Quantum-based QR Code Generator

Project By: Raghav Agarwal

Abstract

- This project demonstrates a quantum-inspired approach to generating QR codes.
- By encoding classical input messages into binary, applying quantum operations to produce a secret code via the Bernstein–Vazirani algorithm.
- Rendering the result as a QR code image, we explore the intersection of quantum computation techniques with practical encoding schemes.

Introduction

- QR codes are widely used for encoding information in a
  format.
- This project leverages quantum circuit principles (Hadamard transforms and the Bernstein–Vazirani algorithm) to generate a binary code that serves as the payload for a QR code.
- The workflow consists of taking a user input string, converting it to binary, applying quantum operations, measuring the result, and then generating the QR code.

Algorithm: Bernstein–Vazirani

The Bernstein–Vazirani (BV) algorithm is designed to identify an unknown bit-string s with a single oracle query. In this context:

- Initialize an n-bit input register and one ancilla qubit.
- Apply Hadamard gates to all qubits to create a superposition.
- Use an oracle that flips the phase of the ancilla conditioned on the
  register and s.
- Apply another round of Hadamard gates to the input register.
- Measure the input register: the result is exactly the hidden string s.
  Here, s corresponds to the secret code extracted from the user's input bits.

Methodology

1. Input Encoding: The userinputs amessage (e.g., "AB"), which is converted to a 16-bit binary string (e.g., 0100000101000010).
2. Quantum Circuit Preparation: A quantum circuit with n qubits (one per bit) plus one ancilla qubit is initialized. Hadamard gates are applied to all qubits, followed by X gates on the ancilla.
3. Bernstein–Vazirani Oracle and Measurement: The BV oracle encodes the input bits into phase shifts on the ancilla qubit. After a second layer of Hadamard gates, measuring the input register reveals the hidden bit-string s in one shot. Here, the secret string is the complementary bit-string of the encoded binary string.
4. QR Code Generation: The resulting secret code is embedded into a QR code using a classical library.

Sample Input and Output

- User Input:

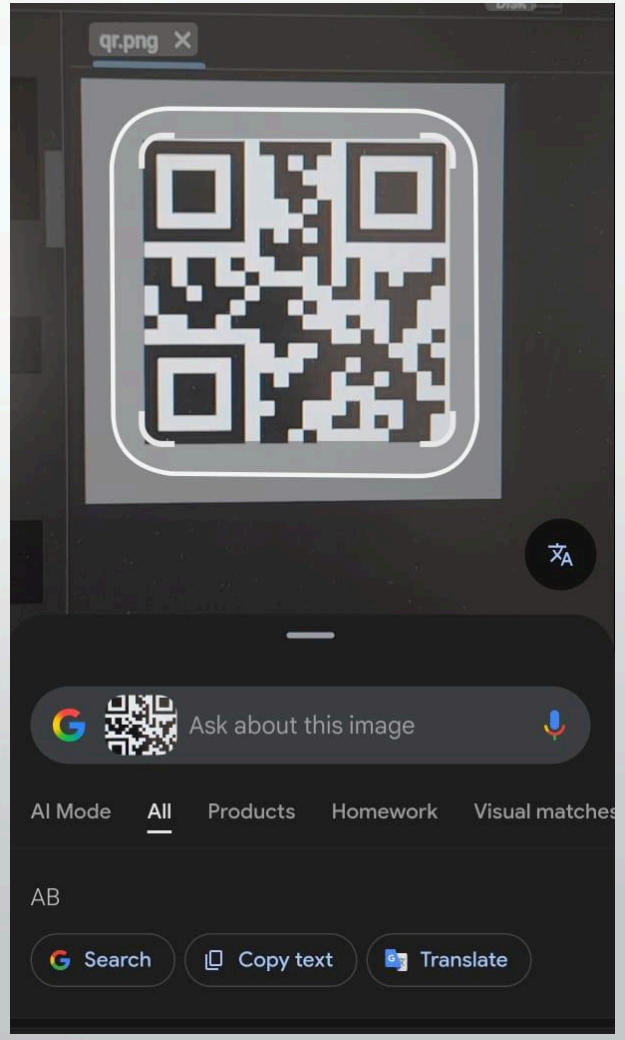
```
Enter the message to encode: AB
```

- Generated Secret Code and Measurement:

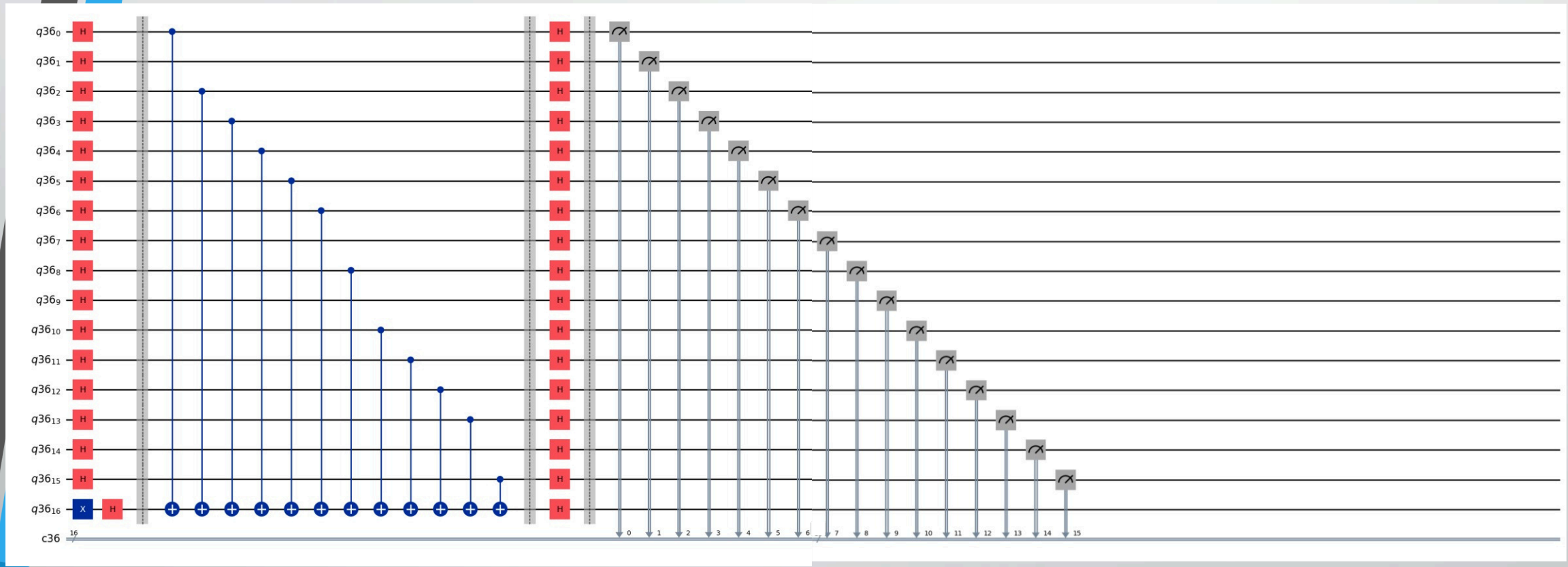
```
Secret code:   0100000101000010
Measurement:   1011111010111101
```

- QR Code Image:

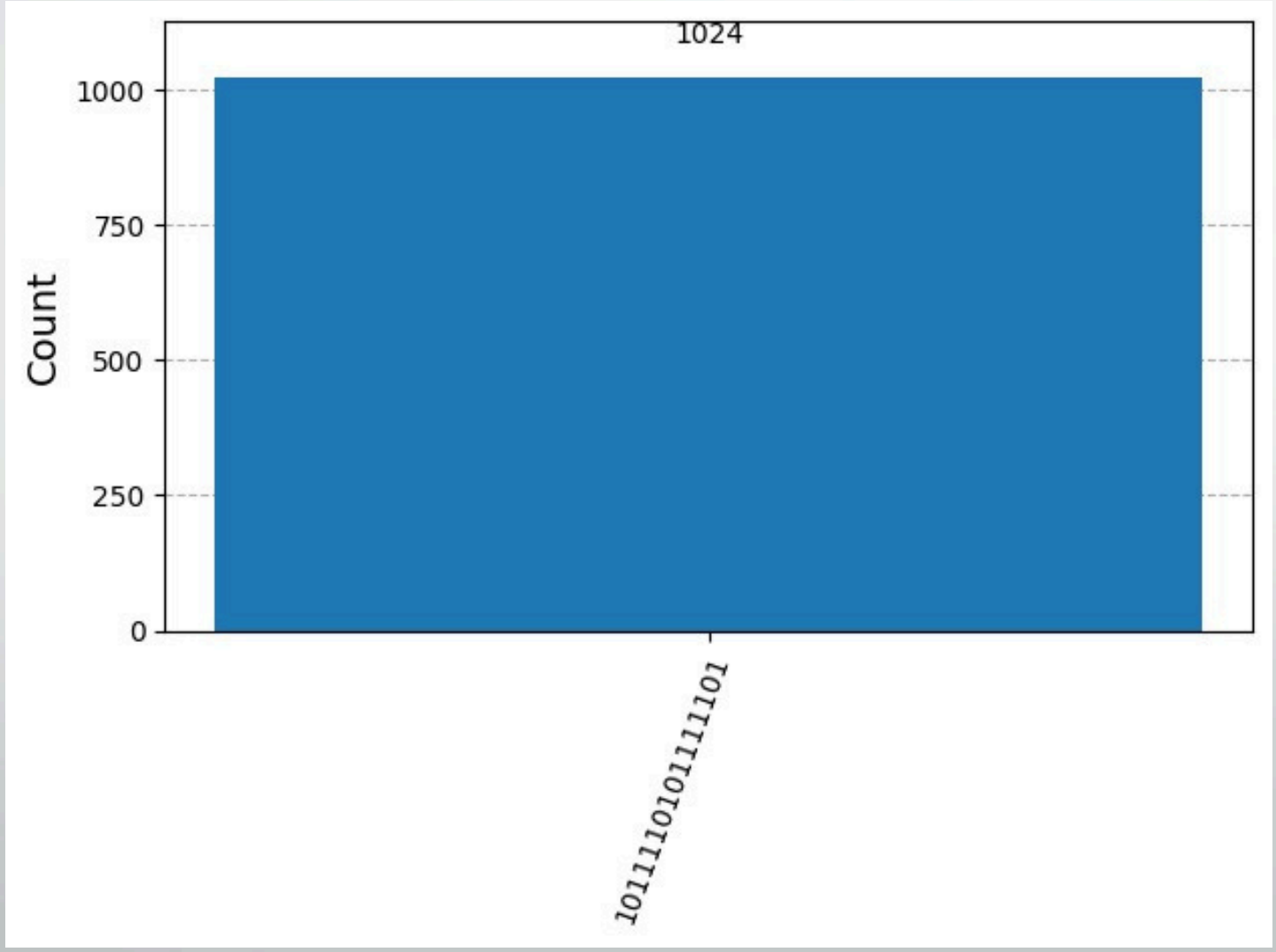
- QR Code Scan Result:



Quantum Circuit Diagram

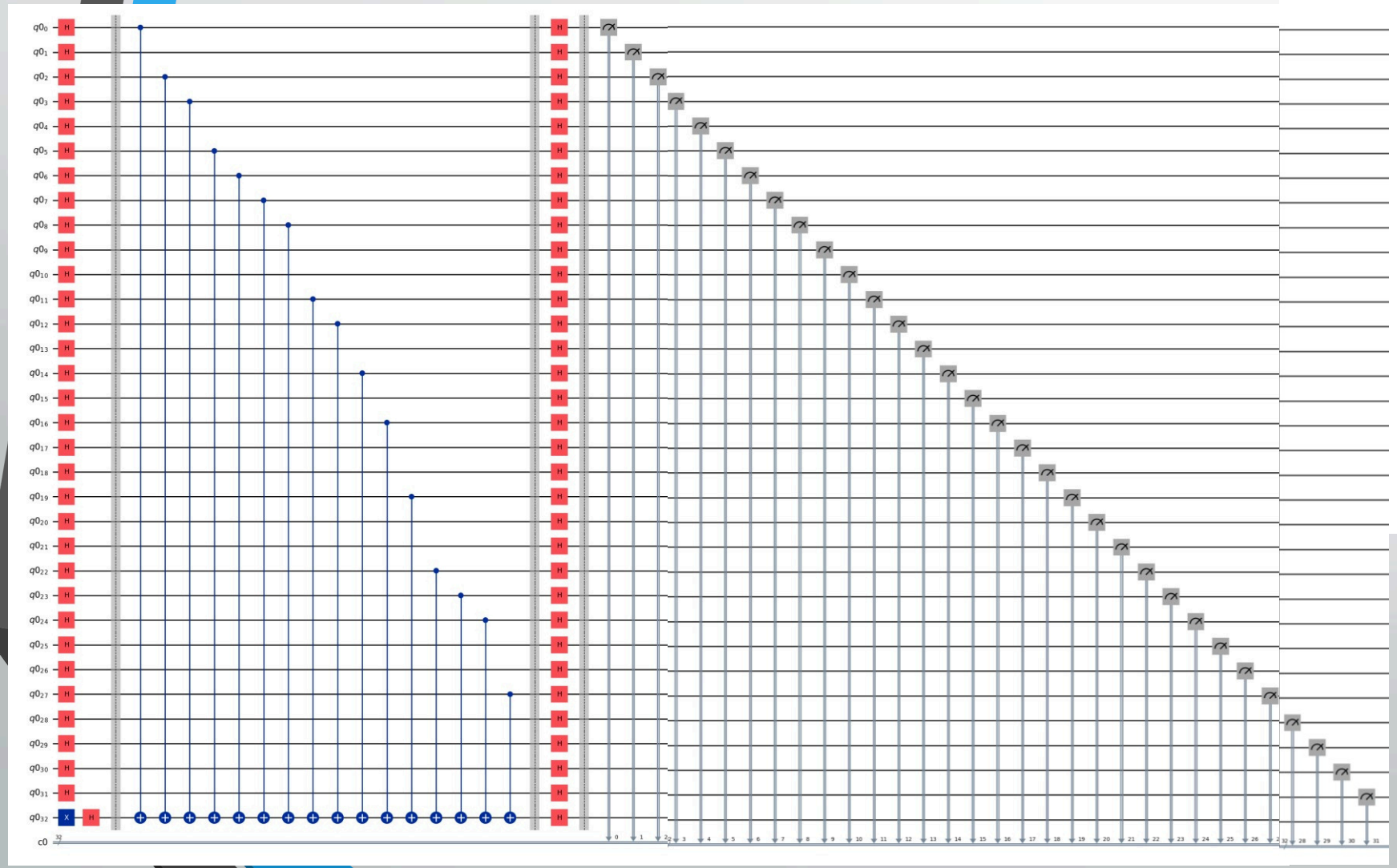


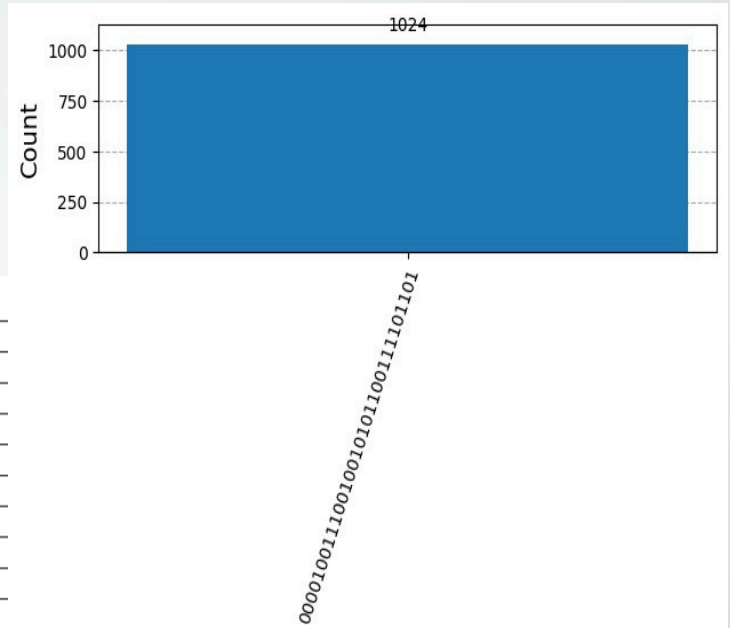
Histogram

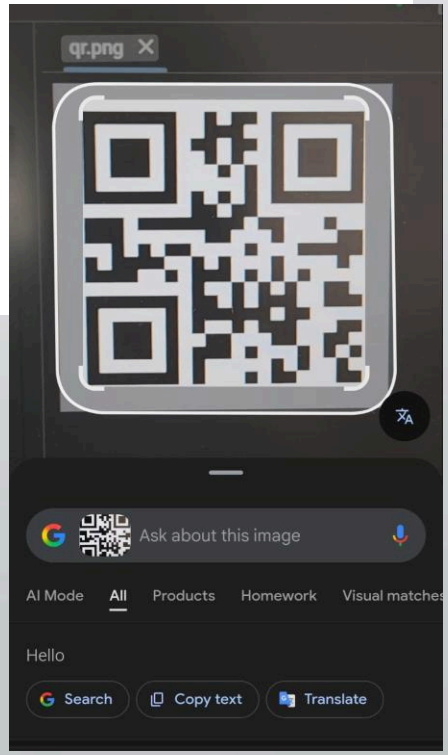


More sample inputs

```
Enter the message to encode: Hello
Secret code:  01001000011001010110110001101111
Measurement:  10110111100110101001001110010000
```



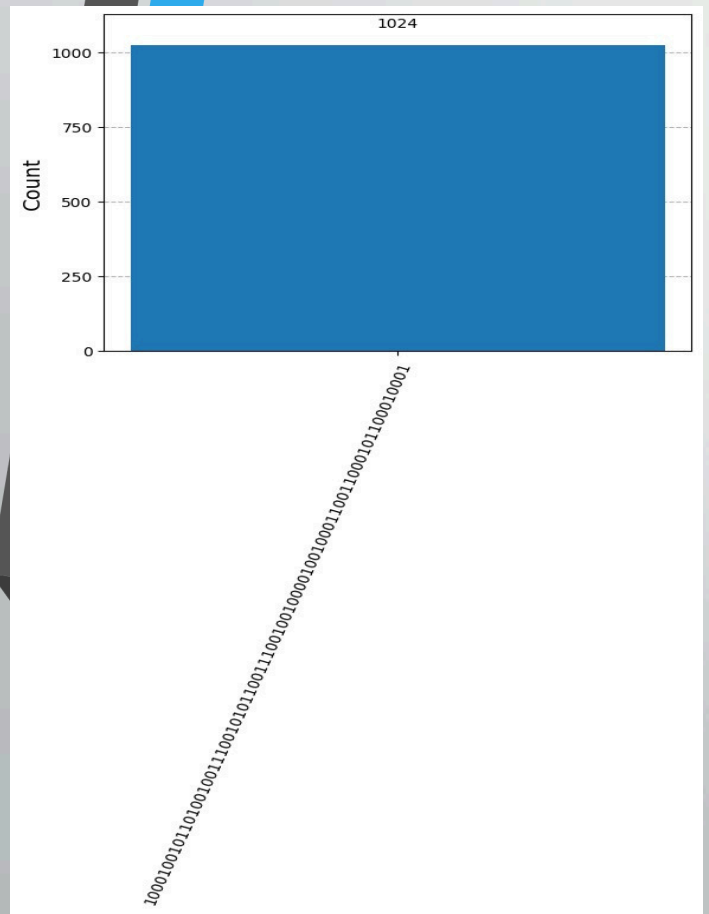


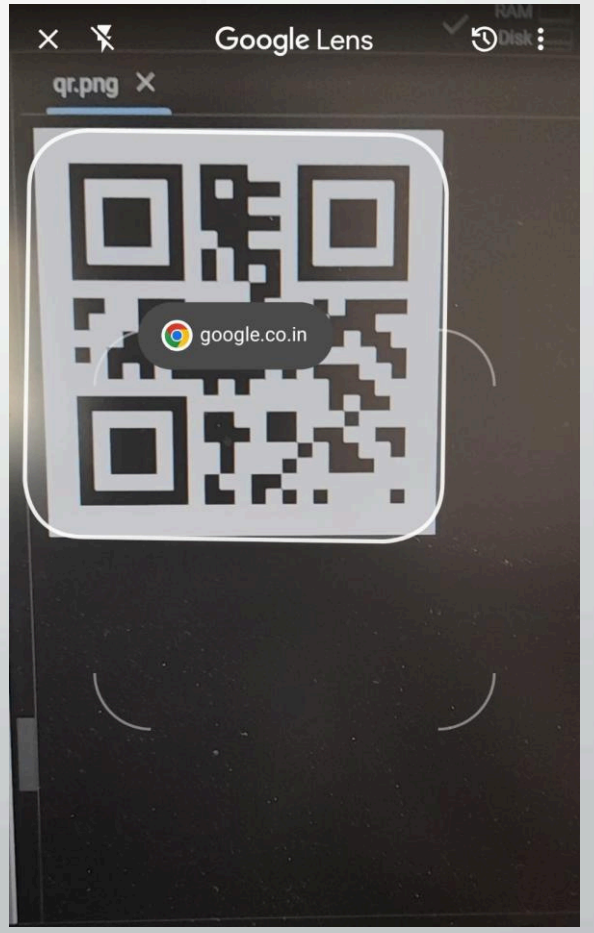


More sample inputs

```
Enter the message to encode: www.google.co.in
```

```
Secret code:  01110111001011100110011101101111011011000110010101100011011010010110111 0
Measurement:  10001000110100011001100010010000100100111001101010011100100101101001000 1
```





Conclusion

- This project illustrates howtheBernstein–Vazirani algorithm can be used to generate unique binarycodesfor QRcodepayloadswitha singlequantum-inspired oracle query.
- The integration of BV algorithm techniques with traditional QR code generation opens new avenues for exploring secure and novel encoding methods.
- Link to the Project Source Code: Project Source Code

Thank You