Computer Organization & Architecture

Cybersecurity Department

Course Code: ***CBS219***

Lecture 2: Computer Evolution & Generations

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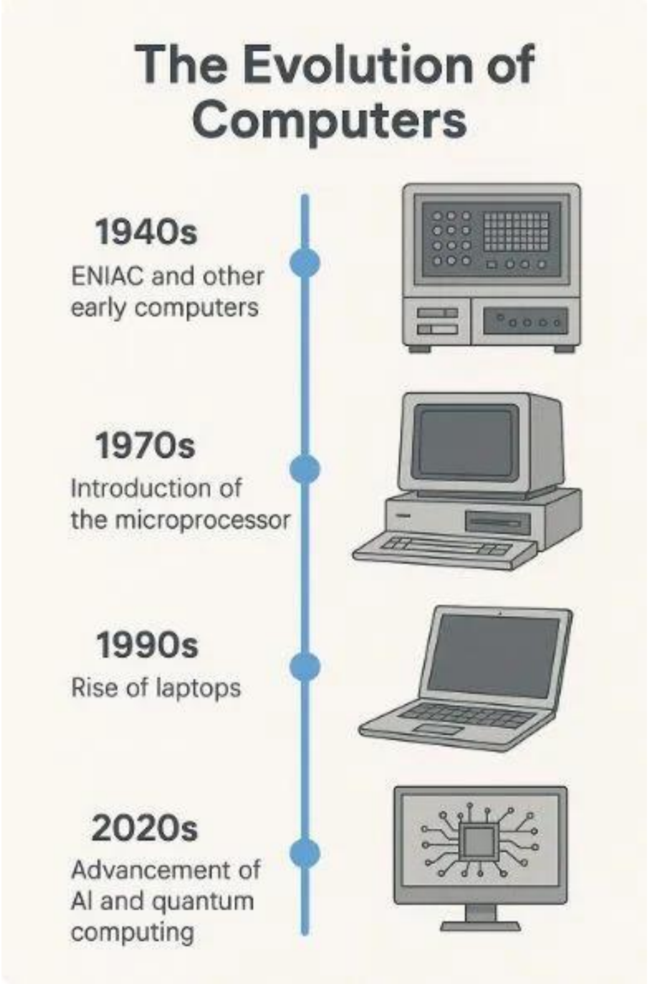
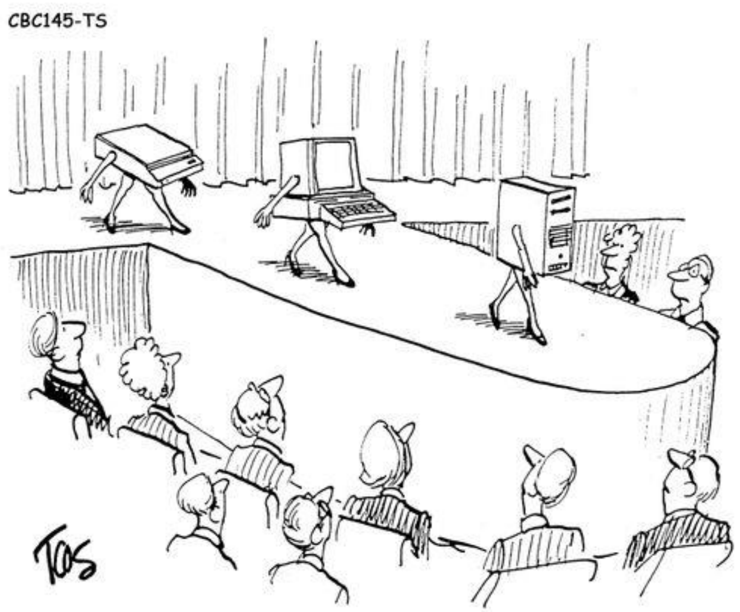
Outlines

- Introduction to Computer Evolution
- Five Generations of Computers
- Von Neumann Architecture
- Modern Computer Characteristics



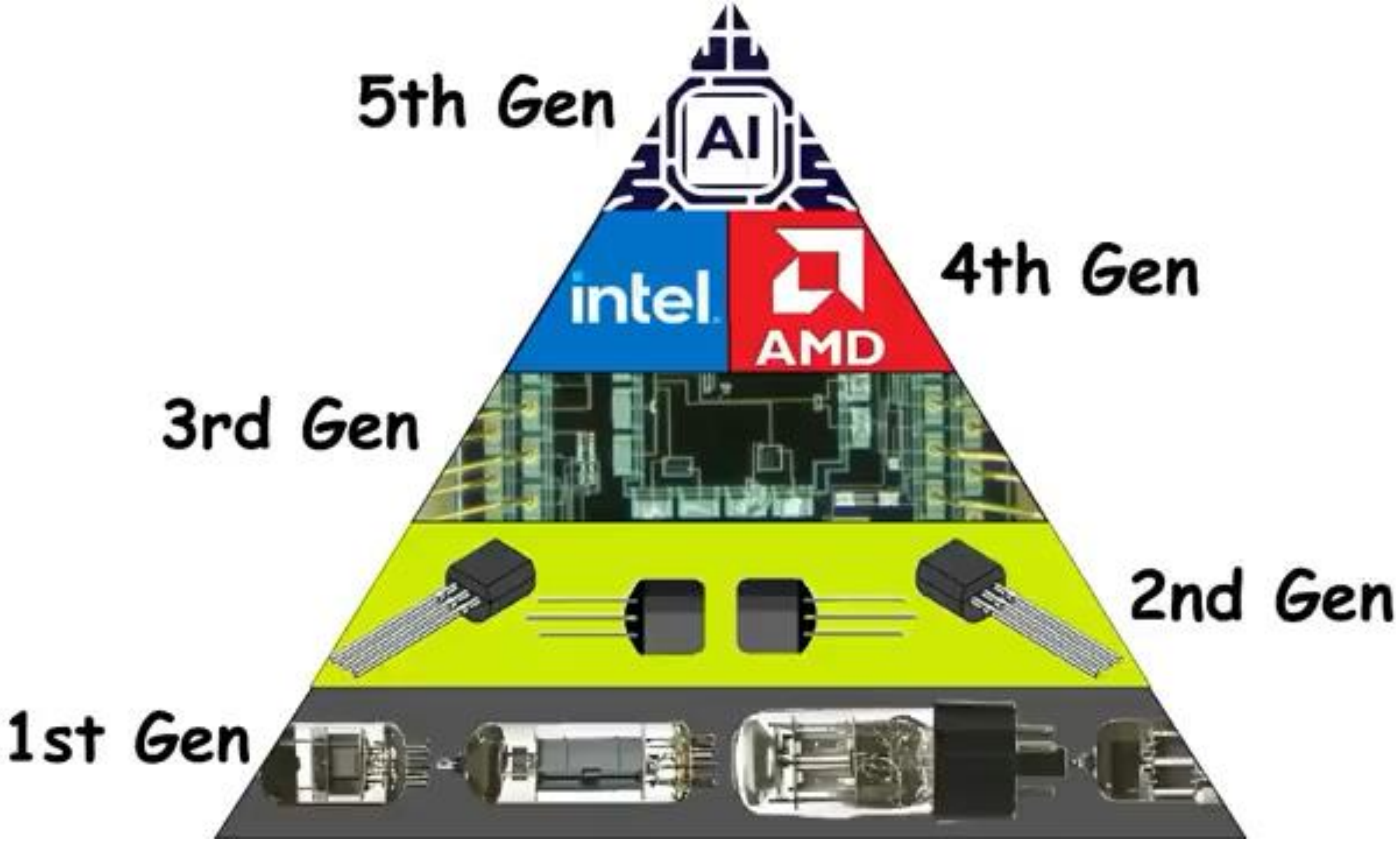
Learning Outcomes



By the end of this lecture, students will be able to:

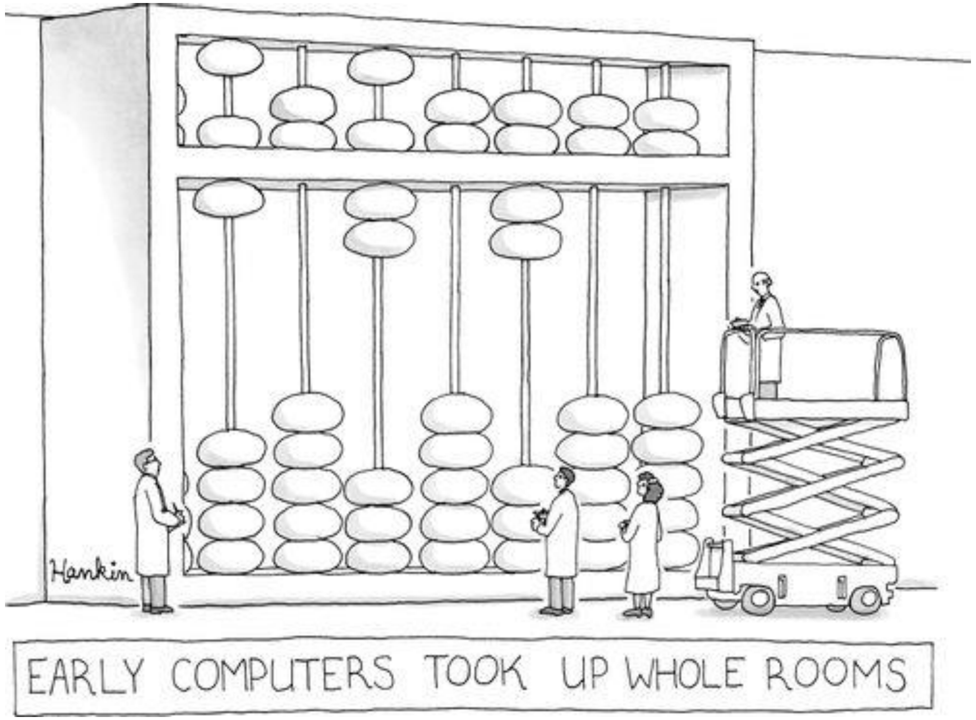
- Describe how computers evolved across five generations.
- Identify key technologies used in each computer generation.
- Explain the Von Neumann Model and the Stored-Program Concept.
- Interpret the data flow in the Von Neumann architecture.
- Recognize key components of modern computers (CPU, GPU, Cache, SSD, Buses).

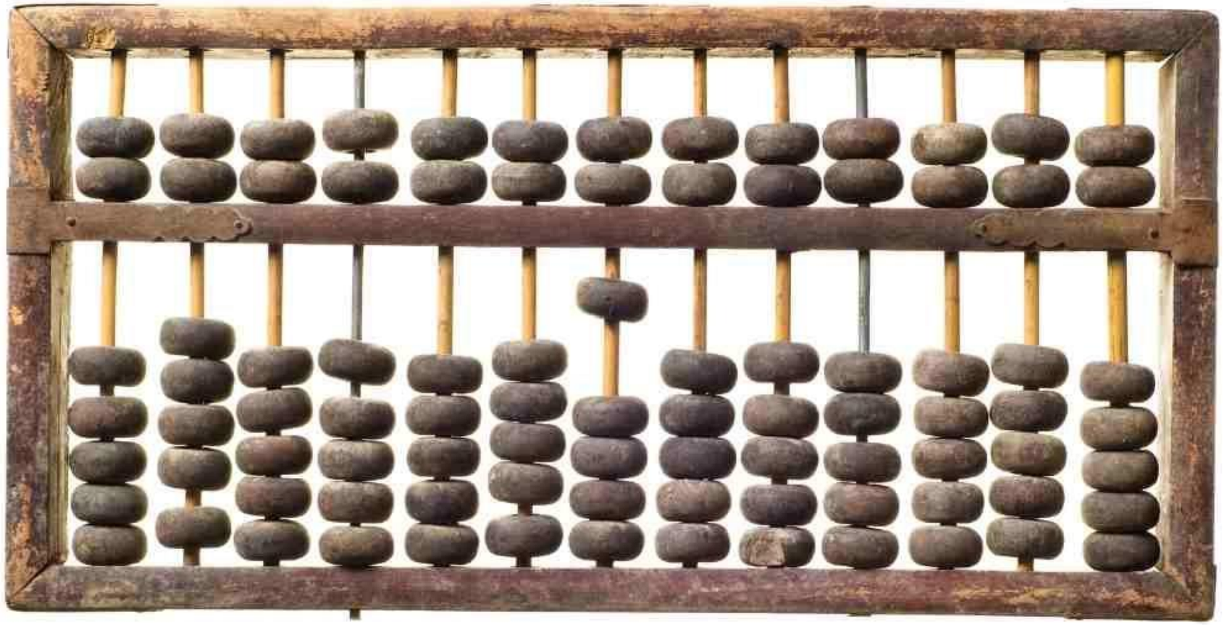
Computer Evolution & Generations


5th Gen
AI
intel
AMD
4th Gen
3rd Gen
2nd Gen
1st Gen

Early Computers: Mechanical Era

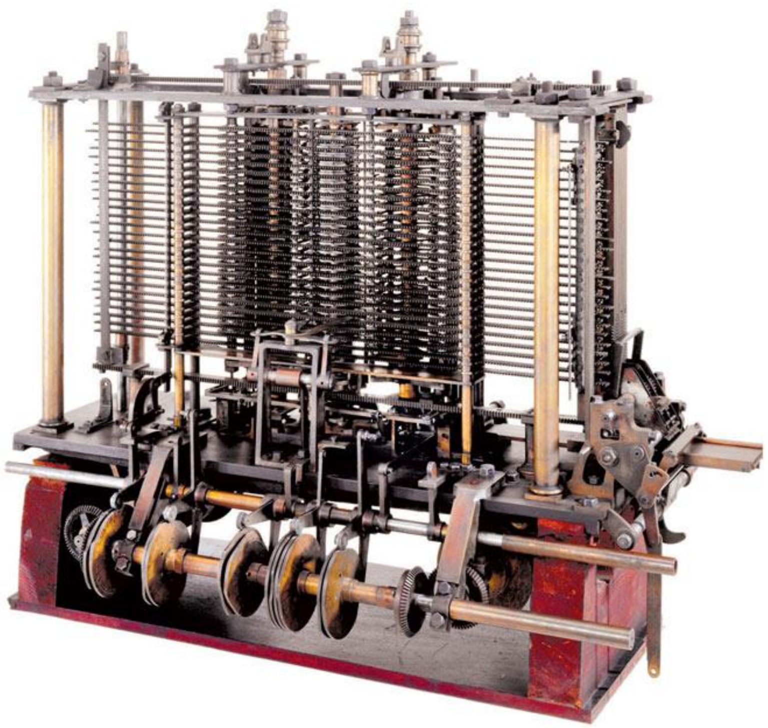
- **Abacus (c. 2500 BC)** – First known calculating device.





Early Computers: Mechanical Era (cont.)

- **Charles Babbage's Analytical Engine (1837)** – mechanical design for a general computer.



Early Computers: Mechanical Era (cont.)

- **Ada Lovelace** – first computer programmer (wrote algorithms for Babbage's machine).

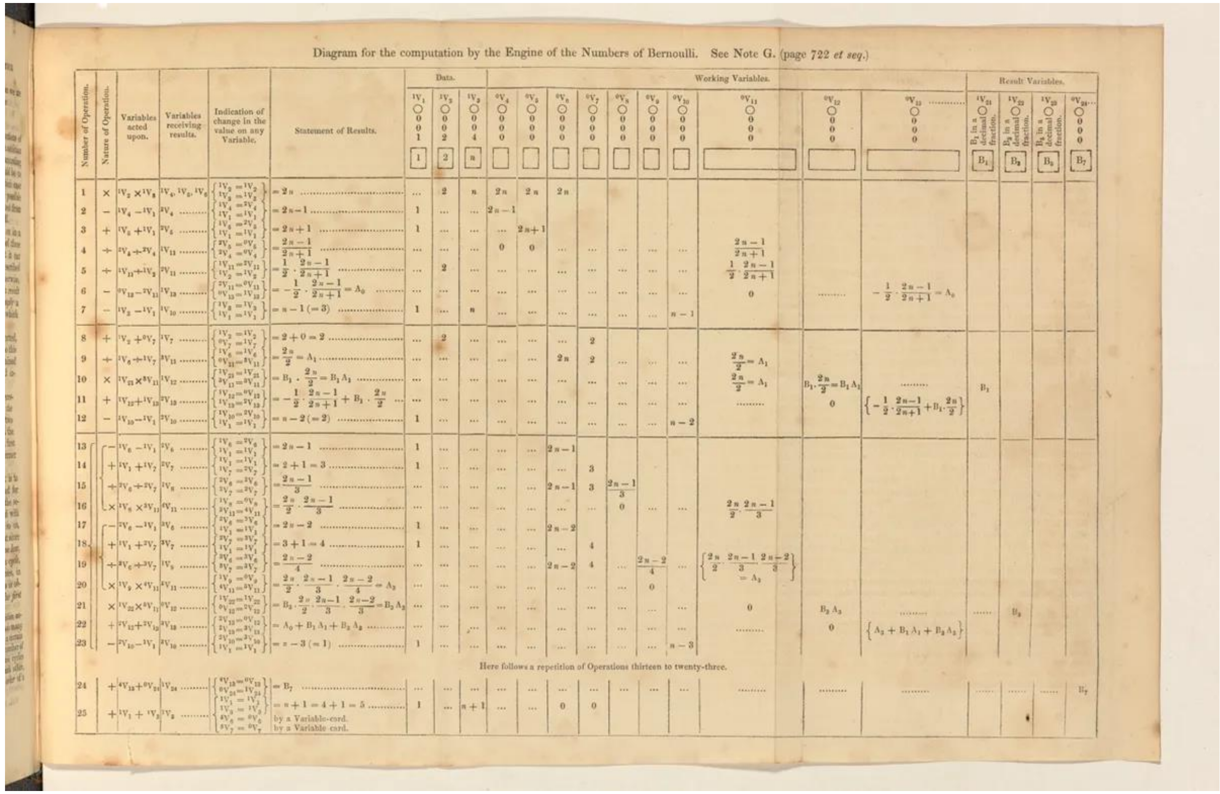


Diagram for the computation by the Engine of the Numbers of Bernoulli. See Note G. (page 722 et seq.)

Here follows a repetition of Operations thirteen to twenty-three.

Electromechanical Era (cont.)

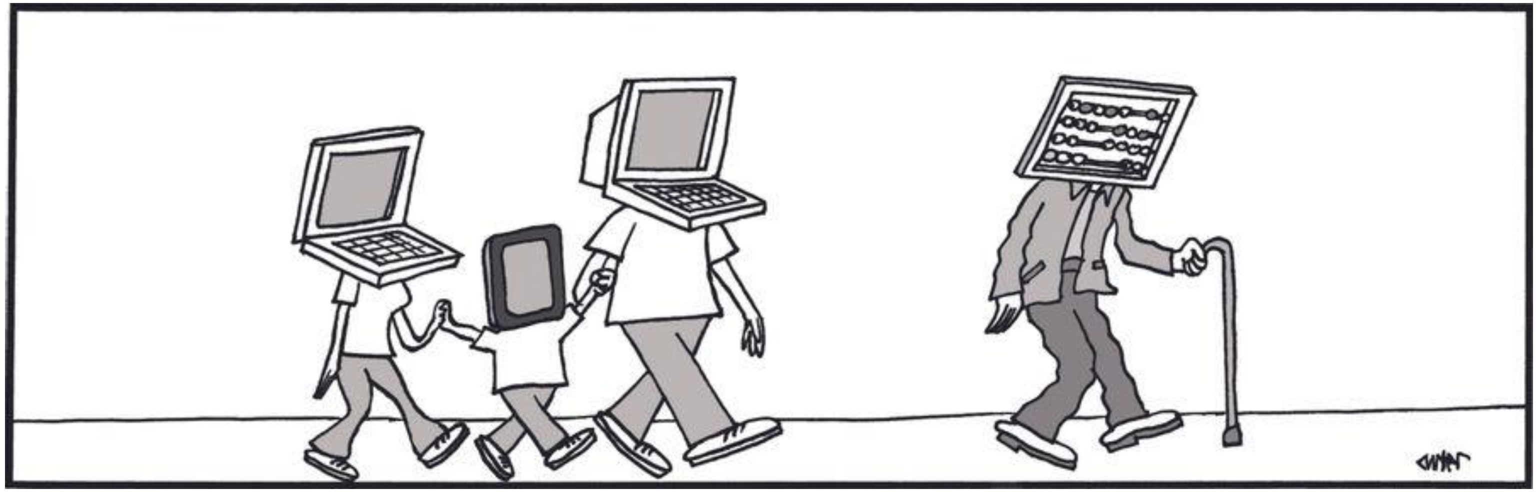
- **Hollerith Tabulating Machine (1890):** used punch cards.

Electromechanical Era (cont.)

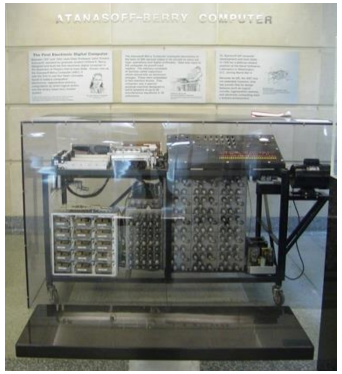
•**Mark I (1944)**: partly mechanical, partly electrical.

Computer Generations

Computers did not always look like laptops or smartphones. The development of computers happened in five major generations, each marked by a major technological breakthrough.



First Generation (1940 – 1956)
Vacuum Tube Computers



- First-generation computers used thousands of vacuum tubes, making them extremely large and power-hungry. These tubes controlled electricity to process calculations, but they generated massive heat and often burned out.
- Computers were operated using punch cards because screens and operating systems did not exist. Users punched holes in paper to give commands, making programming slow and difficult.
- Storage was magnetic drums, which were huge but had extremely tiny capacity. Despite their size, they could only store small amounts of data compared to even a simple USB today.

Second Generation (1956 – 1963) Transistor-Based Computers

- Transistors replaced vacuum tubes, making computers smaller, faster, and more reliable. They required less electricity and produced far less heat, improving performance and durability.

- Punch cards still controlled the computer, meaning programming was still not user-friendly. Although hardware improved, input methods remained old-fashioned and slow.

- Storage improved to magnetic tape, which held more data than magnetic drums. Tape reels allowed easier data transfer and larger capacity.

Third Generation (1964 – 1971) Integrated Circuit Computers

- ICs combined many transistors on a single chip, making computers smaller and more powerful. This breakthrough drastically increased processing speed and reduced wiring complexity.

- Keyboards and monitors were introduced, replacing punch cards for interaction. People could now type commands and view results directly on a screen.

- Operating systems like UNIX appeared, allowing multiple tasks and users. This made computers smarter, more organized, and easier to use.

Fourth Generation (1971 – Present) Microprocessor-Based Computers

- Microprocessors placed the CPU and other components on one tiny chip, creating the personal computer era. This innovation made computers small enough to fit on a desk and affordable for home and office use.

- Graphical User Interfaces (GUI) allowed users to click icons and use a mouse instead of typing commands. Computers became accessible to everyone, not only trained specialists.

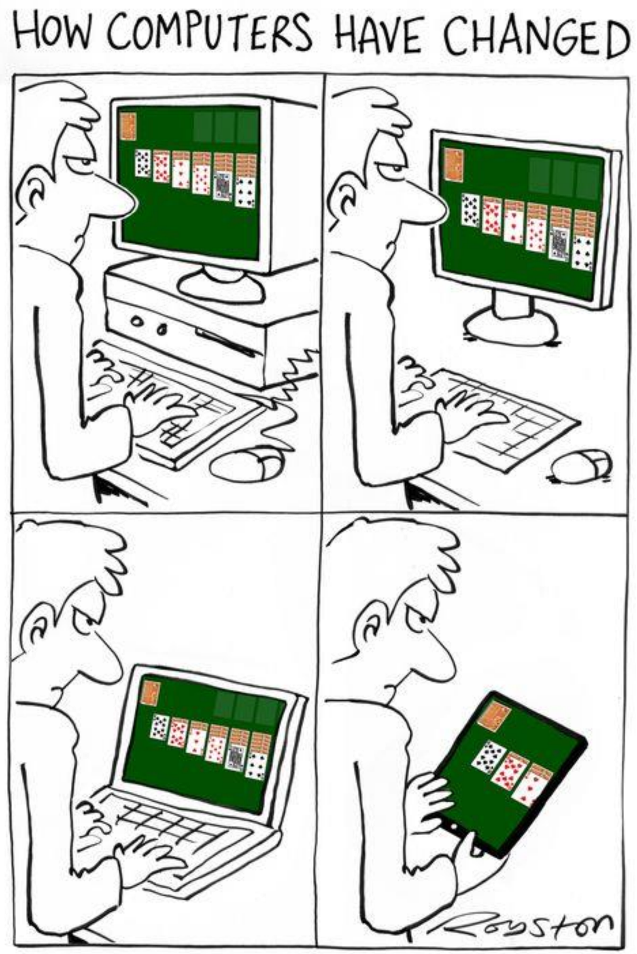
- Storage evolved from floppy disks to CDs, DVDs, and hard drives, enabling large data storage and multimedia use. People could store photos, music, programs, and files with ease.

Fifth Generation (Present and Beyond) Artificial Intelligence and Beyond

- Fifth-generation computers focus on intelligence, learning, and automation rather than size or speed alone. They can analyze data, recognize speech, and make decisions independently.
- AI powers modern technologies like smart assistants, self-driving cars, and intelligent security systems. Devices such as Alexa, Tesla cars, and advanced GPUs use AI to understand and respond to human actions.
- Computers now generate realistic speech, images, and video, pushing the boundaries of creativity and automation. AI can imitate humans so well that it can even create videos of someone speaking without them really doing it.

Recap & Evolution

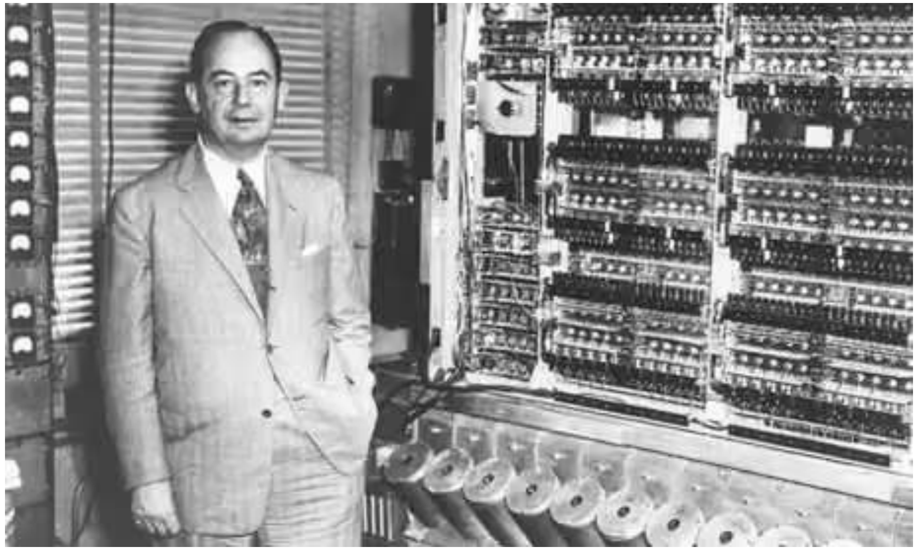
- **1st Generation:** Vacuum tubes → Huge, basic, punch cards
- **2nd Generation:** Transistors → Smaller, faster, still punch cards
- **3rd Generation:** Integrated circuits, monitors, keyboards
- **4th Generation:** Microprocessors, PCs, GUI, internet
- **5th Generation:** AI, automation, smart devices, future tech



Von Neumann Model (1945)

- Proposed by **John Von Neumann**, a Hungarian-American mathematician and computer scientist.

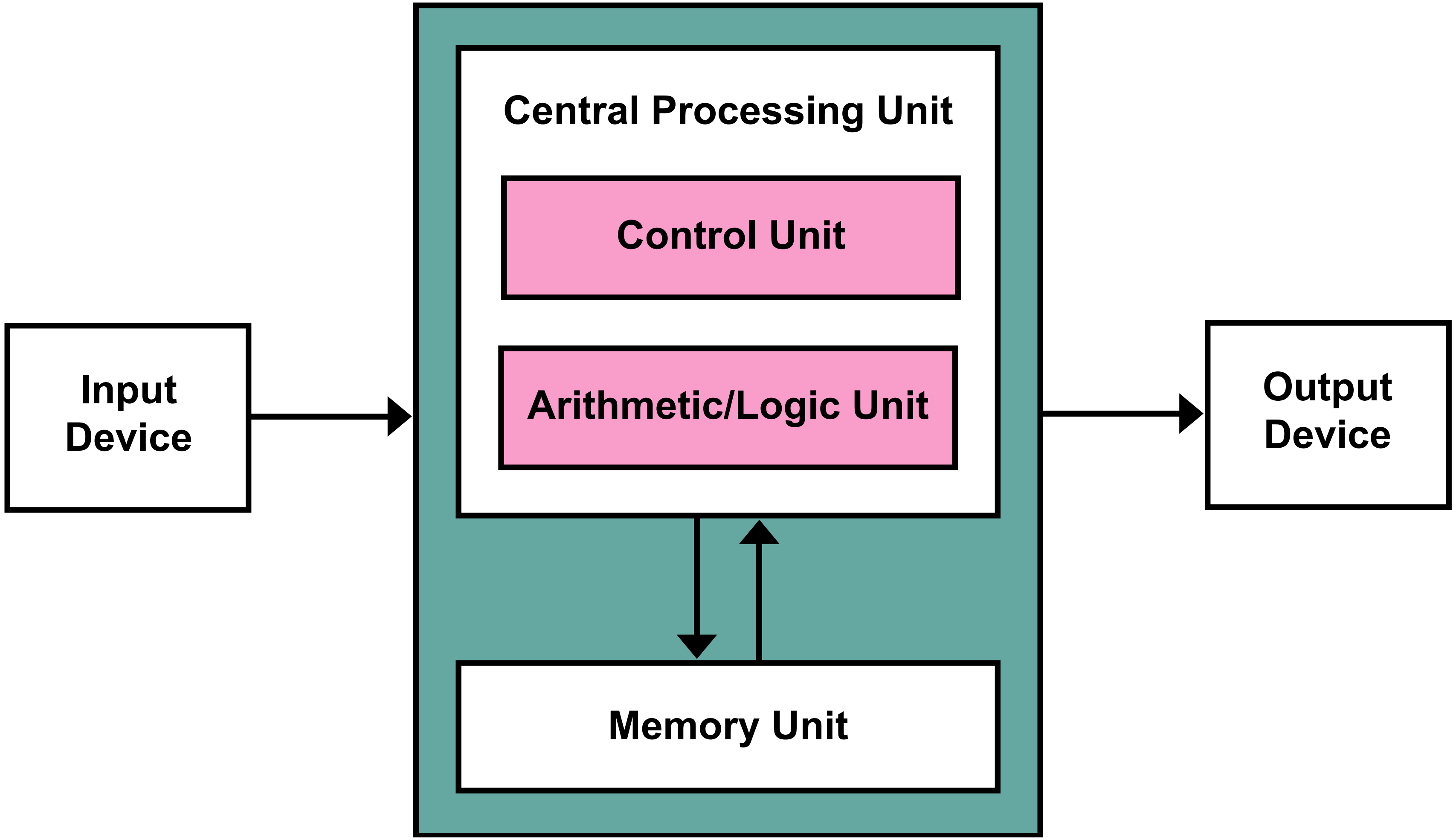
- He introduced a **model** that became the foundation of all modern computers. Both program instructions and data are stored together in the same memory.

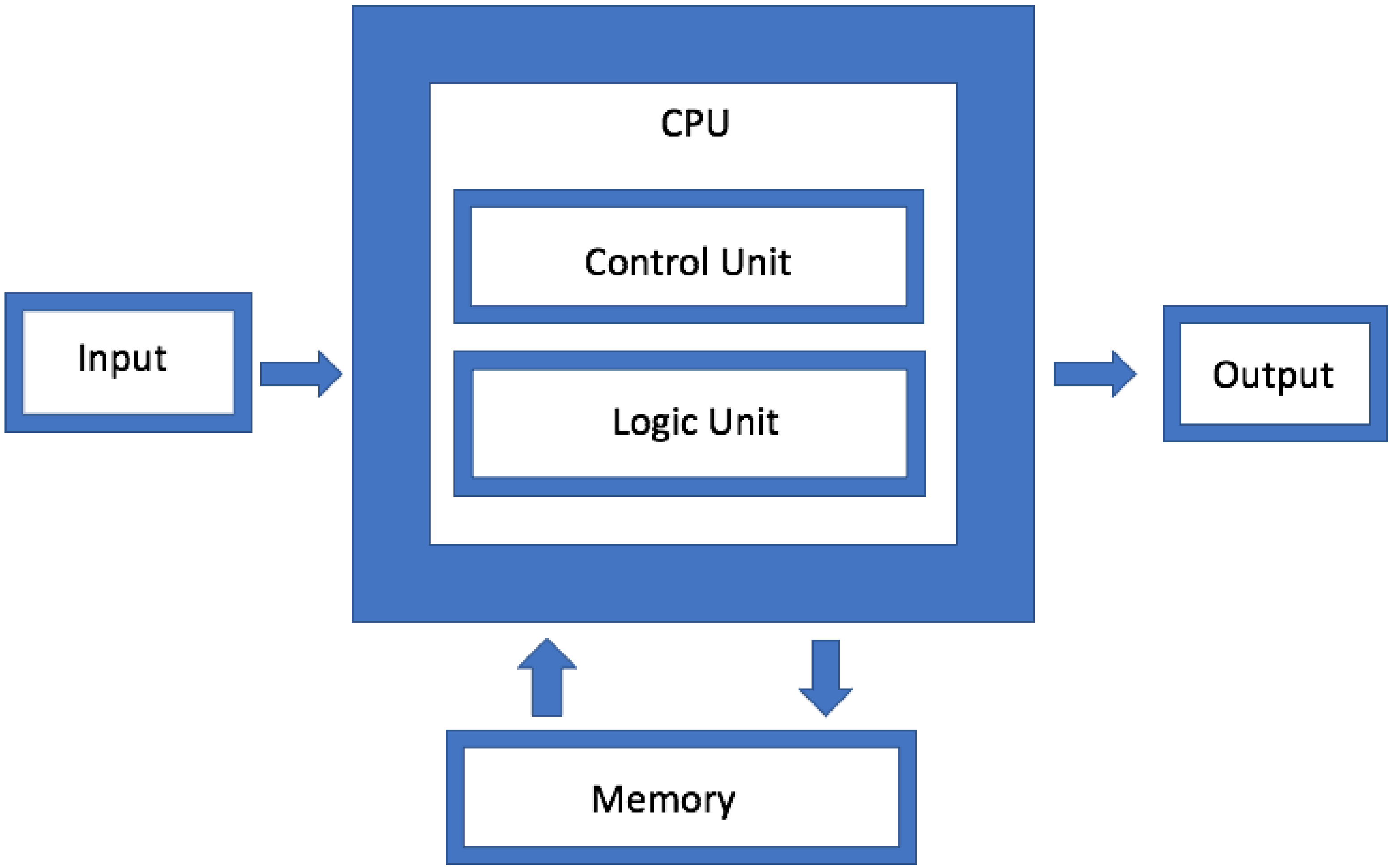


Von Neumann Model (1945) (cont.)

- **Main Components:**
  - **Input Unit** – accepts data and instructions.
  - **Arithmetic Logic Unit (ALU)** – performs all calculations and logical operations.
  - **Control Unit (CU)** – manages the flow of data and instructions between components.
  - **Memory Unit** – stores data and programs.
  - **Output Unit** – displays or outputs the final results.

Von Neumann Architecture Diagram





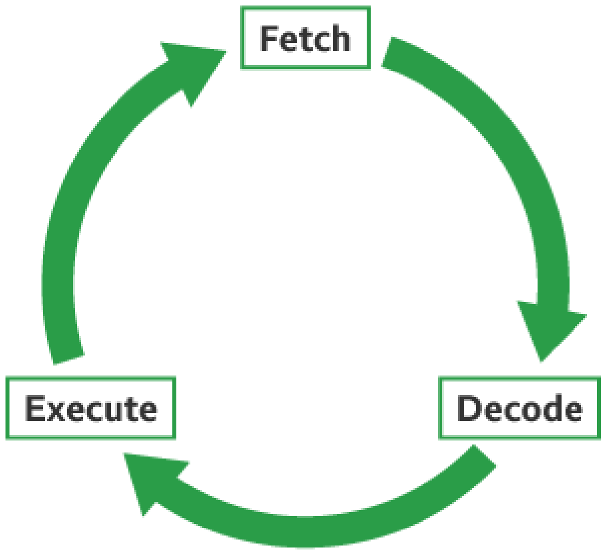
The von Neumann architecture, first described in the 1940s, has been the mainstay of computing up until the 2000s. Data and programs are both stored in the same address space of a computer's memory.

Stored Program Concept

- Proposed as part of the Von Neumann Model.
- **Idea:** Both instructions (the program) and data are kept in the same memory space.

The CPU:

1. **Fetches** the instruction from memory.
2. **Decodes** it to understand what action to perform.
3. **Executes** the operation using ALU or other units.



- This process repeats automatically for every instruction until the program ends.

Data Flow Explanation

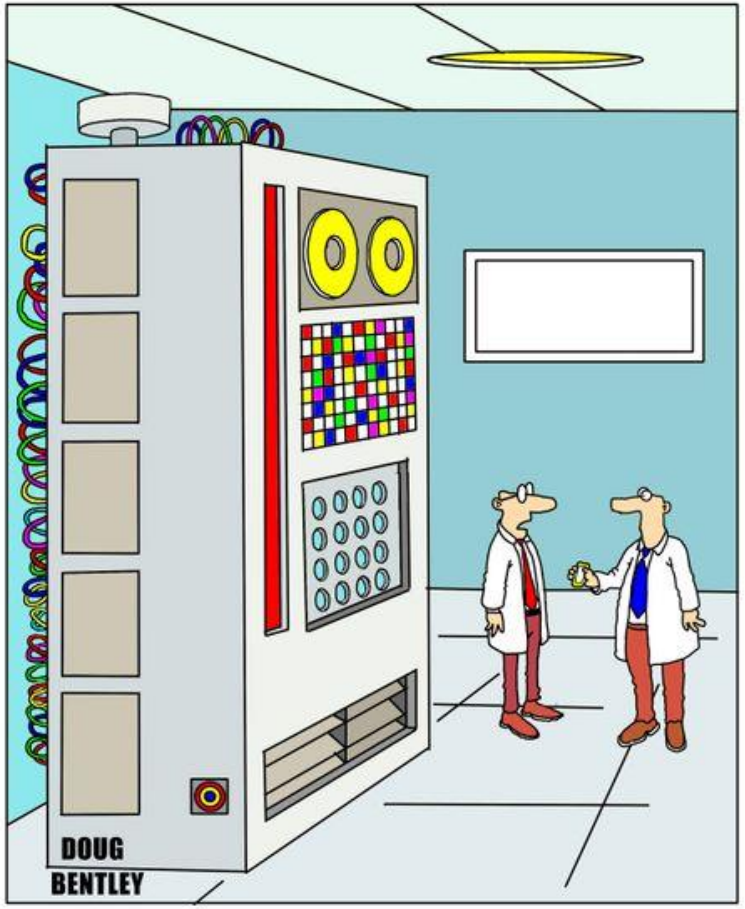
- **Data Flow in Von Neumann Architecture:**
- **Input Unit:** Takes user data or instructions (e.g., keyboard, mouse).
- **Memory Unit:** Temporarily stores both program and data.
- **Control Unit:** Fetches each instruction, decodes it, and sends control signals.
- **ALU:** Performs arithmetic or logical operations based on control signals.
- **Output Unit:** Displays or prints the results (e.g., monitor, printer).
- **Cycle repeats** for the next instruction.

Introduction to Modern Computers

- Modern computers are **powerful digital systems** built on the foundations of Von Neumann’s model.
- They process data **billions of times faster** than early computers.
- Designed for **speed, multitasking, and parallel processing**.

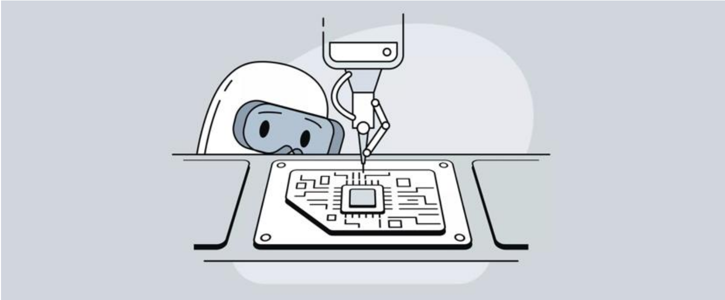
Key Characteristics of Modern Computers

- **Multi-Core Processors:** Multiple CPUs work together to perform tasks simultaneously.
- **Parallel Processing:** Executes many instructions at once.
- **Large Memory & Storage:** Gigabytes of RAM and terabytes of SSDs.
- **High-Speed Communication:** Uses data buses, caches, and networking for fast transfer.



"Fifteen years of my life developing a computer that can tackle seemingly impossible calculations and now you're telling me there's an app on your phone for this?"

Architecture & Components



- Modern computers still use the same basic architecture as earlier computers, but each component is now extremely powerful and optimized. The CPU still follows the fetch-decode-execute cycle, but instead of doing one task at a time, it can run many instructions at once and across multiple cores.
- The CPU is still the "brain" of the computer and follows the same process cycle, but now it is much faster, multi-core, and supports parallel execution. It can run several programs and threads at the same time (e.g., browsing, streaming, and downloading).

Architecture & Components (cont.)

- Its cache memory is a very fast, small memory located close to the CPU. It stores frequently-used data so the CPU can access it instantly without waiting for RAM, which reduces latency and boosts performance.

- The GPU (Graphics Processing Unit) processes images, videos, and complex visuals. Today, GPUs are also used for AI, data science, and simulation because they can process thousands of operations in parallel.

Architecture & Components (cont.)

- Modern computers use SSDs storage instead of hard drives. They store data in flash memory, meaning no moving parts, faster loading, faster boot times, and better reliability.

- The bus system connects the CPU, memory, and I/O devices so they can communicate quickly. Modern buses offer very high-speed data transfer (e.g., PCIe, Thunderbolt). It ensures the system components work together without bottlenecks.

Further Learning Resources

- COA Tutorial: GeeksforGeeks
- Computer Generations Explained (Video)

References

- Plantz, R. G. (2020). Introduction to computer organization: An under-the-hood look at hardware and ARM64 assembly (ARM ed.). No Starch Press.
- Null, L., & Lobur, J. (2018). Essentials of computer organization and architecture (6th ed.). Jones & Bartlett Learning.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Question