Requirement already satisfied: typing-extensions in
/opt/conda/lib/python3.11/site-packages (from qiskit>=1.1.0->qiskit_aer)
(4.12.2)
Requirement already satisfied: symengine<0.14,>=0.11 in
/opt/.qbraided/environments/qbraided_000000/pyenv/lib/python3.11/site-packages (from
qiskit>=1.1.0->qiskit_aer) (0.13.0)
Requirement already satisfied: six>=1.5 in /opt/conda/lib/python3.11/site-
packages (from python-dateutil>=2.8.0->qiskit>=1.1.0->qiskit_aer) (1.16.0)
Requirement already satisfied: pbr>=2.0.0 in
/opt/.qbraided/environments/qbraided_000000/pyenv/lib/python3.11/site-packages (from
stevedore>=3.0.0->qiskit>=1.1.0->qiskit_aer) (6.1.0)
Requirement already satisfied: mpmath<1.4,>=1.1.0 in
/opt/.qbraided/environments/qbraided_000000/pyenv/lib/python3.11/site-packages (from
sympy>=1.3->qiskit>=1.1.0->qiskit_aer) (1.3.0)
Note: you may need to restart the kernel to use updated packages.

```

```
[12]: from qiskit_aer import AerSimulator
```

We've already implemented the Deutsch-Jozsa circuit above, and here we will make use of it to solve the Bernstein-Vazirani problem. First we'll define a function that implements a query gate for the Bernstein-Vazirani problem given any binary string s .

```
[13]: # Replace ?
from qiskit import QuantumCircuit
import numpy as np

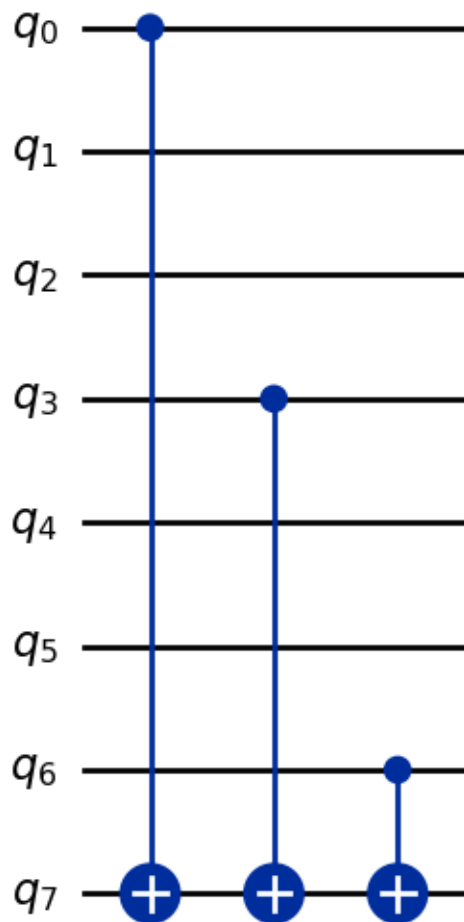
def bv_function(s):
    """
```

```

Create a Bernstein-Vazirani function from a string of 1s and 0s.
"""
qc = QuantumCircuit(len(s) + 1)
for index, bit in enumerate(reversed(s)):
    if bit == "1":
        qc.cx(index, len(s))
return qc

display(bv_function("1001001").draw('mpl'))

```



Now we can run the Deutsch-Jozsa circuit on the function.

```

[14]: # Replace ?
def compile_circuit(function: QuantumCircuit):
    """

```

```
Compiles a circuit for use in the Deutsch-Jozsa algorithm.  
"""
```

```
n = function.num_qubits - 1  
qc = QuantumCircuit(n + 1, n)  
qc.x(n)  
qc.h(range(n + 1))  
qc.compose(function, inplace=True)  
qc.h(range(n))  
qc.measure(range(n), range(n))  
return qc
```

```
[15]: # Replace ?  
def bv_algorithm(function: QuantumCircuit):  
    qc = compile_circuit(function)  
    result = AerSimulator().run(qc, shots=1, memory=True).result()  
    return result.get_memory()[0]  
  
display(bv_algorithm(bv_function("1001001")))
```

```
'1001001'
```

2 End of Notebook