Architecture and working of quantum computing

Sejal wande

Guided by prof. S. V. Raut

Department of Computer Science and Engineering

Dr. Rajendra gode institute of technology,Amravati,Maharashtra,India

wandepralhad@gmail.com

Abstract

Quantum computing is a new and powerful type of computing that works using the laws of quantum physics.
Instead of bits (0 and 1), it uses qubits, which can be both 0 and 1 at the same time.
This paper explains how a quantum computer is built (its architecture) and how it works.
It also explains basic ideas like superposition, entanglement, and quantum gates which make quantum computers much faster than normal computers.

Keywords: *Quantum computing, Qubits, Quantum gates, Architecture, Superposition, Entanglement.*

1. Introduction

A normal computer uses bits that can have only two values — 0 or 1.
A quantum computer uses qubits, which can be 0, 1, or both at the same time.
This property helps the computer to do many calculations together, making it much faster for some problems.

Quantum computing is based on the laws of physics that control very small particles like electrons and photons.
This new technology can help in solving big problems that take normal computers a very long time.

2. Architecture of Quantum Computing

The architecture means the structure or parts of a quantum computer.
It mainly has the following parts:

(a) Quantum Processor (QPU)

It is the main part of the quantum computer, just like the CPU in normal computers.
It has qubits that perform the actual computation.

(b) Quantum Registers

They are small memory units that store qubits while calculations are being done.

(c) Quantum Gates and Circuits

Quantum gates control and change the qubit states.
They are connected in a circuit form to perform tasks or algorithms.

(d) Classical Control System

Quantum computers also need normal (classical) computers to control, send signals, and measure results.

3. Working of Quantum Computing

Quantum computers work on three main principles:

1. Superposition:
A qubit can be both 0 and 1 at the same time.
This allows the computer to do many calculations together.

2. Entanglement:
When two qubits are connected (entangled), changing one qubit affects the other.
This helps in faster communication and processing.

3. Quantum Interference:
Quantum interference helps in getting the correct answer by cancelling out wrong results.

Steps in working:

1. Qubits are prepared.

2. Quantum gates are applied.

3. Algorithm runs using these gates.

4. Result is measured and converted into normal data.

4. Quantum Gates and Circuits

Quantum gates work like logic gates in normal computers.
They perform operations on qubits.

Some common quantum gates are:

Hadamard (H): Creates superposition.

Pauli-X (NOT): Flips the state from 0 to 1 or 1 to 0.

CNOT (Controlled-NOT): Works on two qubits and changes one based on the other.

These gates are connected together to form quantum circuits that run the algorithms.

5. Challenges in Quantum Computing

Quantum computers are still in the research stage and face many problems:

Decoherence: Qubits lose information very fast.

Error correction: It is difficult to correct mistakes in quantum data.

Hardware issues: Quantum computers need very cold temperatures to work properly.

Scalability: It is hard to increase the number of stable qubits.

6. Future Scope

Quantum computing will bring big changes in many fields like data security, artificial intelligence, and medicine. In the future, it can help scientists solve problems faster and improve technology in every area.

7. Conclusion

Quantum computing is a new way of doing calculations using the principles of quantum physics.
Its architecture uses qubits and quantum gates to perform fast and powerful computations.
Though there are still challenges, it has great potential for the future of technology.

8. References

1. IBM Quantum Research, Introduction to Quantum Architecture, 2024.

2. Google Quantum AI Team, Quantum Processor Design Report, 2025.

3. Nielsen & Chuang, Quantum Computation and Quantum Information, Cambridge University Press, 2025 Edition.

4. NIST, Quantum Information Science Progress Report, 2025.

5. Arute, F. et al., Nature Journal – Quantum Processor Study, 2024