Running circuits on Braket devices

Now that we've walked through each of the quantum devices available through the Qiskit-Braket provider, let's take them for a spin! For this example, we'll create a 3-GHZ state on the Rigetti device, but feel free to choose a different QPU from the commented out devices below.

In [ ]:
```
qpu_backend = provider.get_backend("Aspen-M-3")
# qpu_backend = provider.get_backend("Aria")

print(qpu_backend)
```

In [ ]:
```
from qiskit import QuantumCircuit

circuit = QuantumCircuit(3)
circuit.h(0)
circuit.cx(0, 1)
circuit.cx(0, 2)
circuit.draw()
```

In [ ]:
```
# run circuit
qpu_task = qpu_backend.run(circuit, shots=10)
```

Each quantum task you run is assigned a unique ARN (Amazon Resource Name), which you can save and use to retrieve the data for your quantum task after its run, even if you close your notebook.

In [ ]:
```
task_id = qpu_task.task_id()
task_id
```

Now, Braket has a separate feature called "Hybrid *Jobs*", which is beyond the scope of this notebook, but which you can read about in the developer guide.

In [ ]:
```
# Retrieve quantum task data
retrieved_task = qpu_backend.retrieve_job(task_id=task_id)
```

Then you can check the status of the task to see if it's finished:

In [ ]:
```
retrieved_task.status()
```

Note: different devices may have different availability windows, so while your task may not run right away, rest assured it will be added to the queue to be run when the device is back online.

When your task is finished, you can retrieve the data:

In [ ]:
```
data = retrieved_task.result()
```

In [ ]:
```
from qiskit.visualization import plot_histogram
plot_histogram(data.get_counts())
```

Running algorithms on Braket devices

You can also use the Qiskit-Braket provider to run built-in Qiskit algorithms on Braket backends. For example, we can run the VQE algorithm to find the ground state of hydrogen. We'll use the

local simulator since the problem can be expressed in a basis that only requires a few qubits and will run quickly.

In [ ]:
```
from qiskit.quantum_info import SparsePauliOp

# Define the Hamiltonian operator for H2 in terms of Pauli spin operators
H2_op = SparsePauliOp.from_list([('II', -1.052373245772859), ('IZ', 0.3979374248431804
```

In [ ]:
```
# Import some utilities
from qiskit.primitives import BackendEstimator
from qiskit.circuit.library import TwoLocal
from qiskit_algorithms.optimizers import SLSQP
from qiskit_algorithms import VQE

# Define a `BackendEstimator` with a Braket backend
qi = BackendEstimator(local_simulator, options={'seed_simulator':42})
qi.set_transpile_options(seed_transpiler=42)

# Specify VQE configuration
ansatz = TwoLocal(rotation_blocks="ry", entanglement_blocks="cz")
slsqp = SLSQP(maxiter=1)
vqe = VQE(estimator=qi, ansatz=ansatz, optimizer=slsqp)

# Find the ground state
result = vqe.compute_minimum_eigenvalue(H2_op)
print(result)
```

What now?

The sky is the limit! Keep in mind, the Qiskit-Braket provider is still new and experimental, so if you run into a bug or want a new feature supported, consider submitting a GitHub issue and opening a feature branch to join in on the development effort yourself!

In [ ]:
```
print("Quantum Task Summary")
print(t.quantum_tasks_statistics())
print('Note: Charges shown are estimates based on your Amazon Braket simulator and quar
print(f"Estimated cost to run this example: {t.qpu_tasks_cost() + t.simulator_tasks_cos
```

In [1]:
```
!pip install qiskit
```

```
Collecting qiskit
  Downloading qiskit-1.1.1-cp38-abi3-manylinux_2_17_x86_64.manylinux2014_x86_64.whl.me
tadata (12 kB)
Collecting rustworkx>=0.14.0 (from qiskit)
  Downloading rustworkx-0.15.1-cp38-abi3-manylinux_2_17_x86_64.manylinux2014_x86_64.wh
l.metadata (9.9 kB)
Requirement already satisfied: numpy<3,>=1.17 in /home/ec2-user/anaconda3/envs/Jupyter
SystemEnv/lib/python3.10/site-packages (from qiskit) (1.26.4)
Collecting scipy>=1.5 (from qiskit)
  Downloading scipy-1.14.0-cp310-cp310-manylinux_2_17_x86_64.manylinux2014_x86_64.whl.
metadata (60 kB)
     ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 60.8/60.8 kB 6.9 MB/s eta 0:00:00
Collecting sympy>=1.3 (from qiskit)
  Downloading sympy-1.13.0-py3-none-any.whl.metadata (12 kB)
Requirement already satisfied: dill>=0.3 in /home/ec2-user/anaconda3/envs/JupyterSyste
mEnv/lib/python3.10/site-packages (from qiskit) (0.3.8)
Requirement already satisfied: python-dateutil>=2.8.0 in /home/ec2-user/anaconda3/env
s/JupyterSystemEnv/lib/python3.10/site-packages (from qiskit) (2.9.0)
Collecting stevedore>=3.0.0 (from qiskit)
  Downloading stevedore-5.2.0-py3-none-any.whl.metadata (2.3 kB)
Requirement already satisfied: typing-extensions in /home/ec2-user/anaconda3/envs/Jupy
terSystemEnv/lib/python3.10/site-packages (from qiskit) (4.11.0)
Collecting symengine>=0.11 (from qiskit)
  Downloading symengine-0.11.0-cp310-cp310-manylinux_2_12_x86_64.manylinux2010_x86_64.
whl.metadata (1.2 kB)
Requirement already satisfied: six>=1.5 in /home/ec2-user/anaconda3/envs/JupyterSystem
Env/lib/python3.10/site-packages (from python-dateutil>=2.8.0->qiskit) (1.16.0)
Collecting pbr!=2.1.0,>=2.0.0 (from stevedore>=3.0.0->qiskit)
  Downloading pbr-6.0.0-py2.py3-none-any.whl.metadata (1.3 kB)
Collecting mpmath<1.4,>=1.1.0 (from sympy>=1.3->qiskit)
  Downloading mpmath-1.3.0-py3-none-any.whl.metadata (8.6 kB)
Downloading qiskit-1.1.1-cp38-abi3-manylinux_2_17_x86_64.manylinux2014_x86_64.whl (4.3
MB)
   ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 4.3/4.3 MB 95.0 MB/s eta 0:00:00:00:01
Downloading rustworkx-0.15.1-cp38-abi3-manylinux_2_17_x86_64.manylinux2014_x86_64.whl
(2.0 MB)
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Downloading scipy-1.14.0-cp310-cp310-manylinux_2_17_x86_64.manylinux2014_x86_64.whl (4
1.1 MB)
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0:01
Downloading stevedore-5.2.0-py3-none-any.whl (49 kB)
   ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 49.7/49.7 kB 9.4 MB/s eta 0:00:00
Downloading symengine-0.11.0-cp310-cp310-manylinux_2_12_x86_64.manylinux2010_x86_64.wh
l (39.4 MB)
   ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 39.4/39.4 MB 15.7 MB/s eta 0:00:00:00:010
0:01
Downloading sympy-1.13.0-py3-none-any.whl (6.2 MB)
   ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 6.2/6.2 MB 37.2 MB/s eta 0:00:00:00:01
Downloading mpmath-1.3.0-py3-none-any.whl (536 kB)
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Downloading pbr-6.0.0-py2.py3-none-any.whl (107 kB)
   ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 107.5/107.5 kB 1.5 MB/s eta 0:00:00ta 0:0
0:01
Installing collected packages: mpmath, sympy, symengine, scipy, rustworkx, pbr, steved
ore, qiskit
Successfully installed mpmath-1.3.0 pbr-6.0.0 qiskit-1.1.1 rustworkx-0.15.1 scipy-1.1
4.0 stevedore-5.2.0 symengine-0.11.0 sympy-1.13.0
```

In [2]:
```
!pip install qiskit-aer
```

```
Collecting qiskit-aer
  Downloading qiskit_aer-0.14.2-cp310-cp310-manylinux_2_17_x86_64.manylinux2014_x86_6
4.whl.metadata (8.1 kB)
Requirement already satisfied: qiskit>=0.45.2 in /home/ec2-user/anaconda3/envs/Jupyter
SystemEnv/lib/python3.10/site-packages (from qiskit-aer) (1.1.1)
Requirement already satisfied: numpy>=1.16.3 in /home/ec2-user/anaconda3/envs/JupyterS
ystemEnv/lib/python3.10/site-packages (from qiskit-aer) (1.26.4)
Requirement already satisfied: scipy>=1.0 in /home/ec2-user/anaconda3/envs/JupyterSyst
emEnv/lib/python3.10/site-packages (from qiskit-aer) (1.14.0)
Requirement already satisfied: psutil>=5 in /home/ec2-user/anaconda3/envs/JupyterSyste
mEnv/lib/python3.10/site-packages (from qiskit-aer) (5.9.8)
Requirement already satisfied: rustworkx>=0.14.0 in /home/ec2-user/anaconda3/envs/Jupy
terSystemEnv/lib/python3.10/site-packages (from qiskit>=0.45.2->qiskit-aer) (0.15.1)
Requirement already satisfied: sympy>=1.3 in /home/ec2-user/anaconda3/envs/JupyterSyst
emEnv/lib/python3.10/site-packages (from qiskit>=0.45.2->qiskit-aer) (1.13.0)
Requirement already satisfied: dill>=0.3 in /home/ec2-user/anaconda3/envs/JupyterSyste
mEnv/lib/python3.10/site-packages (from qiskit>=0.45.2->qiskit-aer) (0.3.8)
Requirement already satisfied: python-dateutil>=2.8.0 in /home/ec2-user/anaconda3/env
s/JupyterSystemEnv/lib/python3.10/site-packages (from qiskit>=0.45.2->qiskit-aer) (2.
9.0)
Requirement already satisfied: stevedore>=3.0.0 in /home/ec2-user/anaconda3/envs/Jupyt
erSystemEnv/lib/python3.10/site-packages (from qiskit>=0.45.2->qiskit-aer) (5.2.0)
Requirement already satisfied: typing-extensions in /home/ec2-user/anaconda3/envs/Jupy
terSystemEnv/lib/python3.10/site-packages (from qiskit>=0.45.2->qiskit-aer) (4.11.0)
Requirement already satisfied: symengine>=0.11 in /home/ec2-user/anaconda3/envs/Jupyte
rSystemEnv/lib/python3.10/site-packages (from qiskit>=0.45.2->qiskit-aer) (0.11.0)
Requirement already satisfied: six>=1.5 in /home/ec2-user/anaconda3/envs/JupyterSystem
Env/lib/python3.10/site-packages (from python-dateutil>=2.8.0->qiskit>=0.45.2->qiskit-
aer) (1.16.0)
Requirement already satisfied: pbr!=2.1.0,>=2.0.0 in /home/ec2-user/anaconda3/envs/Jup
yterSystemEnv/lib/python3.10/site-packages (from stevedore>=3.0.0->qiskit>=0.45.2->qis
kit-aer) (6.0.0)
Requirement already satisfied: mpmath<1.4,>=1.1.0 in /home/ec2-user/anaconda3/envs/Jup
yterSystemEnv/lib/python3.10/site-packages (from sympy>=1.3->qiskit>=0.45.2->qiskit-ae
r) (1.3.0)
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hl (12.4 MB)
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1
Installing collected packages: qiskit-aer
Successfully installed qiskit-aer-0.14.2
```

In [3]:
```
!pip install qiskit-machine-learning
```

```
Collecting qiskit-machine-learning
  Downloading qiskit_machine_learning-0.7.2-py3-none-any.whl.metadata (12 kB)
Requirement already satisfied: qiskit>=0.44 in /home/ec2-user/anaconda3/envs/JupyterSystemEnv/lib/python3.10/site-packages (from qiskit-machine-learning) (1.1.1)
Collecting qiskit-algorithms>=0.2.0 (from qiskit-machine-learning)
  Downloading qiskit_algorithms-0.3.0-py3-none-any.whl.metadata (4.2 kB)
Requirement already satisfied: scipy>=1.4 in /home/ec2-user/anaconda3/envs/JupyterSystemEnv/lib/python3.10/site-packages (from qiskit-machine-learning) (1.14.0)
Requirement already satisfied: numpy>=1.17 in /home/ec2-user/anaconda3/envs/JupyterSystemEnv/lib/python3.10/site-packages (from qiskit-machine-learning) (1.26.4)
Requirement already satisfied: psutil>=5 in /home/ec2-user/anaconda3/envs/JupyterSystemEnv/lib/python3.10/site-packages (from qiskit-machine-learning) (5.9.8)
Collecting scikit-learn>=1.2.0 (from qiskit-machine-learning)
  Downloading scikit_learn-1.5.1-cp310-cp310-manylinux_2_17_x86_64.manylinux2014_x86_64.whl.metadata (12 kB)
Collecting fastdtw (from qiskit-machine-learning)
  Downloading fastdtw-0.3.4.tar.gz (133 kB)
     ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 133.4/133.4 kB 15.3 MB/s eta 0:00:00
  Preparing metadata (setup.py) ... done
Requirement already satisfied: setuptools>=40.1.0 in /home/ec2-user/anaconda3/envs/JupyterSystemEnv/lib/python3.10/site-packages (from qiskit-machine-learning) (69.5.1)
Requirement already satisfied: dill>=0.3.4 in /home/ec2-user/anaconda3/envs/JupyterSystemEnv/lib/python3.10/site-packages (from qiskit-machine-learning) (0.3.8)
Requirement already satisfied: rustworkx>=0.14.0 in /home/ec2-user/anaconda3/envs/JupyterSystemEnv/lib/python3.10/site-packages (from qiskit>=0.44->qiskit-machine-learning) (0.15.1)
Requirement already satisfied: sympy>=1.3 in /home/ec2-user/anaconda3/envs/JupyterSystemEnv/lib/python3.10/site-packages (from qiskit>=0.44->qiskit-machine-learning) (1.13.0)
Requirement already satisfied: python-dateutil>=2.8.0 in /home/ec2-user/anaconda3/envs/JupyterSystemEnv/lib/python3.10/site-packages (from qiskit>=0.44->qiskit-machine-learning) (2.9.0)
Requirement already satisfied: stevedore>=3.0.0 in /home/ec2-user/anaconda3/envs/JupyterSystemEnv/lib/python3.10/site-packages (from qiskit>=0.44->qiskit-machine-learning) (5.2.0)
Requirement already satisfied: typing-extensions in /home/ec2-user/anaconda3/envs/JupyterSystemEnv/lib/python3.10/site-packages (from qiskit>=0.44->qiskit-machine-learning) (4.11.0)
Requirement already satisfied: symengine>=0.11 in /home/ec2-user/anaconda3/envs/JupyterSystemEnv/lib/python3.10/site-packages (from qiskit>=0.44->qiskit-machine-learning) (0.11.0)
Collecting joblib>=1.2.0 (from scikit-learn>=1.2.0->qiskit-machine-learning)
  Downloading joblib-1.4.2-py3-none-any.whl.metadata (5.4 kB)
Collecting threadpoolctl>=3.1.0 (from scikit-learn>=1.2.0->qiskit-machine-learning)
  Downloading threadpoolctl-3.5.0-py3-none-any.whl.metadata (13 kB)
Requirement already satisfied: six>=1.5 in /home/ec2-user/anaconda3/envs/JupyterSystemEnv/lib/python3.10/site-packages (from python-dateutil>=2.8.0->qiskit>=0.44->qiskit-machine-learning) (1.16.0)
Requirement already satisfied: pbr!=2.1.0,>=2.0.0 in /home/ec2-user/anaconda3/envs/JupyterSystemEnv/lib/python3.10/site-packages (from stevedore>=3.0.0->qiskit>=0.44->qiskit-machine-learning) (6.0.0)
Requirement already satisfied: mpmath<1.4,>=1.1.0 in /home/ec2-user/anaconda3/envs/JupyterSystemEnv/lib/python3.10/site-packages (from sympy>=1.3->qiskit>=0.44->qiskit-machine-learning) (1.3.0)
Downloading qiskit_machine_learning-0.7.2-py3-none-any.whl (97 kB)
   ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 97.8/97.8 kB 17.5 MB/s eta 0:00:00
Downloading qiskit_algorithms-0.3.0-py3-none-any.whl (308 kB)
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Downloading scikit_learn-1.5.1-cp310-cp310-manylinux_2_17_x86_64.manylinux2014_x86_64.whl (13.4 MB)
   ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 13.4/13.4 MB 38.8 MB/s eta 0:00:00:00:010:01
Downloading joblib-1.4.2-py3-none-any.whl (301 kB)
```

```
   ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 301.8/301.8 kB 40.6 MB/s eta 0:00:00
Downloading threadpoolctl-3.5.0-py3-none-any.whl (18 kB)
Building wheels for collected packages: fastdtw
  Building wheel for fastdtw (setup.py) ... done
  Created wheel for fastdtw: filename=fastdtw-0.3.4-cp310-cp310-linux_x86_64.whl size=
106097 sha256=7700c2b597fdeba382bc29a85581447b94a152bb107a63a0e8644766cea043ba
  Stored in directory: /home/ec2-user/.cache/pip/wheels/73/c8/f7/c25448dab74c3acf4848b
c25d513c736bb93910277e1528ef4
Successfully built fastdtw
Installing collected packages: threadpoolctl, joblib, fastdtw, scikit-learn, qiskit-al
gorithms, qiskit-machine-learning
Successfully installed fastdtw-0.3.4 joblib-1.4.2 qiskit-algorithms-0.3.0 qiskit-machi
ne-learning-0.7.2 scikit-learn-1.5.1 threadpoolctl-3.5.0
```

In [4]:
```
!pip install amazon-braket-sdk
```

```
Collecting amazon-braket-sdk
  Downloading amazon_braket_sdk-1.83.0-py3-none-any.whl.metadata (14 kB)
Collecting amazon-braket-schemas>=1.21.3 (from amazon-braket-sdk)
  Downloading amazon_braket_schemas-1.22.0-py3-none-any.whl.metadata (5.9 kB)
Collecting amazon-braket-default-simulator>=1.26.0 (from amazon-braket-sdk)
  Downloading amazon_braket_default_simulator-1.26.0-py3-none-any.whl.metadata (6.3 k
B)
Collecting oqpy~=0.3.5 (from amazon-braket-sdk)
  Downloading oqpy-0.3.6-py3-none-any.whl.metadata (8.3 kB)
Collecting backoff (from amazon-braket-sdk)
  Downloading backoff-2.2.1-py3-none-any.whl.metadata (14 kB)
Collecting boltons (from amazon-braket-sdk)
  Downloading boltons-24.0.0-py3-none-any.whl.metadata (1.5 kB)
Requirement already satisfied: boto3>=1.28.53 in /home/ec2-user/anaconda3/envs/Jupyter
SystemEnv/lib/python3.10/site-packages (from amazon-braket-sdk) (1.34.101)
Requirement already satisfied: cloudpickle==2.2.1 in /home/ec2-user/anaconda3/envs/Jup
yterSystemEnv/lib/python3.10/site-packages (from amazon-braket-sdk) (2.2.1)
Requirement already satisfied: nest-asyncio in /home/ec2-user/anaconda3/envs/JupyterSy
stemEnv/lib/python3.10/site-packages (from amazon-braket-sdk) (1.6.0)
Collecting networkx (from amazon-braket-sdk)
  Downloading networkx-3.3-py3-none-any.whl.metadata (5.1 kB)
Requirement already satisfied: numpy in /home/ec2-user/anaconda3/envs/JupyterSystemEn
v/lib/python3.10/site-packages (from amazon-braket-sdk) (1.26.4)
Collecting openpulse (from amazon-braket-sdk)
  Downloading openpulse-0.5.0-py3-none-any.whl.metadata (2.0 kB)
Collecting openqasm3 (from amazon-braket-sdk)
  Downloading openqasm3-1.0.0-py3-none-any.whl.metadata (6.0 kB)
Requirement already satisfied: sympy in /home/ec2-user/anaconda3/envs/JupyterSystemEn
v/lib/python3.10/site-packages (from amazon-braket-sdk) (1.13.0)
Collecting backports.entry-points-selectable (from amazon-braket-sdk)
  Downloading backports.entry_points_selectable-1.3.0-py3-none-any.whl.metadata (4.1 k
B)
Collecting opt-einsum (from amazon-braket-default-simulator>=1.26.0->amazon-braket-sd
k)
  Downloading opt_einsum-3.3.0-py3-none-any.whl.metadata (6.5 kB)
Collecting pydantic>2 (from amazon-braket-default-simulator>=1.26.0->amazon-braket-sd
k)
  Downloading pydantic-2.8.2-py3-none-any.whl.metadata (125 kB)
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Requirement already satisfied: scipy in /home/ec2-user/anaconda3/envs/JupyterSystemEn
v/lib/python3.10/site-packages (from amazon-braket-default-simulator>=1.26.0->amazon-b
raket-sdk) (1.14.0)
Collecting antlr4-python3-runtime==4.9.2 (from amazon-braket-default-simulator>=1.26.0
->amazon-braket-sdk)
  Downloading antlr4-python3-runtime-4.9.2.tar.gz (117 kB)
     ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 117.2/117.2 kB 2.2 MB/s eta 0:00:00a 0:0
0:01
  Preparing metadata (setup.py) ... done
Requirement already satisfied: botocore<1.35.0,>=1.34.101 in /home/ec2-user/anaconda3/
envs/JupyterSystemEnv/lib/python3.10/site-packages (from boto3>=1.28.53->amazon-braket
-sdk) (1.34.101)
Requirement already satisfied: jmespath<2.0.0,>=0.7.1 in /home/ec2-user/anaconda3/env
s/JupyterSystemEnv/lib/python3.10/site-packages (from boto3>=1.28.53->amazon-braket-sd
k) (1.0.1)
Requirement already satisfied: s3transfer<0.11.0,>=0.10.0 in /home/ec2-user/anaconda3/
envs/JupyterSystemEnv/lib/python3.10/site-packages (from boto3>=1.28.53->amazon-braket
-sdk) (0.10.1)
Collecting mypy-extensions>=0.2.0 (from oqpy~=0.3.5->amazon-braket-sdk)
  Downloading mypy_extensions-1.0.0-py3-none-any.whl.metadata (1.1 kB)
Requirement already satisfied: mpmath<1.4,>=1.1.0 in /home/ec2-user/anaconda3/envs/Jup
yterSystemEnv/lib/python3.10/site-packages (from sympy->amazon-braket-sdk) (1.3.0)
Requirement already satisfied: python-dateutil<3.0.0,>=2.1 in /home/ec2-user/anaconda
3/envs/JupyterSystemEnv/lib/python3.10/site-packages (from botocore<1.35.0,>=1.34.101-
```

```
>boto3>=1.28.53->amazon-braket-sdk) (2.9.0)
Requirement already satisfied: urllib3!=2.2.0,<3,>=1.25.4 in /home/ec2-user/anaconda3/
envs/JupyterSystemEnv/lib/python3.10/site-packages (from botocore<1.35.0,>=1.34.101->b
oto3>=1.28.53->amazon-braket-sdk) (2.2.1)
Collecting annotated-types>=0.4.0 (from pydantic>2->amazon-braket-default-simulator>=
1.26.0->amazon-braket-sdk)
  Downloading annotated_types-0.7.0-py3-none-any.whl.metadata (15 kB)
Collecting pydantic-core==2.20.1 (from pydantic>2->amazon-braket-default-simulator>=1.
26.0->amazon-braket-sdk)
  Downloading pydantic_core-2.20.1-cp310-cp310-manylinux_2_17_x86_64.manylinux2014_x86
_64.whl.metadata (6.6 kB)
Requirement already satisfied: typing-extensions>=4.6.1 in /home/ec2-user/anaconda3/en
vs/JupyterSystemEnv/lib/python3.10/site-packages (from pydantic>2->amazon-braket-defau
lt-simulator>=1.26.0->amazon-braket-sdk) (4.11.0)
Requirement already satisfied: six>=1.5 in /home/ec2-user/anaconda3/envs/JupyterSystem
Env/lib/python3.10/site-packages (from python-dateutil<3.0.0,>=2.1->botocore<1.35.0,>=
1.34.101->boto3>=1.28.53->amazon-braket-sdk) (1.16.0)
Downloading amazon_braket_sdk-1.83.0-py3-none-any.whl (313 kB)
   ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 313.7/313.7 kB 5.1 MB/s eta 0:00:00:00:01
Downloading amazon_braket_default_simulator-1.26.0-py3-none-any.whl (223 kB)
   ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 224.0/224.0 kB 36.3 MB/s eta 0:00:00
Downloading amazon_braket_schemas-1.22.0-py3-none-any.whl (125 kB)
   ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 125.6/125.6 kB 3.0 MB/s eta 0:00:00:00:01
Downloading oqpy-0.3.6-py3-none-any.whl (36 kB)
Downloading openpulse-0.5.0-py3-none-any.whl (377 kB)
   ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 377.0/377.0 kB 7.2 MB/s eta 0:00:00:00:01
Downloading openqasm3-1.0.0-py3-none-any.whl (539 kB)
   ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 539.8/539.8 kB 7.3 MB/s eta 0:00:00:00:01
Downloading backoff-2.2.1-py3-none-any.whl (15 kB)
Downloading backports.entry_points_selectable-1.3.0-py3-none-any.whl (6.2 kB)
Downloading boltons-24.0.0-py3-none-any.whl (191 kB)
   ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 191.7/191.7 kB 27.1 MB/s eta 0:00:00
Downloading networkx-3.3-py3-none-any.whl (1.7 MB)
   ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 1.7/1.7 MB 16.9 MB/s eta 0:00:0000:01
Downloading mypy_extensions-1.0.0-py3-none-any.whl (4.7 kB)
Downloading pydantic-2.8.2-py3-none-any.whl (423 kB)
   ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 423.9/423.9 kB 9.6 MB/s eta 0:00:00:00:01
Downloading pydantic_core-2.20.1-cp310-cp310-manylinux_2_17_x86_64.manylinux2014_x86_6
4.whl (2.1 MB)
   ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 2.1/2.1 MB 10.3 MB/s eta 0:00:00:00:01
Downloading opt_einsum-3.3.0-py3-none-any.whl (65 kB)
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Downloading annotated_types-0.7.0-py3-none-any.whl (13 kB)
Building wheels for collected packages: antlr4-python3-runtime
  Building wheel for antlr4-python3-runtime (setup.py) ... done
  Created wheel for antlr4-python3-runtime: filename=antlr4_python3_runtime-4.9.2-py3-
none-any.whl size=144548 sha256=2631efc9065ede62056b3931e9d6f4d1c9be977ddd359b2cf5209b
29a154dc58
  Stored in directory: /home/ec2-user/.cache/pip/wheels/af/c8/1f/dd6d90c5974896e85709e
017986a6f72fcf32343bea042bc03
Successfully built antlr4-python3-runtime
Installing collected packages: openqasm3, antlr4-python3-runtime, pydantic-core, opt-e
insum, networkx, mypy-extensions, boltons, backports.entry-points-selectable, backoff,
annotated-types, pydantic, openpulse, oqpy, amazon-braket-schemas, amazon-braket-defau
lt-simulator, amazon-braket-sdk
Successfully installed amazon-braket-default-simulator-1.26.0 amazon-braket-schemas-1.
22.0 amazon-braket-sdk-1.83.0 annotated-types-0.7.0 antlr4-python3-runtime-4.9.2 backo
ff-2.2.1 backports.entry-points-selectable-1.3.0 boltons-24.0.0 mypy-extensions-1.0.0
networkx-3.3 openpulse-0.5.0 openqasm3-1.0.0 opt-einsum-3.3.0 oqpy-0.3.6 pydantic-2.8.
2 pydantic-core-2.20.1
```

In [5]:
```
!pip install pandas
```

```
Requirement already satisfied: pandas in /home/ec2-user/anaconda3/envs/JupyterSystemEn
v/lib/python3.10/site-packages (1.5.3)
Requirement already satisfied: python-dateutil>=2.8.1 in /home/ec2-user/anaconda3/env
s/JupyterSystemEnv/lib/python3.10/site-packages (from pandas) (2.9.0)
Requirement already satisfied: pytz>=2020.1 in /home/ec2-user/anaconda3/envs/JupyterSy
stemEnv/lib/python3.10/site-packages (from pandas) (2024.1)
Requirement already satisfied: numpy>=1.21.0 in /home/ec2-user/anaconda3/envs/JupyterS
ystemEnv/lib/python3.10/site-packages (from pandas) (1.26.4)
Requirement already satisfied: six>=1.5 in /home/ec2-user/anaconda3/envs/JupyterSystem
Env/lib/python3.10/site-packages (from python-dateutil>=2.8.1->pandas) (1.16.0)
```

In [6]:
```
!pip install numpy
```

```
Requirement already satisfied: numpy in /home/ec2-user/anaconda3/envs/JupyterSystemEn
v/lib/python3.10/site-packages (1.26.4)
```

In [7]:
```
!pip install scikit-learn
```

```
Requirement already satisfied: scikit-learn in /home/ec2-user/anaconda3/envs/JupyterSy
stemEnv/lib/python3.10/site-packages (1.5.1)
Requirement already satisfied: numpy>=1.19.5 in /home/ec2-user/anaconda3/envs/JupyterS
ystemEnv/lib/python3.10/site-packages (from scikit-learn) (1.26.4)
Requirement already satisfied: scipy>=1.6.0 in /home/ec2-user/anaconda3/envs/JupyterSy
stemEnv/lib/python3.10/site-packages (from scikit-learn) (1.14.0)
Requirement already satisfied: joblib>=1.2.0 in /home/ec2-user/anaconda3/envs/JupyterS
ystemEnv/lib/python3.10/site-packages (from scikit-learn) (1.4.2)
Requirement already satisfied: threadpoolctl>=3.1.0 in /home/ec2-user/anaconda3/envs/J
upyterSystemEnv/lib/python3.10/site-packages (from scikit-learn) (3.5.0)
```

In [8]:
```
!pip install matplotlib
```

```
Collecting matplotlib
  Downloading matplotlib-3.9.1-cp310-cp310-manylinux_2_17_x86_64.manylinux2014_x86_64.
whl.metadata (11 kB)
Collecting contourpy>=1.0.1 (from matplotlib)
  Downloading contourpy-1.2.1-cp310-cp310-manylinux_2_17_x86_64.manylinux2014_x86_64.w
hl.metadata (5.8 kB)
Collecting cycler>=0.10 (from matplotlib)
  Downloading cycler-0.12.1-py3-none-any.whl.metadata (3.8 kB)
Collecting fonttools>=4.22.0 (from matplotlib)
  Downloading fonttools-4.53.1-cp310-cp310-manylinux_2_17_x86_64.manylinux2014_x86_64.
whl.metadata (162 kB)
     ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 162.6/162.6 kB 9.8 MB/s eta 0:00:00
Collecting kiwisolver>=1.3.1 (from matplotlib)
  Downloading kiwisolver-1.4.5-cp310-cp310-manylinux_2_12_x86_64.manylinux2010_x86_64.
whl.metadata (6.4 kB)
Requirement already satisfied: numpy>=1.23 in /home/ec2-user/anaconda3/envs/JupyterSys
temEnv/lib/python3.10/site-packages (from matplotlib) (1.26.4)
Requirement already satisfied: packaging>=20.0 in /home/ec2-user/anaconda3/envs/Jupyte
rSystemEnv/lib/python3.10/site-packages (from matplotlib) (24.0)
Collecting pillow>=8 (from matplotlib)
  Downloading pillow-10.4.0-cp310-cp310-manylinux_2_17_x86_64.manylinux2014_x86_64.wh
l.metadata (9.2 kB)
Collecting pyparsing>=2.3.1 (from matplotlib)
  Downloading pyparsing-3.1.2-py3-none-any.whl.metadata (5.1 kB)
Requirement already satisfied: python-dateutil>=2.7 in /home/ec2-user/anaconda3/envs/J
upyterSystemEnv/lib/python3.10/site-packages (from matplotlib) (2.9.0)
Requirement already satisfied: six>=1.5 in /home/ec2-user/anaconda3/envs/JupyterSystem
Env/lib/python3.10/site-packages (from python-dateutil>=2.7->matplotlib) (1.16.0)
Downloading matplotlib-3.9.1-cp310-cp310-manylinux_2_17_x86_64.manylinux2014_x86_64.wh
l (8.3 MB)
   ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 8.3/8.3 MB 35.9 MB/s eta 0:00:00:00:0100:0
1
Downloading contourpy-1.2.1-cp310-cp310-manylinux_2_17_x86_64.manylinux2014_x86_64.whl
(305 kB)
   ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 305.2/305.2 kB 45.2 MB/s eta 0:00:00
Downloading cycler-0.12.1-py3-none-any.whl (8.3 kB)
Downloading fonttools-4.53.1-cp310-cp310-manylinux_2_17_x86_64.manylinux2014_x86_64.wh
l (4.6 MB)
   ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 4.6/4.6 MB 53.5 MB/s eta 0:00:00:00:01
Downloading kiwisolver-1.4.5-cp310-cp310-manylinux_2_12_x86_64.manylinux2010_x86_64.wh
l (1.6 MB)
   ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 1.6/1.6 MB 20.1 MB/s eta 0:00:0000:01
Downloading pillow-10.4.0-cp310-cp310-manylinux_2_17_x86_64.manylinux2014_x86_64.whl
(4.4 MB)
   ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 4.4/4.4 MB 113.9 MB/s eta 0:00:0000:01
Downloading pyparsing-3.1.2-py3-none-any.whl (103 kB)
   ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 103.2/103.2 kB 18.6 MB/s eta 0:00:00
Installing collected packages: pyparsing, pillow, kiwisolver, fonttools, cycler, conto
urpy, matplotlib
Successfully installed contourpy-1.2.1 cycler-0.12.1 fonttools-4.53.1 kiwisolver-1.4.5
matplotlib-3.9.1 pillow-10.4.0 pyparsing-3.1.2
```

In [9]:
```
!pip show scikit-learn
```

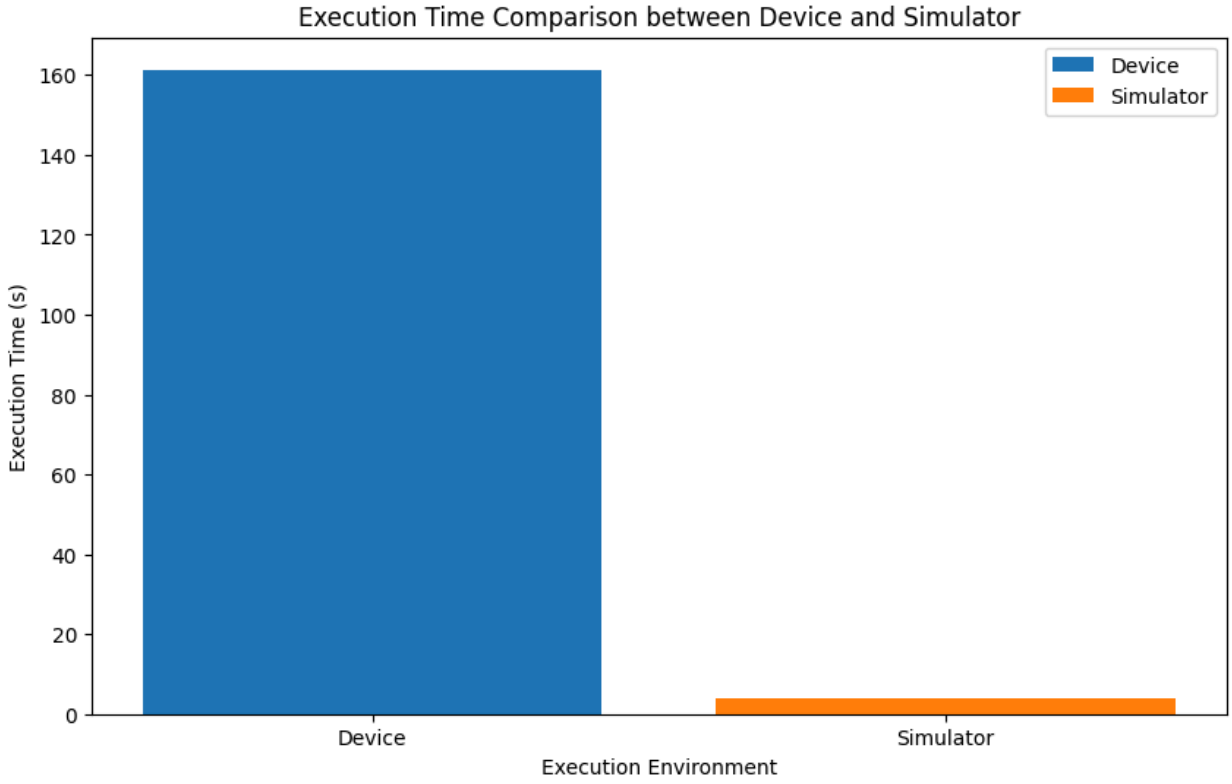
```
Name: scikit-learn
Version: 1.5.1
Summary: A set of python modules for machine learning and data mining
Home-page: https://scikit-learn.org
Author:
Author-email:
License: new BSD
Location: /home/ec2-user/anaconda3/envs/JupyterSystemEnv/lib/python3.10/site-packages
Requires: joblib, numpy, scipy, threadpoolctl
Required-by: qiskit-machine-learning
```

In [13]:

```python
import sys
sys.path.insert(0, '/home/ec2-user/anaconda3/envs/JupyterSystemEnv/lib/python3.10/site

# Import necessary libraries
import numpy as np
from braket.aws import AwsDevice, AwsQuantumTask, AwsSession
from braket.circuits import Circuit
from sklearn.datasets import make_blobs
from sklearn.preprocessing import StandardScaler
from sklearn.model_selection import train_test_split
import time
import matplotlib.pyplot as plt

# Setup AWS session
aws_session = AwsSession()

# Function to create a quantum SVM circuit
def create_quantum_svm_circuit(feature_map, train_data, test_data):
    circuit = Circuit()

    # Feature map construction
    feature_map.construct_circuit(circuit, train_data)

    # Insert quantum gates for SVM
    # Example: Here you would define your quantum SVM algorithm using Qiskit, PennyLan

    return circuit

# Generate synthetic dataset
X, y = make_blobs(n_samples=10000, centers=2, random_state=42)
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.3, random_state=

# Normalize data
scaler = StandardScaler().fit(X_train)
X_train_scaled = scaler.transform(X_train)
X_test_scaled = scaler.transform(X_test)

# Define feature map (example, can be replaced with actual quantum feature map)
class QuantumFeatureMap:
    def __init__(self):
        pass

    def construct_circuit(self, circuit, data):
        # Example: apply Hadamard gate to each qubit for each feature
        for i in range(data.shape[1]):
            circuit.h(i)

# Initialize AWS Quantum Device
device_arn = "arn:aws:braket:us-east-1::device/qpu/ionq/Aria-2"  # Example device ARN
device = AwsDevice(device_arn)

# Simulate on the device
```

```
results_device = []
execution_times_device = []

for i in range(5):  # Run 5 times for averaging
    start_time = time.time()
    # Create circuit
    quantum_circuit_device = create_quantum_svm_circuit(QuantumFeatureMap(), X_train_s

    # Execute on device
    task_device = device.run(quantum_circuit_device, shots=1000)
    results_device.append(task_device.result())

    execution_time = time.time() - start_time
    execution_times_device.append(execution_time)

# Simulate on the simulator
simulator = AwsDevice("arn:aws:braket:::device/quantum-simulator/amazon/sv1")
results_simulator = []
execution_times_simulator = []

for i in range(5):  # Run 5 times for averaging
    start_time = time.time()

    # Create circuit
    quantum_circuit_simulator = create_quantum_svm_circuit(QuantumFeatureMap(), X_trai

    # Execute on simulator
    task_simulator = simulator.run(quantum_circuit_simulator, shots=1000)
    results_simulator.append(task_simulator.result())

    execution_time = time.time() - start_time
    execution_times_simulator.append(execution_time)

# Process results (adjusted to handle Braket's result format)
def process_results(results):
    metrics = []
    for result in results:
        if 'estimation_stats' in result.additional_metadata:
            metric = result.additional_metadata['estimation_stats']
            metrics.append(metric)
        else:
            # Handle case where estimation_stats is not found
            metrics.append(None)  # or any default value as per your needs
    return metrics


metrics_device = process_results(results_device)
metrics_simulator = process_results(results_simulator)

# Example: Plotting execution times
plt.figure(figsize=(10, 6))
plt.bar(['Device'] * 5, execution_times_device, label='Device')
plt.bar(['Simulator'] * 5, execution_times_simulator, label='Simulator')
plt.xlabel('Execution Environment')
plt.ylabel('Execution Time (s)')
plt.title('Execution Time Comparison between Device and Simulator')
plt.legend()
plt.show()

# Example: Numerical comparison of efficiency and accuracy
print("Device Execution Times:", execution_times_device)
print("Simulator Execution Times:", execution_times_simulator)
```

```
print("Device Metrics:", metrics_device)
print("Simulator Metrics:", metrics_simulator)
```




```
Device Execution Times: [161.31334948539734, 20.034186124801636, 20.405076026916504, 1
8.35497522354126, 18.26329278945923]
Simulator Execution Times: [3.8448312282562256, 3.0793092250823975, 2.678688526153564
5, 2.6981091499328613, 1.6811378002166748]
Device Metrics: [None, None, None, None, None]
Simulator Metrics: [None, None, None, None, None]
```

In [ ]: