JLUG Tech Cohort 2025

Electronics and Quantum Technology

11th October 2025

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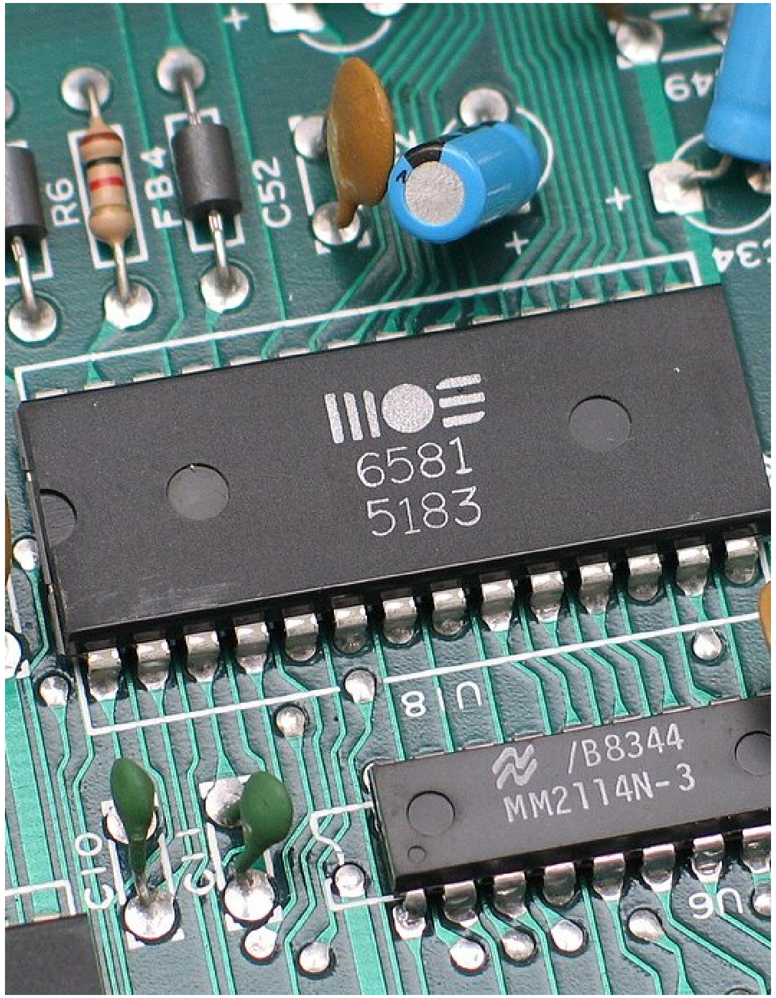
What is Electronics?

Electronics is the branch of science and engineering that controls the flow of electrons through components like resistors, capacitors, and transistors to perform useful operations — such as processing data, sensing the environment, and communicating information.

Examples: Mobile phones and computers, TVs and music system, Medical devices, Cars, satellites, and robots.

In short, “Electronics makes electricity *think*.”



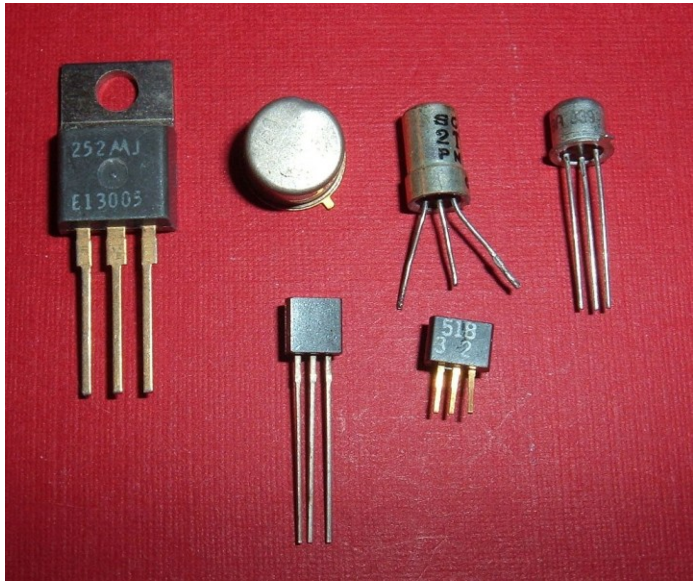
Transistors: The Heart of Electronics

A transistor is a tiny **semiconductor device** that can **amplify** or **switch** electronic signals.
It's made mainly from materials like **silicon** and works by controlling the movement of electrons.

- Acts as an electronic switch or amplifier
- Used in logic gates, microprocessors, and memory chips
- Foundation of all modern electronics

Fun fact: The smallest transistors today are just a few *nanometers* wide — millions could fit on the tip of a pencil!

World's first transistor (1947)



Modern Transistors

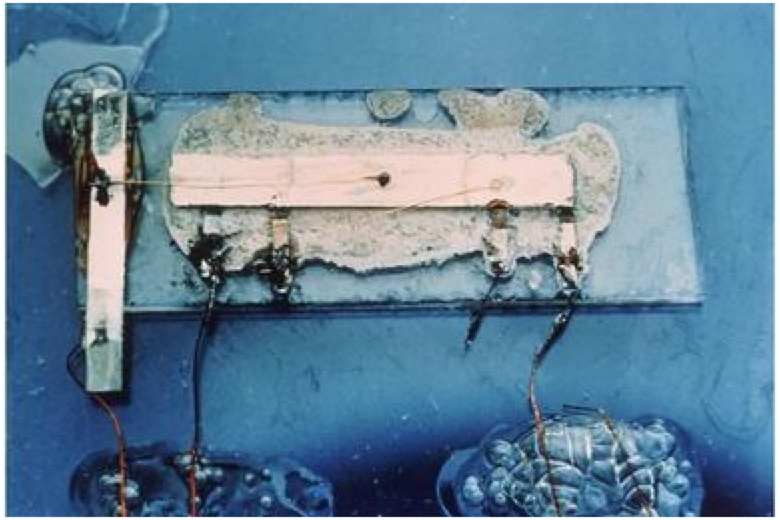
Integrated Circuits — Miniaturizing the World

An **Integrated Circuit** is a small chip that contains **many interconnected electronic components** — transistors, resistors, capacitors — all built on a single piece of silicon.

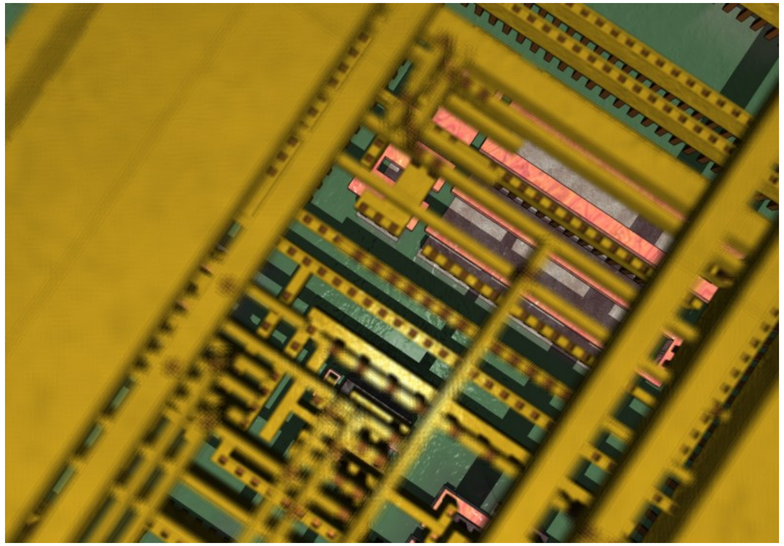
Why it matters:

- **Miniaturization:** Thousands → billions of transistors on one chip.
- **Speed:** Signals travel tiny distances — faster operations.
- **Reliability:** Fewer soldered joints, less failure.
- **Cost-efficiency:** Mass production reduces cost dramatically.

Fun fact: The chips in today's smartphones contain **over 15 billion transistors** — all inside something smaller than your fingernail!



World's first IC (1958)



Internal View of an IC

The CPU — Brain of the Computer

The **Central Processing Unit** is the part of a computer that **executes instructions** — performing calculations, logic operations, and data movement.

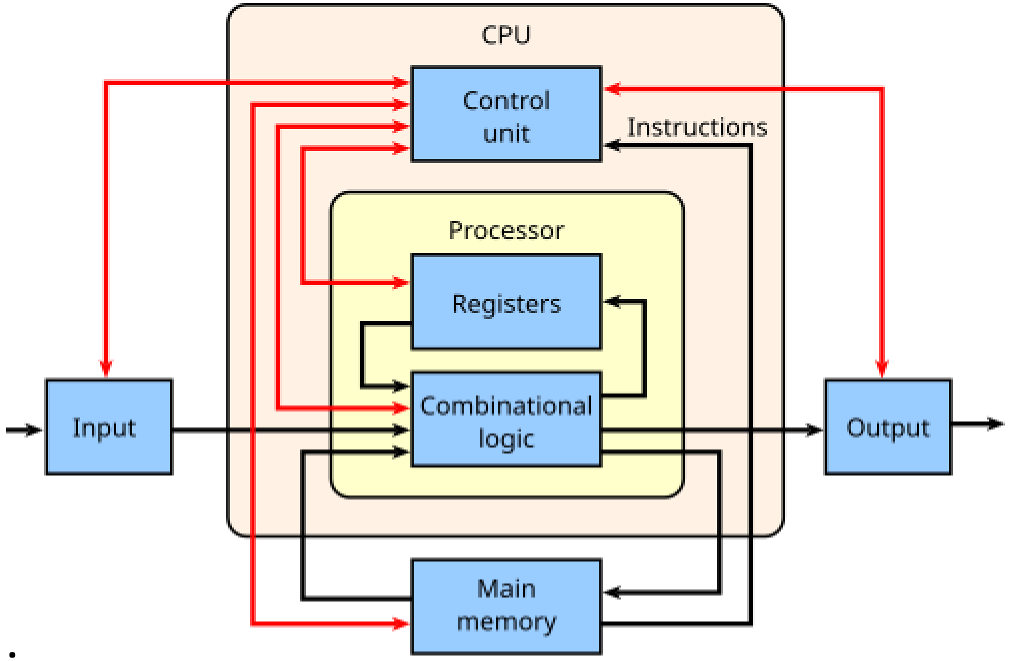
How it works:

- **Fetch:** Gets an instruction from memory.
- **Decode:** Understands what needs to be done.
- **Execute:** Performs the action (like adding two numbers).

Why it matters:

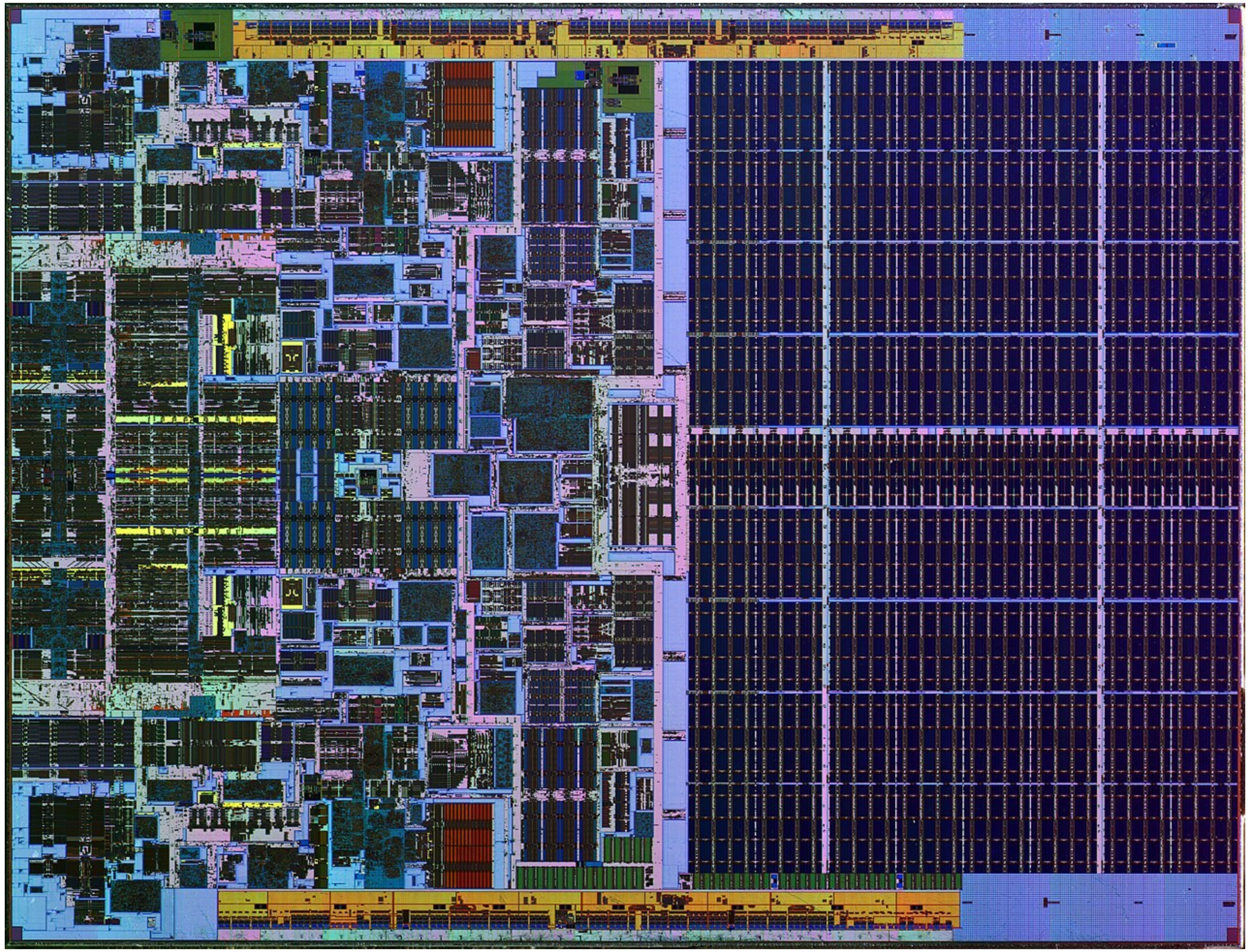
- The CPU controls almost everything a computer does.
- Billions of transistors inside allow fast and parallel processing.

Fun fact: Modern CPUs can perform **billions of operations per second**, all through tiny switches flipping on and off!



CPU Block Diagram

A high-end CPU manufactured by Intel



Internal (IC) view of Intel’s Xeon processor

The GPU — The Parallel Thinker

A **Graphics Processing Unit** is a chip designed to **handle thousands of tasks at the same time**.

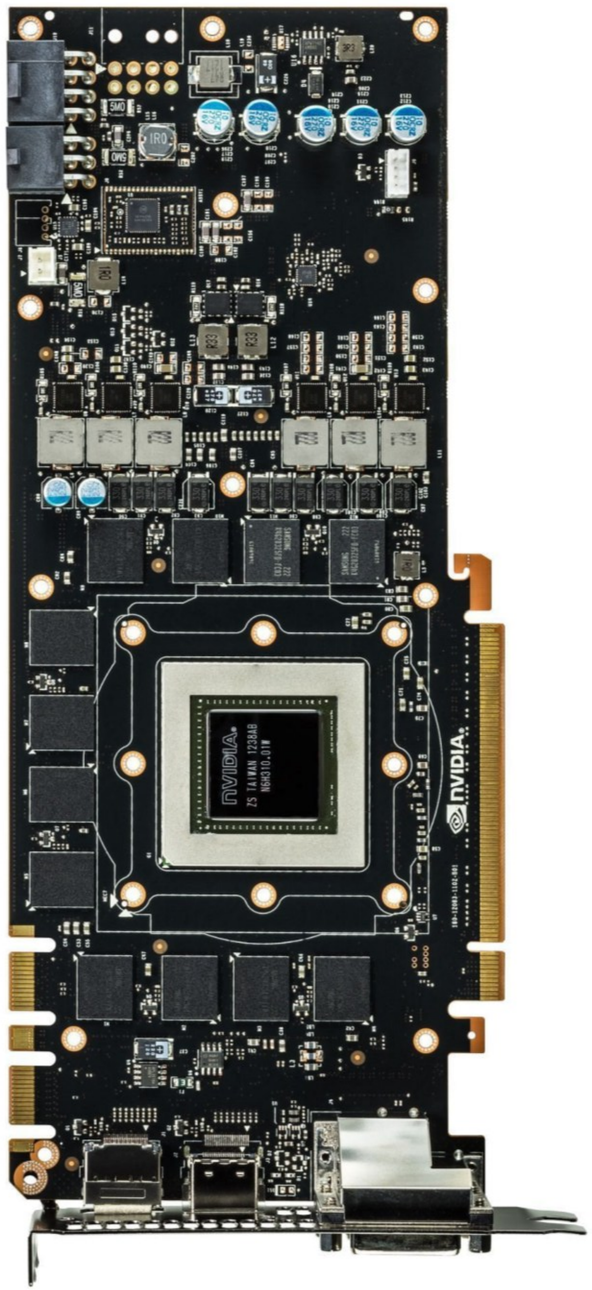
Why it matters:

- Renders graphics smoothly for games and videos.
- Accelerates AI, machine learning, and scientific computations.
- Works alongside the CPU to make computers faster and more capable.

Analogy:

CPU = a single chef following instructions carefully.
GPU = a kitchen full of chefs cooking many dishes at once.

Modern GPUs contain **thousands of small cores** — compared to a CPU’s handful — enabling massive parallelism.



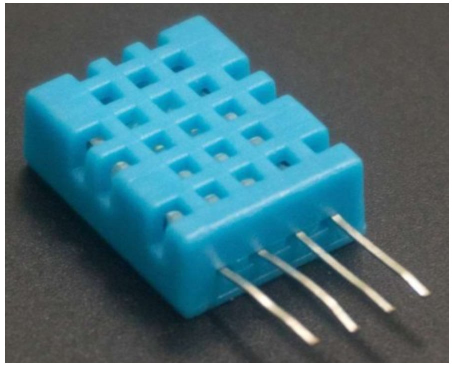
Internal view of an Nvidia GPU

Sensors — The Senses of Machines

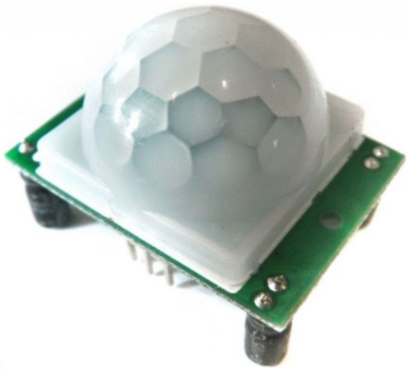
A **sensor** is a device that detects physical quantities and converts them into electrical signals that machines can process.

Sensor Type	Example	What it detects
Temperature	DHT11	Heat/Cold
Motion	PIR	Movement
Distance	Ultrasonic	Proximity
Light	LDR	Brightness

Without sensors, your phone wouldn't know when to adjust brightness, and smart devices wouldn't know when you're nearby!

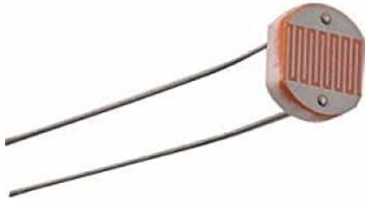


DHT11 Sensor



PIR Sensor

Ultrasonic Sensor



LDR Sensor

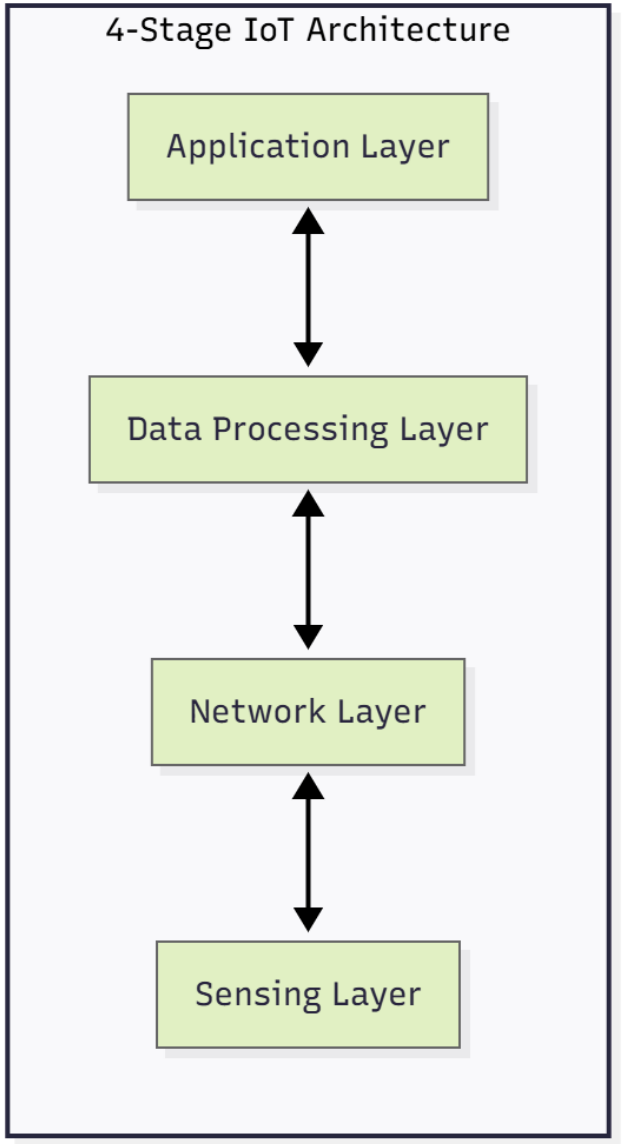
Internet of Things (IoT) — Connecting the World

The **Internet of Things (IoT)** is a system of **smart devices connected via the internet** that can monitor, collect, and exchange data to perform intelligent actions.

Examples of IoT in Everyday Life:

- **Smart Home:** Automatic lights, thermostats, security cameras
- **Wearables:** Smart watches, fitness trackers
- **Industry:** Sensors in factories for predictive maintenance

By 2030, there will be **over 25 billion connected IoT devices** globally!



All of this builds the world we know today —
now, let’s see what lies beyond it.

There’s Plenty of Room at the Bottom

“Nature isn’t classical, dammit, and if you want to make a simulation of nature, you’d better make it quantum mechanical.”

~ Richard Feynman

(Won the Nobel Prize in Physics (1965) for his contributions to the field of quantum mechanics)

Classical vs Quantum: A Speed Comparison

Task	Classical Computer	Quantum Computer
Factoring large numbers	Thousands of years	Seconds / Minutes
Searching unsorted database	Millions of steps	Square root of classical steps
Simulating molecules	Extremely slow	Efficient / Fast
Optimization problems	Very long	Exponentially fast

Quantum computers can **solve certain problems in seconds** that would take classical supercomputers **millions of years**.

The famous Chandelier View of a Quantum Computer’s dilution refrigerator

Latest Breakthroughs in Quantum Computing

1. Majorana Qubits (Microsoft)

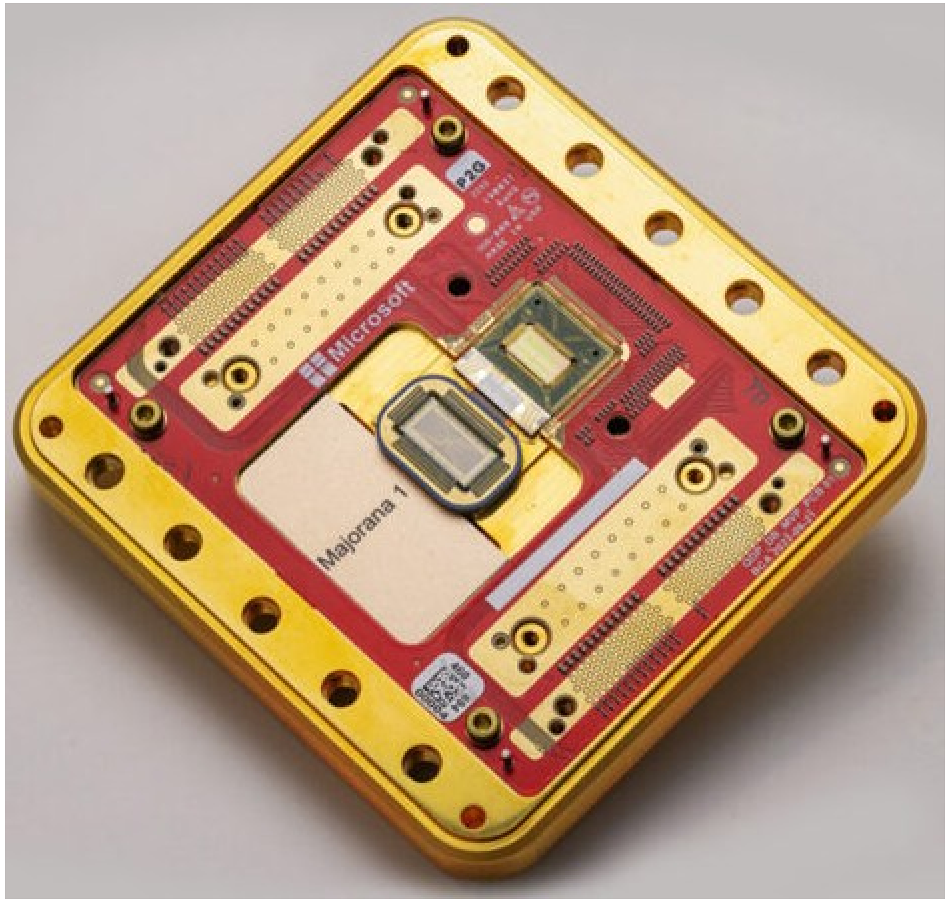
- A **new state of matter** discovered recently.
- Promises **more stable qubits** with longer coherence times.
- Could make quantum computers **less error-prone**.

2. Google's Error Correction Breakthrough

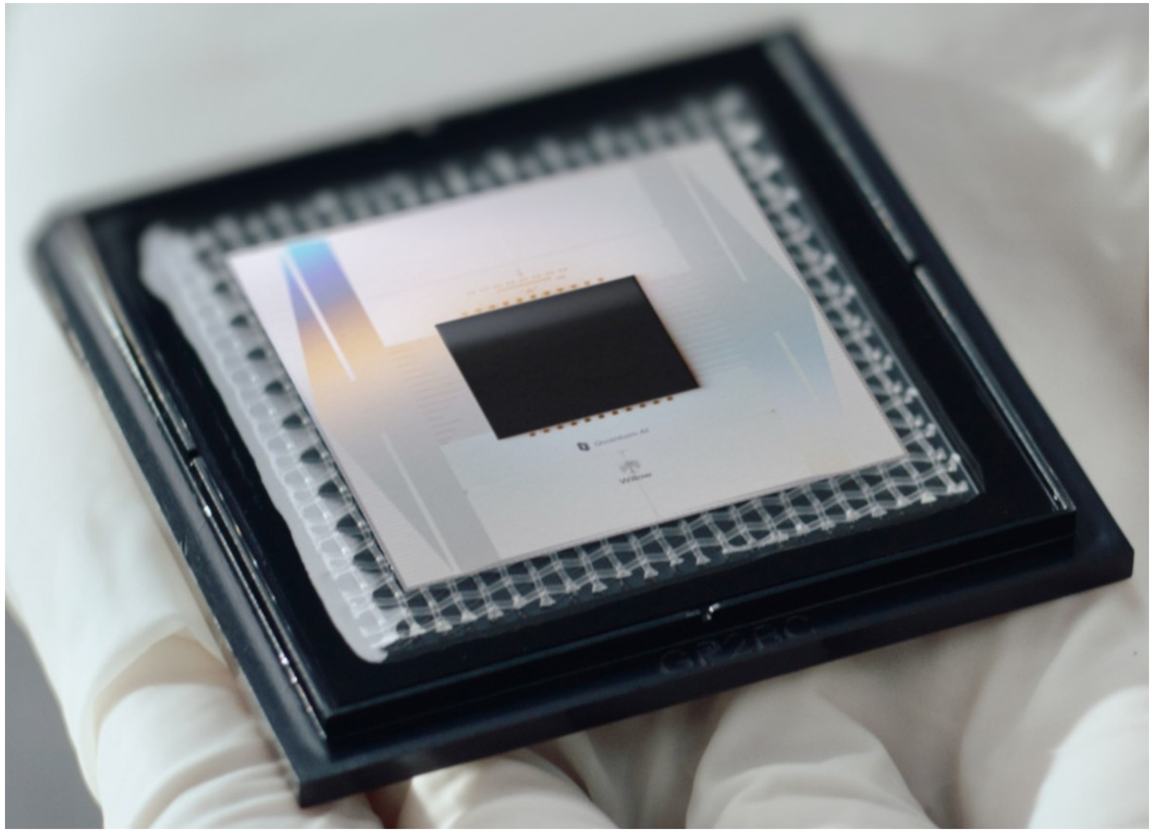
- Achieved **high-fidelity error correction**.
- Their new chip demonstrates **exponential speedup** for certain tasks.
- Raises fascinating hypotheses about **parallel computations across multiple universes**.

3. Other Key Notes

- Quantum computing research is **accelerating rapidly** worldwide.
- Tech giants and universities are racing to **build scalable, reliable quantum machines.**



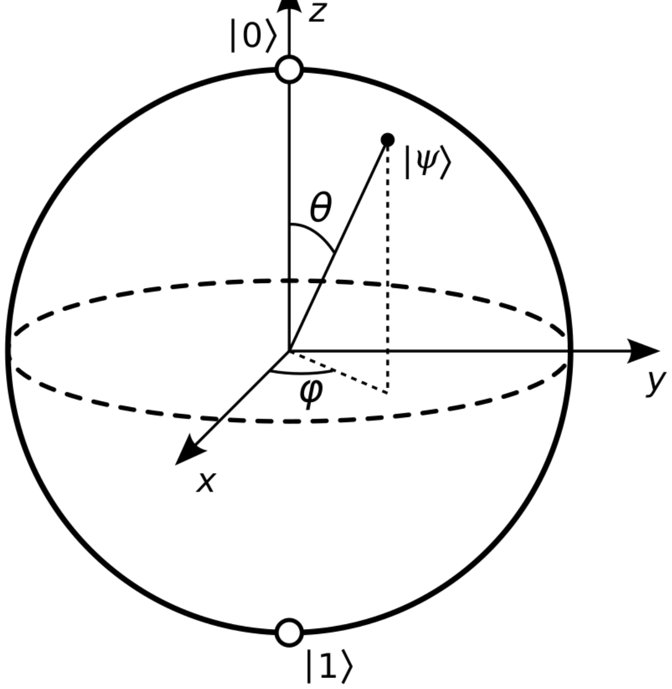
Microsoft's Majorana 1, consisting of topological qubits, a whole new state of matter



Google's Willow chip, which took quantum error correction to extreme levels

Quantum Properties Behind a Qubit

A **qubit** (short for *quantum bit*) is the fundamental unit of information in quantum computing—like a classical bit, but with a twist from quantum physics. The properties of a qubit are



Bloch sphere representation of a single qubit

1. Superposition

- A qubit can be **0, 1, or both at the same time**.
- This allows quantum computers to **explore many possibilities simultaneously**.

2. Entanglement

- Qubits can become **linked**, so the state of one instantly affects the other, no matter the distance.
- This enables **powerful coordination and computation**.

3. Measurement

- Observing a qubit **forces it into a definite state** (0 or 1).
- Measurement collapses the superposition, giving us the **result of a computation**.

Quantum Computing Algorithms

Shor's Algorithm

- Solves **factoring large numbers** exponentially faster than classical computers.
- Important for **cryptography** (breaking certain encryption methods).

Grover's Algorithm

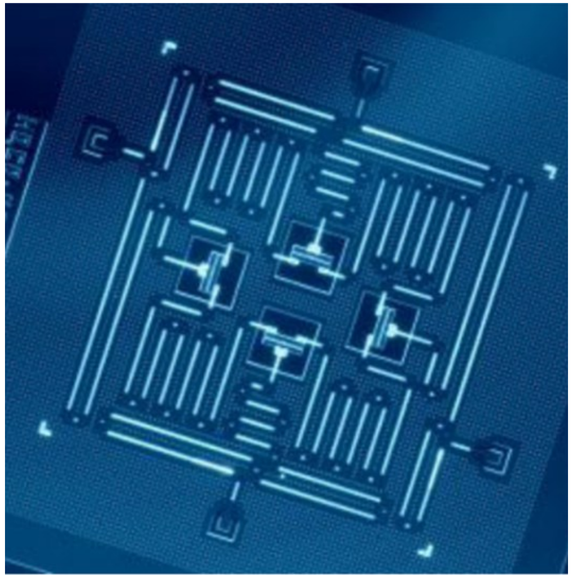
- Speeds up **searching unsorted databases**.
- Reduces search time from **N steps** to $\sqrt{N}$ **steps**.

Quantum Phase Estimation

- Used as a **building block for complex quantum algorithms**, like factoring, chemistry simulations, and solving linear equations.
- Crucial for **simulating quantum systems** efficiently.

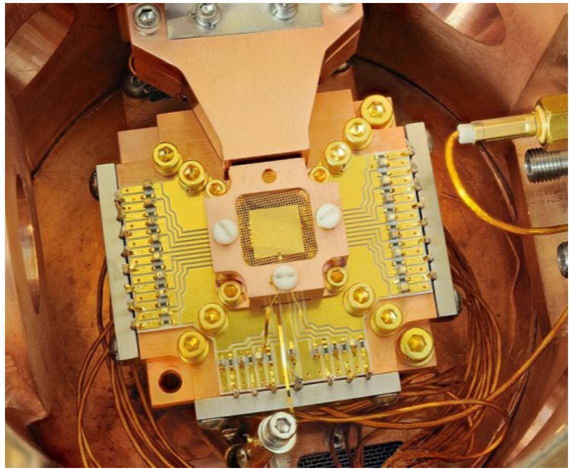
Some algorithms can give **exponential speedups**, solving problems in seconds that classical computers might take millions of years to finish.

Different Types of Qubits



Superconducting Qubits

- Made using **superconducting circuits** cooled to near absolute zero.
- Fast operations, widely used by Google, IBM, and Rigetti.

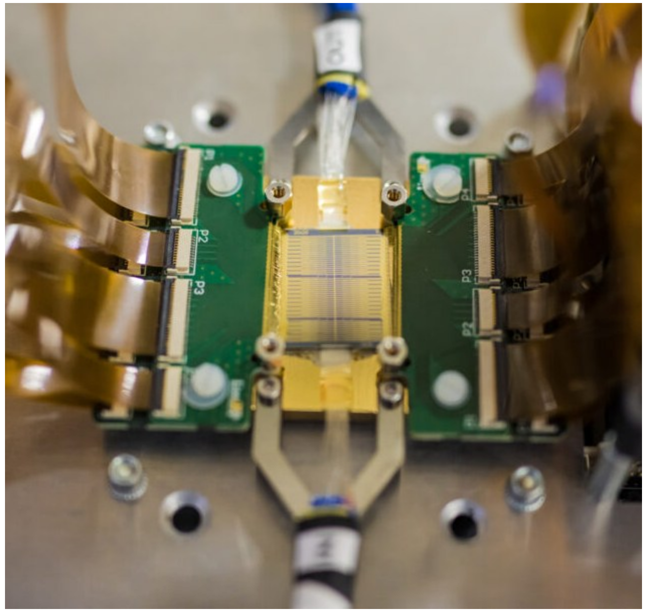


Ion-Trap Qubits

- Individual **ions trapped** with electrical/magnetic fields.
- Very stable and long coherence times, used by IonQ, Honeywell.

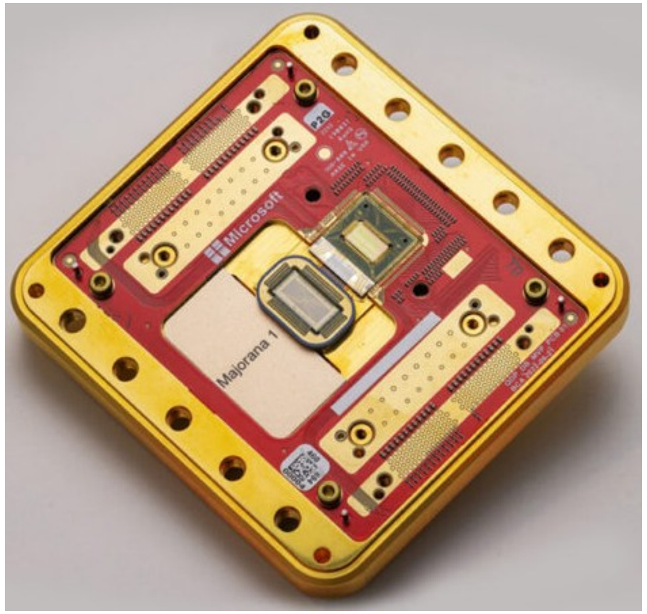
Photonic Qubits

- Use **particles of light** (photons) to encode quantum information.
- Useful for **communication and networking**.



Majorana Qubits

- Use **exotic particles** called Majorana fermions.
- Very stable, potentially **error-resistant**, by Microsoft.



The Road Ahead in Quantum Computing

1. Hybrid Quantum-Classical Systems
   - Combining classical computers with quantum processors to tackle complex problems efficiently.
2. Quantum Internet
   - Network of entangled qubits across distances for ultra-secure communication and distributed quantum computing.
3. Quantum Sensors & Secure Communication
   - Extremely sensitive sensors for medicine, geology, navigation.
   - Quantum encryption promises **unhackable communication**.

“The Future Belongs to the Curious.”

Thank You

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