Quantum Cryptography Simulation using the BB84 Protocol (with Eavesdropper Detection)

Abstract

This project simulates the **BB84 Quantum Key Distribution protocol** using Python and Qiskit to demonstrate secure communication through quantum mechanics. It models an eavesdropper's interference and shows how her actions increase the error rate, thereby revealing her presence. The simulation highlights the BB84 protocol's effectiveness in ensuring both **data security and eavesdropper detection** in quantum cryptography.

Jayalashmi J
24MSRDF013

Quantum Cryptography Simulation using the BB84 Protocol (with Eavesdropper Detection)

Introduction

Quantum cryptography leverages principles of quantum mechanics to enable secure communication. The BB84 protocol, invented in 1984 by Charles Bennett and Gilles Brassard, is the first and most widely recognized protocol for Quantum Key Distribution (QKD). It enables two communicating parties (commonly referred to as Alice and Bob) to establish a shared secret key, with the assurance that any attempt at eavesdropping can be detected through quantum disturbances.

Objectives

- Simulate the BB84 QKD protocol using Python and Qiskit.
- Demonstrate the protocol’s essential steps including bit generation, quantum encoding, transmission, measurement, and key sifting.
- Incorporate an 'Eve' eavesdropper simulation to show how her interference increases the error rate, thereby revealing her presence.

Method and Code Overview

The BB84 protocol is implemented using Qiskit, IBM’s open-source quantum computing framework. This simulation allows us to mimic quantum state preparation, measurement, and communication steps between two users using virtual quantum circuits.

Qiskit Tools

- QuantumCircuit: Used to encode quantum states representing bits.
- Aer Simulator: Executes quantum circuits and simulates measurement outcomes without physical quantum hardware.

Steps

1. Random Bit and Basis Generation: Alice generates a random bit string and a random sequence of measurement bases (Z or X). Bob independently generates his own basis sequence.
2. Quantum Encoding: Each bit is encoded as a quantum state using corresponding gates in the Qiskit QuantumCircuit object.
3. Eavesdropper Intervention: Eve measures each qubit using a random basis and then resends a new qubit to Bob, disturbing the quantum state when her basis differs from Alice’s.
4. Measurement: Bob measures the received qubits in his chosen bases.

5. Key Sifting: Alice and Bob publicly compare their measurement bases (not the key bits). Bits measured with matching bases form the ‘sifted key’.
6. Error Rate and Security Check: A subset of bits is compared to estimate the error rate. A high error rate implies eavesdropping activity.

Eavesdropper Detection

Without Eve: The error rate is approximately 0%, demonstrating secure communication and correct key exchange.
With Eve: The error rate increases significantly, often to around 25%, as random measurement by Eve disturbs quantum states. In this specific simulation, the error rate reached 40%, clearly indicating an eavesdropper’s interference.

Project Results

Two simulation runs were conducted to evaluate the BB84 protocol:
- No Eve: The error rate was 0.00%, confirming secure quantum key generation.
- With Eve: The error rate rose to 40.00%, confirming successful detection of an eavesdropper.

These outcomes demonstrate a key principle of quantum cryptography — any attempt to intercept or measure qubits introduces detectable disturbances.

Conclusions

The BB84 protocol ensures the confidentiality of communication through quantum mechanics. Its core advantage lies in built-in eavesdropper detection: any intrusion disrupts quantum coherence, introducing measurable errors. This simulation effectively showcases the BB84 mechanism using Python and Qiskit, illustrating how quantum cryptography ensures data security in theory and practice.

Possible Extensions

- Statistical Analysis: Execute multiple simulations to observe average error rate variations.
- Partial Eavesdropping: Model Eve as an intermittent attacker, affecting only certain qubits.
- Visualization: Implement matplotlib to graphically display key lengths and error rates.
- Real Quantum Hardware: Adapt the program to Qiskit’s real quantum backends for live experiments.

References

- Bennett, C.H. & Brassard, G. (1984). 'Quantum cryptography: Public key distribution and coin tossing.'
- Qiskit Textbook: https://qiskit.org/textbook/ch-algorithms/quantum-key-distribution.html

Programming codes

```
# bb84_qkd.py
# Quantum Cryptography Simulation using BB84 Protocol
# Works with latest Qiskit + Qiskit Aer (2025 compatible)

from qiskit import QuantumCircuit
from qiskit_aer import Aer
import random

def random_bits(n):
"""Generate n random bits"""
return [random.randint(0, 1) for _ in range(n)]

def random_bases(n):
"""Generate n random bases (0 = Z, 1 = X)"""
return [random.randint(0, 1) for _ in range(n)]

def encode_qubits(bits, bases):
"""Encode bits into qubits depending on basis"""
qubits = []
for bit, basis in zip(bits, bases):
```

```
qc = QuantumCircuit(1, 1)
if basis == 0:
if bit == 1:
qc.x(0)  # apply X gate
else:
if bit == 1:
qc.x(0)
qc.h(0)  # apply H gate for X basis
qubits.append(qc)
return qubits


def measure_qubits(qubits, bases):
"""Measure qubits in chosen bases"""
backend = Aer.get_backend('qasm_simulator')
results = []
for qc, basis in zip(qubits, bases):
new_qc = qc.copy()  # avoid in-place modification
if basis == 1:
new_qc.h(0)  # measure in X basis
new_qc.measure(0, 0)
result = backend.run(new_qc, shots=1, memory=True).result()
measured_bit = int(result.get_memory()[0])
results.append(measured_bit)
return results
```

```
def sift_keys(sender_bases, receiver_bases, sender_bits, receiver_bits):
"""Compare bases and keep only matching ones"""
key = [s for s, sb, rb in zip(sender_bits, sender_bases, receiver_bases) if sb == rb]
received_key = [r for r, sb, rb in zip(receiver_bits, sender_bases, receiver_bases) if sb == rb]
return key, received_key


# Step 2: Simulate BB84
n = 20  # number of qubits
alice_bits = random_bits(n)
alice_bases = random_bases(n)
bob_bases = random_bases(n)


print("Alice's bits:   ", alice_bits)
print("Alice's bases:  ", alice_bases)
print("Bob's bases:    ", bob_bases)


# Encode and measure
qubits = encode_qubits(alice_bits, alice_bases)
bob_results = measure_qubits(qubits, bob_bases)


# Key sifting
alice_key, bob_key = sift_keys(alice_bases, bob_bases, alice_bits, bob_results)


print("Alice's key (sifted):", alice_key)
```

print("Bob's key (sifted):", bob_key)

# Step 3: Check for mismatch (Eve detection)

errors = sum([1 for a, b in zip(alice_key, bob_key) if a != b])

error_rate = (errors / len(alice_key)) * 100 if alice_key else 0

print(f"Error rate: {error_rate:.2f}%")

if error_rate > 20:

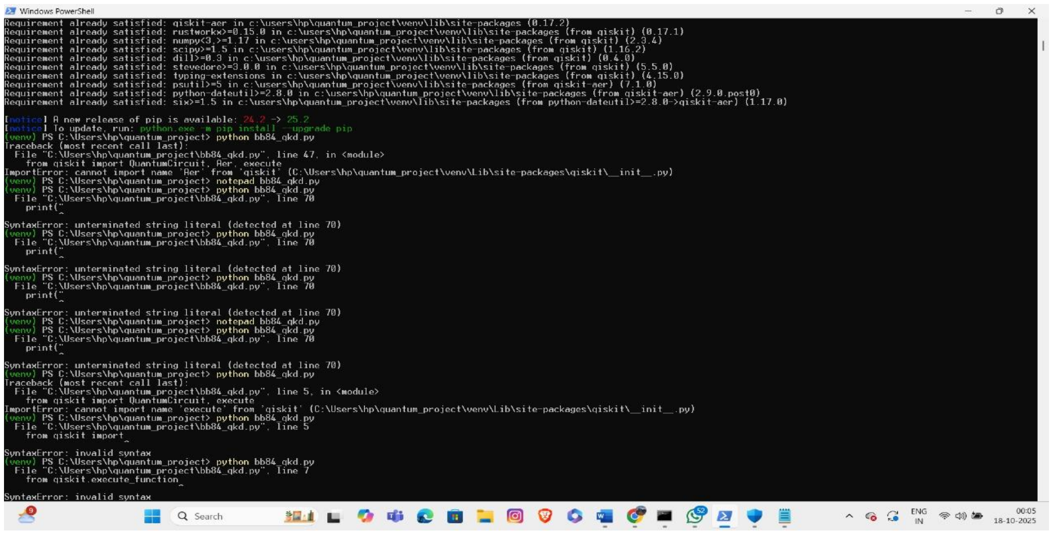
print("Possible eavesdropper detected (Eve may be listening!)")

else:

print("Secure quantum key established!")

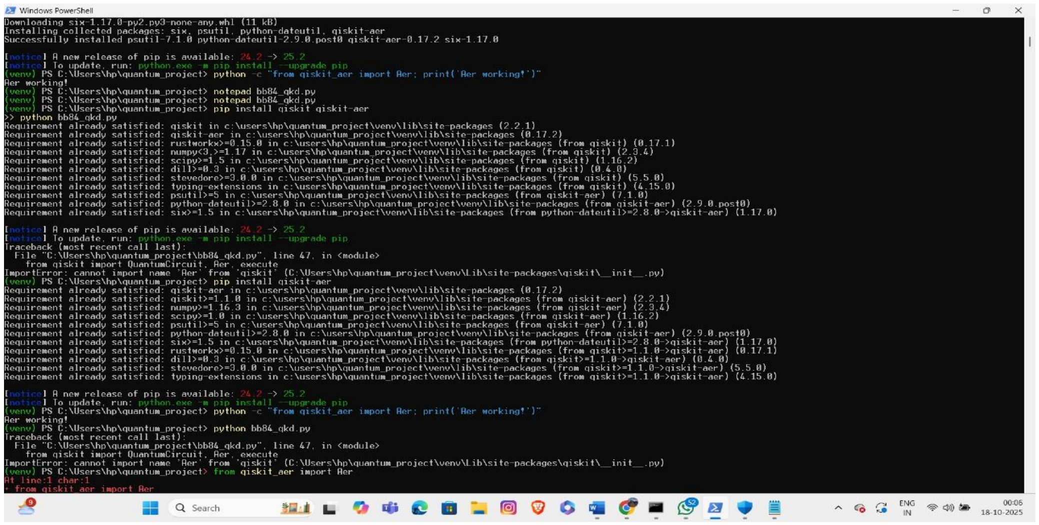
Step by step program outcome

Step 1:



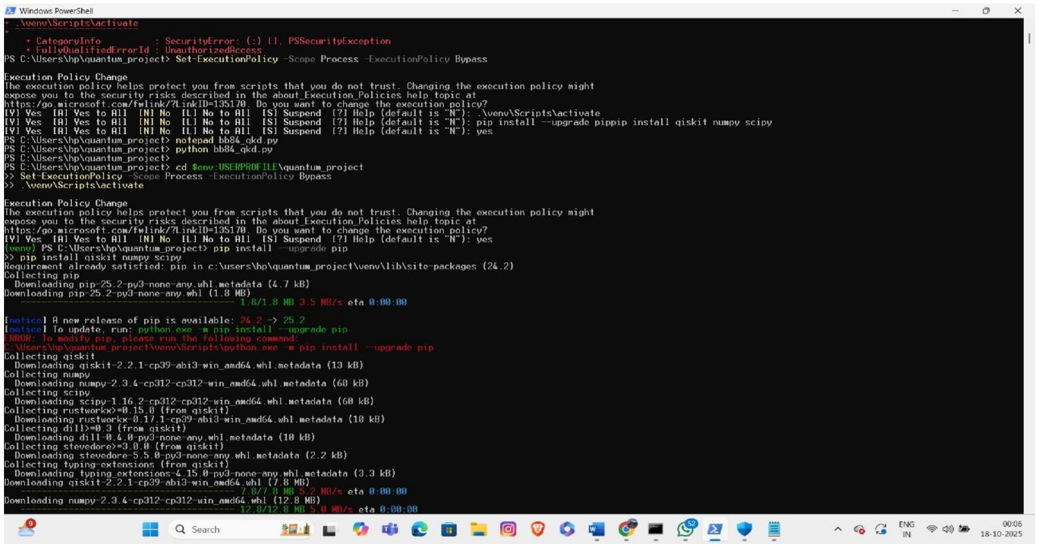
```
Requirement already satisfied: qiskit-aer in c:\users\hp\quantum_project\venv\lib\site-packages (0.17.2)
Requirement already satisfied: rustworkx>=0.15.0 in c:\users\hp\quantum_project\venv\lib\site-packages (from qiskit) (0.17.1)
Requirement already satisfied: numpy<3,>=1.17 in c:\users\hp\quantum_project\venv\lib\site-packages (from qiskit) (2.3.4)
Requirement already satisfied: scipy>=1.5 in c:\users\hp\quantum_project\venv\lib\site-packages (from qiskit) (1.16.2)
Requirement already satisfied: dill>=0.3 in c:\users\hp\quantum_project\venv\lib\site-packages (from qiskit) (0.4.0)
Requirement already satisfied: stevedore>=3.0.0 in c:\users\hp\quantum_project\venv\lib\site-packages (from qiskit) (5.5.0)
Requirement already satisfied: typing-extensions in c:\users\hp\quantum_project\venv\lib\site-packages (from qiskit) (4.15.0)
Requirement already satisfied: psutil>=5 in c:\users\hp\quantum_project\venv\lib\site-packages (from qiskit-aer) (7.1.0)
Requirement already satisfied: python-dateutil>=2.8.0 in c:\users\hp\quantum_project\venv\lib\site-packages (from qiskit-aer) (2.9.0.post0)
Requirement already satisfied: six>=1.5 in c:\users\hp\quantum_project\venv\lib\site-packages (from python-dateutil>=2.8.0->qiskit-aer) (1.17.0)

[notice] A new release of pip is available: 24.2 -> 25.2
[notice] To update, run: python.exe -m pip install --upgrade pip
(venv) PS C:\Users\hp\quantum_project> python bb84_qkd.py
Traceback (most recent call last):
  File "C:\Users\hp\quantum_project\bb84_qkd.py", line 47, in <module>
    from qiskit import QuantumCircuit, Aer, execute
ImportError: cannot import name 'Aer' from 'qiskit' (C:\Users\hp\quantum_project\venv\Lib\site-packages\qiskit\__init__.py)
(venv) PS C:\Users\hp\quantum_project> notepad bb84_qkd.py
(venv) PS C:\Users\hp\quantum_project> python bb84_qkd.py
  File "C:\Users\hp\quantum_project\bb84_qkd.py", line 70
    print("
          ^
SyntaxError: unterminated string literal (detected at line 70)
(venv) PS C:\Users\hp\quantum_project> python bb84_qkd.py
  File "C:\Users\hp\quantum_project\bb84_qkd.py", line 70
    print("
          ^
SyntaxError: unterminated string literal (detected at line 70)
(venv) PS C:\Users\hp\quantum_project> python bb84_qkd.py
  File "C:\Users\hp\quantum_project\bb84_qkd.py", line 70
    print("
          ^
SyntaxError: unterminated string literal (detected at line 70)
(venv) PS C:\Users\hp\quantum_project> notepad bb84_qkd.py
(venv) PS C:\Users\hp\quantum_project> python bb84_qkd.py
  File "C:\Users\hp\quantum_project\bb84_qkd.py", line 70
    print("
          ^
SyntaxError: unterminated string literal (detected at line 70)
(venv) PS C:\Users\hp\quantum_project> python bb84_qkd.py
Traceback (most recent call last):
  File "C:\Users\hp\quantum_project\bb84_qkd.py", line 5, in <module>
    from qiskit import QuantumCircuit, execute
ImportError: cannot import name 'execute' from 'qiskit' (C:\Users\hp\quantum_project\venv\Lib\site-packages\qiskit\__init__.py)
(venv) PS C:\Users\hp\quantum_project> python bb84_qkd.py
  File "C:\Users\hp\quantum_project\bb84_qkd.py", line 5
    from qiskit import
                      ^
SyntaxError: invalid syntax
(venv) PS C:\Users\hp\quantum_project> python bb84_qkd.py
  File "C:\Users\hp\quantum_project\bb84_qkd.py", line 7
    from qiskit.execute_function
                                ^
SyntaxError: invalid syntax
```

Step 2:



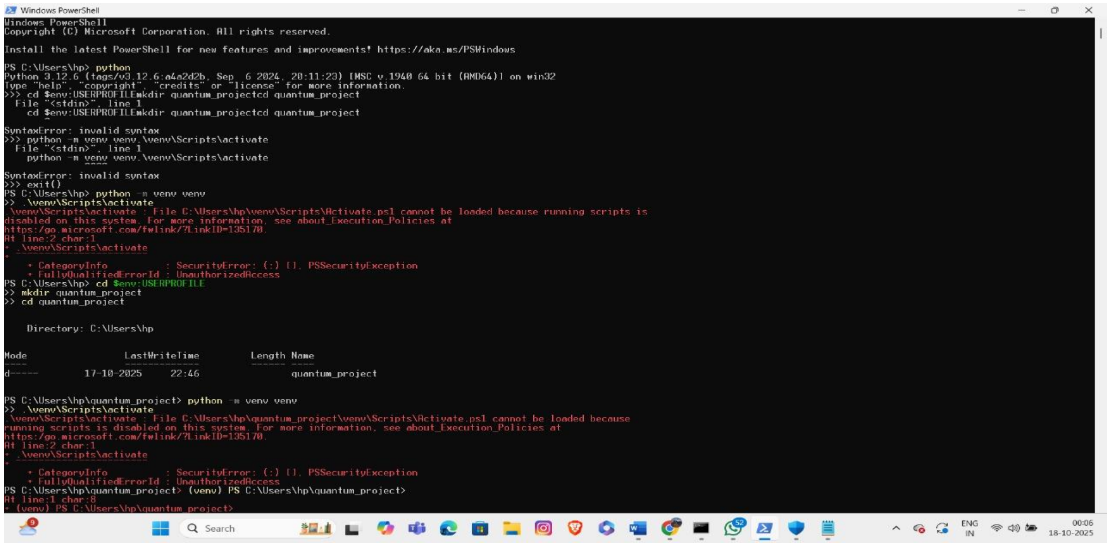
```
Downloading six-1.17.0-py2.py3-none-any.whl (11 kB)
Installing collected packages: six, psutil, python-dateutil, qiskit-aer
Successfully installed psutil-7.1.0 python-dateutil-2.9.0.post0 qiskit-aer-0.17.2 six-1.17.0

[notice] A new release of pip is available: 24.2 -> 25.2
[notice] To update, run: python.exe -m pip install --upgrade pip
(venv) PS C:\Users\hp\quantum_project> python -c "from qiskit_aer import Aer; print('Aer working!')"
Aer working!
(venv) PS C:\Users\hp\quantum_project> notepad bb84_qkd.py
(venv) PS C:\Users\hp\quantum_project> notepad bb84_qkd.py
(venv) PS C:\Users\hp\quantum_project> pip install qiskit qiskit-aer
>> python bb84_qkd.py
Requirement already satisfied: qiskit in c:\users\hp\quantum_project\venv\lib\site-packages (2.2.1)
Requirement already satisfied: qiskit-aer in c:\users\hp\quantum_project\venv\lib\site-packages (0.17.2)
Requirement already satisfied: rustworkx>=0.15.0 in c:\users\hp\quantum_project\venv\lib\site-packages (from qiskit) (0.17.1)
Requirement already satisfied: numpy<3,>=1.17 in c:\users\hp\quantum_project\venv\lib\site-packages (from qiskit) (2.3.4)
Requirement already satisfied: scipy>=1.5 in c:\users\hp\quantum_project\venv\lib\site-packages (from qiskit) (1.16.2)
Requirement already satisfied: dill>=0.3 in c:\users\hp\quantum_project\venv\lib\site-packages (from qiskit) (0.4.0)
Requirement already satisfied: stevedore>=3.0.0 in c:\users\hp\quantum_project\venv\lib\site-packages (from qiskit) (5.5.0)
Requirement already satisfied: typing-extensions in c:\users\hp\quantum_project\venv\lib\site-packages (from qiskit) (4.15.0)
Requirement already satisfied: psutil>=5 in c:\users\hp\quantum_project\venv\lib\site-packages (from qiskit-aer) (7.1.0)
Requirement already satisfied: python-dateutil>=2.8.0 in c:\users\hp\quantum_project\venv\lib\site-packages (from qiskit-aer) (2.9.0.post0)
Requirement already satisfied: six>=1.5 in c:\users\hp\quantum_project\venv\lib\site-packages (from python-dateutil>=2.8.0->qiskit-aer) (1.17.0)

[notice] A new release of pip is available: 24.2 -> 25.2
[notice] To update, run: python.exe -m pip install --upgrade pip
Traceback (most recent call last):
  File "C:\Users\hp\quantum_project\bb84_qkd.py", line 47, in <module>
    from qiskit import QuantumCircuit, Aer, execute
ImportError: cannot import name 'Aer' from 'qiskit' (C:\Users\hp\quantum_project\venv\Lib\site-packages\qiskit\__init__.py)
(venv) PS C:\Users\hp\quantum_project> pip install qiskit-aer
Requirement already satisfied: qiskit-aer in c:\users\hp\quantum_project\venv\lib\site-packages (0.17.2)
Requirement already satisfied: qiskit>=1.1.0 in c:\users\hp\quantum_project\venv\lib\site-packages (from qiskit-aer) (2.2.1)
Requirement already satisfied: numpy>=1.16.3 in c:\users\hp\quantum_project\venv\lib\site-packages (from qiskit-aer) (2.3.4)
Requirement already satisfied: scipy>=1.0 in c:\users\hp\quantum_project\venv\lib\site-packages (from qiskit-aer) (1.16.2)
Requirement already satisfied: psutil>=5 in c:\users\hp\quantum_project\venv\lib\site-packages (from qiskit-aer) (7.1.0)
Requirement already satisfied: python-dateutil>=2.8.0 in c:\users\hp\quantum_project\venv\lib\site-packages (from qiskit-aer) (2.9.0.post0)
Requirement already satisfied: six>=1.5 in c:\users\hp\quantum_project\venv\lib\site-packages (from python-dateutil>=2.8.0->qiskit-aer) (1.17.0)
Requirement already satisfied: rustworkx>=0.15.0 in c:\users\hp\quantum_project\venv\lib\site-packages (from qiskit>=1.1.0->qiskit-aer) (0.17.1)
Requirement already satisfied: dill>=0.3 in c:\users\hp\quantum_project\venv\lib\site-packages (from qiskit>=1.1.0->qiskit-aer) (0.4.0)
Requirement already satisfied: stevedore>=3.0.0 in c:\users\hp\quantum_project\venv\lib\site-packages (from qiskit>=1.1.0->qiskit-aer) (5.5.0)
Requirement already satisfied: typing-extensions in c:\users\hp\quantum_project\venv\lib\site-packages (from qiskit>=1.1.0->qiskit-aer) (4.15.0)

[notice] A new release of pip is available: 24.2 -> 25.2
[notice] To update, run: python.exe -m pip install --upgrade pip
(venv) PS C:\Users\hp\quantum_project> python -c "from qiskit_aer import Aer; print('Aer working!')"
Aer working!
(venv) PS C:\Users\hp\quantum_project> python bb84_qkd.py
Traceback (most recent call last):
  File "C:\Users\hp\quantum_project\bb84_qkd.py", line 47, in <module>
    from qiskit import QuantumCircuit, Aer, execute
ImportError: cannot import name 'Aer' from 'qiskit' (C:\Users\hp\quantum_project\venv\Lib\site-packages\qiskit\__init__.py)
(venv) PS C:\Users\hp\quantum_project> from qiskit_aer import Aer
At line:1 char:1
+ from qiskit_aer import Aer
```

Step 3:



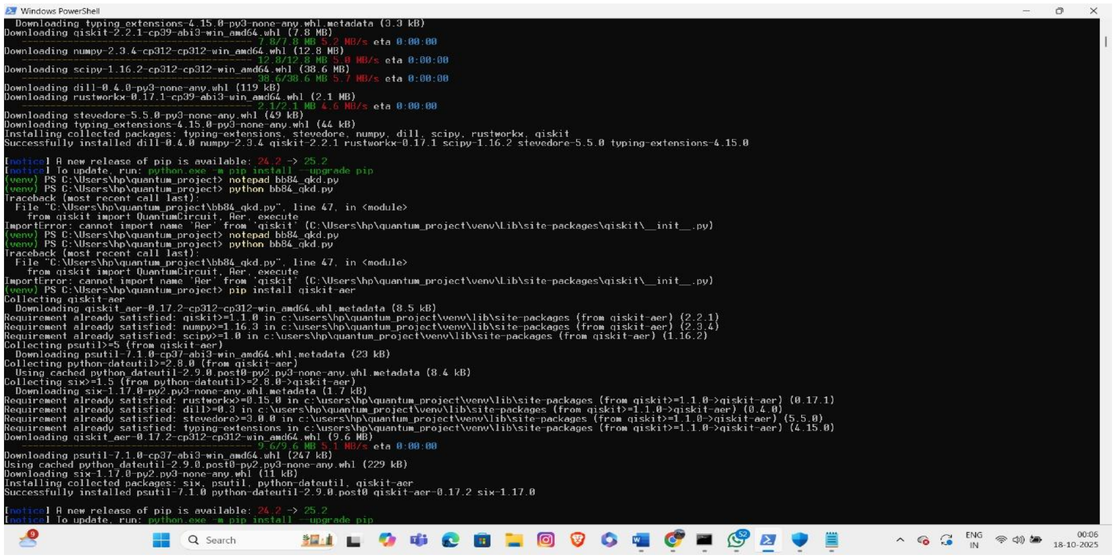
```
+ .\venv\Scripts\activate
+
    + CategoryInfo          : SecurityError: (:) [], PSSecurityException
    + FullyQualifiedErrorId : UnauthorizedAccess
PS C:\Users\hp\quantum_project> Set-ExecutionPolicy -Scope Process -ExecutionPolicy Bypass

Execution Policy Change
The execution policy helps protect you from scripts that you do not trust. Changing the execution policy might
expose you to the security risks described in the about_Execution_Policies help topic at
https:/go.microsoft.com/fwlink/?LinkID=135170. Do you want to change the execution policy?
[Y] Yes  [A] Yes to All  [N] No  [L] No to All  [S] Suspend  [?] Help (default is "N"): .\venv\Scripts\activate
[Y] Yes  [A] Yes to All  [N] No  [L] No to All  [S] Suspend  [?] Help (default is "N"): pip install --upgrade pippip install qiskit numpy scipy
[Y] Yes  [A] Yes to All  [N] No  [L] No to All  [S] Suspend  [?] Help (default is "N"): yes
PS C:\Users\hp\quantum_project> notepad bb84_qkd.py
PS C:\Users\hp\quantum_project> python bb84_qkd.py
PS C:\Users\hp\quantum_project>
PS C:\Users\hp\quantum_project> cd $env:USERPROFILE\quantum_project
>> Set-ExecutionPolicy -Scope Process -ExecutionPolicy Bypass
>> .\venv\Scripts\activate

Execution Policy Change
The execution policy helps protect you from scripts that you do not trust. Changing the execution policy might
expose you to the security risks described in the about_Execution_Policies help topic at
https:/go.microsoft.com/fwlink/?LinkID=135170. Do you want to change the execution policy?
[Y] Yes  [A] Yes to All  [N] No  [L] No to All  [S] Suspend  [?] Help (default is "N"): yes
(venv) PS C:\Users\hp\quantum_project> pip install --upgrade pip
>> pip install qiskit numpy scipy
Requirement already satisfied: pip in c:\users\hp\quantum_project\venv\lib\site-packages (24.2)
Collecting pip
  Downloading pip-25.2-py3-none-any.whl.metadata (4.7 kB)
Downloading pip-25.2-py3-none-any.whl (1.8 MB)
   ---------------------------------------- 1.8/1.8 MB 3.5 MB/s eta 0:00:00

[notice] A new release of pip is available: 24.2 -> 25.2
[notice] To update, run: python.exe -m pip install --upgrade pip
ERROR: To modify pip, please run the following command:
C:\Users\hp\quantum_project\venv\Scripts\python.exe -m pip install --upgrade pip
Collecting qiskit
  Downloading qiskit-2.2.1-cp39-abi3-win_amd64.whl.metadata (13 kB)
Collecting numpy
  Downloading numpy-2.3.4-cp312-cp312-win_amd64.whl.metadata (60 kB)
Collecting scipy
  Downloading scipy-1.16.2-cp312-cp312-win_amd64.whl.metadata (60 kB)
Collecting rustworkx>=0.15.0 (from qiskit)
  Downloading rustworkx-0.17.1-cp39-abi3-win_amd64.whl.metadata (10 kB)
Collecting dill>=0.3 (from qiskit)
  Downloading dill-0.4.0-py3-none-any.whl.metadata (10 kB)
Collecting stevedore>=3.0.0 (from qiskit)
  Downloading stevedore-5.5.0-py3-none-any.whl.metadata (2.2 kB)
Collecting typing-extensions (from qiskit)
  Downloading typing_extensions-4.15.0-py3-none-any.whl.metadata (3.3 kB)
Downloading qiskit-2.2.1-cp39-abi3-win_amd64.whl (7.8 MB)
   ---------------------------------------- 7.8/7.8 MB 5.2 MB/s eta 0:00:00
Downloading numpy-2.3.4-cp312-cp312-win_amd64.whl (12.8 MB)
   ---------------------------------------- 12.8/12.8 MB 5.0 MB/s eta 0:00:00
```

Step 4:



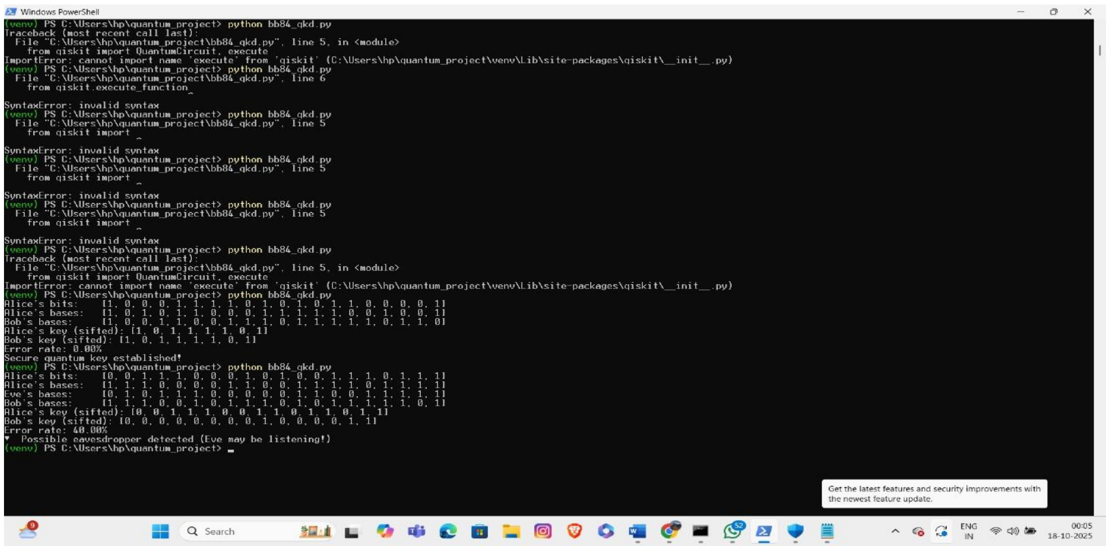
```
Windows PowerShell
Copyright (C) Microsoft Corporation. All rights reserved.

Install the latest PowerShell for new features and improvements! https://aka.ms/PSWindows

PS C:\Users\hp> python
Python 3.12.6 (tags/v3.12.6:a4a2d2b, Sep  6 2024, 20:11:23) [MSC v.1940 64 bit (AMD64)] on win32
Type "help", "copyright", "credits" or "license" for more information.
>>> cd $env:USERPROFILEmkdir quantum_projectcd quantum_project
  File "<stdin>", line 1
    cd $env:USERPROFILEmkdir quantum_projectcd quantum_project
       ^
SyntaxError: invalid syntax
>>> python -m venv venv.\venv\Scripts\activate
  File "<stdin>", line 1
    python -m venv venv.\venv\Scripts\activate
              ^^^^
SyntaxError: invalid syntax
>>> exit()
PS C:\Users\hp> python -m venv venv
>> .\venv\Scripts\activate
.\venv\Scripts\activate : File C:\Users\hp\venv\Scripts\Activate.ps1 cannot be loaded because running scripts is
disabled on this system. For more information, see about_Execution_Policies at
https:/go.microsoft.com/fwlink/?LinkID=135170.
At line:2 char:1
+ .\venv\Scripts\activate
+
    + CategoryInfo          : SecurityError: (:) [], PSSecurityException
    + FullyQualifiedErrorId : UnauthorizedAccess
PS C:\Users\hp> cd $env:USERPROFILE
>> mkdir quantum_project
>> cd quantum_project


    Directory: C:\Users\hp


Mode                 LastWriteTime         Length Name
----                 -------------         ------ ----
d-----        17-10-2025     22:46                quantum_project


PS C:\Users\hp\quantum_project> python -m venv venv
>> .\venv\Scripts\activate
.\venv\Scripts\activate : File C:\Users\hp\quantum_project\venv\Scripts\Activate.ps1 cannot be loaded because
running scripts is disabled on this system. For more information, see about_Execution_Policies at
https:/go.microsoft.com/fwlink/?LinkID=135170.
At line:2 char:1
+ .\venv\Scripts\activate
+
    + CategoryInfo          : SecurityError: (:) [], PSSecurityException
    + FullyQualifiedErrorId : UnauthorizedAccess
PS C:\Users\hp\quantum_project> (venv) PS C:\Users\hp\quantum_project>
At line:1 char:8
+ (venv) PS C:\Users\hp\quantum_project>
```

Step 5:



```
  Downloading typing_extensions-4.15.0-py3-none-any.whl.metadata (3.3 kB)
Downloading qiskit-2.2.1-cp39-abi3-win_amd64.whl (7.8 MB)
   ---------------------------------------- 7.8/7.8 MB 5.2 MB/s eta 0:00:00
Downloading numpy-2.3.4-cp312-cp312-win_amd64.whl (12.8 MB)
   ---------------------------------------- 12.8/12.8 MB 5.0 MB/s eta 0:00:00
Downloading scipy-1.16.2-cp312-cp312-win_amd64.whl (38.6 MB)
   ---------------------------------------- 38.6/38.6 MB 5.7 MB/s eta 0:00:00
Downloading dill-0.4.0-py3-none-any.whl (119 kB)
Downloading rustworkx-0.17.1-cp39-abi3-win_amd64.whl (2.1 MB)
   ---------------------------------------- 2.1/2.1 MB 4.6 MB/s eta 0:00:00
Downloading stevedore-5.5.0-py3-none-any.whl (49 kB)
Downloading typing_extensions-4.15.0-py3-none-any.whl (44 kB)
Installing collected packages: typing-extensions, stevedore, numpy, dill, scipy, rustworkx, qiskit
Successfully installed dill-0.4.0 numpy-2.3.4 qiskit-2.2.1 rustworkx-0.17.1 scipy-1.16.2 stevedore-5.5.0 typing-extensions-4.15.0

[notice] A new release of pip is available: 24.2 -> 25.2
[notice] To update, run: python.exe -m pip install --upgrade pip
(venv) PS C:\Users\hp\quantum_project> notepad bb84_qkd.py
(venv) PS C:\Users\hp\quantum_project> python bb84_qkd.py
Traceback (most recent call last):
  File "C:\Users\hp\quantum_project\bb84_qkd.py", line 47, in <module>
    from qiskit import QuantumCircuit, Aer, execute
ImportError: cannot import name 'Aer' from 'qiskit' (C:\Users\hp\quantum_project\venv\Lib\site-packages\qiskit\__init__.py)
(venv) PS C:\Users\hp\quantum_project> notepad bb84_qkd.py
(venv) PS C:\Users\hp\quantum_project> python bb84_qkd.py
Traceback (most recent call last):
  File "C:\Users\hp\quantum_project\bb84_qkd.py", line 47, in <module>
    from qiskit import QuantumCircuit, Aer, execute
ImportError: cannot import name 'Aer' from 'qiskit' (C:\Users\hp\quantum_project\venv\Lib\site-packages\qiskit\__init__.py)
(venv) PS C:\Users\hp\quantum_project> pip install qiskit-aer
Collecting qiskit-aer
  Downloading qiskit_aer-0.17.2-cp312-cp312-win_amd64.whl.metadata (8.5 kB)
Requirement already satisfied: qiskit>=1.1.0 in c:\users\hp\quantum_project\venv\lib\site-packages (from qiskit-aer) (2.2.1)
Requirement already satisfied: numpy>=1.16.3 in c:\users\hp\quantum_project\venv\lib\site-packages (from qiskit-aer) (2.3.4)
Requirement already satisfied: scipy>=1.0 in c:\users\hp\quantum_project\venv\lib\site-packages (from qiskit-aer) (1.16.2)
Collecting psutil>=5 (from qiskit-aer)
  Downloading psutil-7.1.0-cp37-abi3-win_amd64.whl.metadata (23 kB)
Collecting python-dateutil>=2.8.0 (from qiskit-aer)
  Using cached python_dateutil-2.9.0.post0-py2.py3-none-any.whl.metadata (8.4 kB)
Collecting six>=1.5 (from python-dateutil>=2.8.0->qiskit-aer)
  Downloading six-1.17.0-py2.py3-none-any.whl.metadata (1.7 kB)
Requirement already satisfied: rustworkx>=0.15.0 in c:\users\hp\quantum_project\venv\lib\site-packages (from qiskit>=1.1.0->qiskit-aer) (0.17.1)
Requirement already satisfied: dill>=0.3 in c:\users\hp\quantum_project\venv\lib\site-packages (from qiskit>=1.1.0->qiskit-aer) (0.4.0)
Requirement already satisfied: stevedore>=3.0.0 in c:\users\hp\quantum_project\venv\lib\site-packages (from qiskit>=1.1.0->qiskit-aer) (5.5.0)
Requirement already satisfied: typing-extensions in c:\users\hp\quantum_project\venv\lib\site-packages (from qiskit>=1.1.0->qiskit-aer) (4.15.0)
Downloading qiskit_aer-0.17.2-cp312-cp312-win_amd64.whl (9.6 MB)
   ---------------------------------------- 9.6/9.6 MB 5.1 MB/s eta 0:00:00
Downloading psutil-7.1.0-cp37-abi3-win_amd64.whl (247 kB)
Using cached python_dateutil-2.9.0.post0-py2.py3-none-any.whl (229 kB)
Downloading six-1.17.0-py2.py3-none-any.whl (11 kB)
Installing collected packages: six, psutil, python-dateutil, qiskit-aer
Successfully installed psutil-7.1.0 python-dateutil-2.9.0.post0 qiskit-aer-0.17.2 six-1.17.0

[notice] A new release of pip is available: 24.2 -> 25.2
[notice] To update, run: python.exe -m pip install --upgrade pip
```

Output



```
(venv) PS C:\Users\hp\quantum_project> python bb84_qkd.py
Traceback (most recent call last):
  File "C:\Users\hp\quantum_project\bb84_qkd.py", line 5, in <module>
    from qiskit import QuantumCircuit, execute
ImportError: cannot import name 'execute' from 'qiskit' (C:\Users\hp\quantum_project\venv\Lib\site-packages\qiskit\__init__.py)
(venv) PS C:\Users\hp\quantum_project> python bb84_qkd.py
  File "C:\Users\hp\quantum_project\bb84_qkd.py", line 6
    from qiskit.execute_function
                                ^

SyntaxError: invalid syntax
(venv) PS C:\Users\hp\quantum_project> python bb84_qkd.py
  File "C:\Users\hp\quantum_project\bb84_qkd.py", line 5
    from qiskit import
                      ^

SyntaxError: invalid syntax
(venv) PS C:\Users\hp\quantum_project> python bb84_qkd.py
  File "C:\Users\hp\quantum_project\bb84_qkd.py", line 5
    from qiskit import
                      ^

SyntaxError: invalid syntax
(venv) PS C:\Users\hp\quantum_project> python bb84_qkd.py
  File "C:\Users\hp\quantum_project\bb84_qkd.py", line 5
    from qiskit import
                      ^

SyntaxError: invalid syntax
(venv) PS C:\Users\hp\quantum_project> python bb84_qkd.py
Traceback (most recent call last):
  File "C:\Users\hp\quantum_project\bb84_qkd.py", line 5, in <module>
    from qiskit import QuantumCircuit, execute
ImportError: cannot import name 'execute' from 'qiskit' (C:\Users\hp\quantum_project\venv\Lib\site-packages\qiskit\__init__.py)
(venv) PS C:\Users\hp\quantum_project> python bb84_qkd.py
Alice's bits:    [1, 0, 0, 0, 1, 1, 1, 1, 0, 1, 0, 1, 0, 1, 1, 0, 0, 0, 0, 1]
Alice's bases:   [1, 0, 1, 0, 1, 1, 0, 0, 0, 1, 1, 1, 1, 1, 0, 0, 1, 0, 0, 1]
Bob's bases:     [1, 0, 0, 1, 1, 0, 0, 1, 1, 1, 0, 1, 1, 1, 1, 1, 0, 1, 1, 0]
Alice's key (sifted): [1, 0, 1, 1, 1, 1, 0, 1]
Bob's key (sifted): [1, 0, 1, 1, 1, 1, 0, 1]
Error rate: 0.00%
Secure quantum key established!
(venv) PS C:\Users\hp\quantum_project> python bb84_qkd.py
Alice's bits:    [0, 0, 1, 1, 1, 0, 0, 0, 1, 0, 1, 0, 0, 1, 1, 1, 0, 1, 1, 1]
Alice's bases:   [1, 1, 1, 0, 0, 0, 0, 1, 1, 0, 0, 1, 1, 1, 1, 0, 1, 1, 1, 1]
Eve's bases:     [0, 1, 0, 1, 1, 1, 0, 0, 0, 0, 0, 1, 1, 0, 0, 1, 1, 1, 1, 1]
Bob's bases:     [1, 1, 1, 0, 0, 1, 0, 1, 1, 1, 0, 1, 0, 1, 1, 1, 1, 1, 0, 1]
Alice's key (sifted): [0, 0, 1, 1, 1, 0, 0, 1, 1, 0, 1, 1, 0, 1, 1]
Bob's key (sifted): [0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 1, 1]
Error rate: 40.00%
▼  Possible eavesdropper detected (Eve may be listening!)
(venv) PS C:\Users\hp\quantum_project> _
```

Windows PowerShell
Get the latest features and security improvements with the newest feature update.
Search
ENG IN
00:05
18-10-2025