University of Engineering and Technology (UET),
Peshawar, Pakistan

Lecture 1

CSE-304: Computer Organization and Architecture

BY:

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Slides are taken from student resources of William Stallings website

Course Description

- **The computer lies at the heart of computing. All students of computing should acquire some understanding and appreciation of a computer system's functional components, their characteristics, their performance, and their interactions. It is important to understand Computer Architecture in order to structure a program so that it runs efficiently on a real machine.**
- **This course will cover the basic concepts of Computer Architecture that are important for you to understand, including the CPU control and data path, memory systems including caching and virtual memory, and input/output subsystems. It covers topics such as instruction set design, hardware and software methods for exploiting parallelism, input/output systems and multiprocessor concepts.**

Course Details

Credit hours: 3

Grading:

- **Mid term Exam: 30%**
- **Sessional (Quiz, Assignments etc): 20%**
- **Final term Exam: 50%**

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Text Book

- **Computer Organization and Architecture**

By:

William Stallings

- **Computer Organization and Design**

By:

Petterson D. A and Hennessy J. L

References

- **Computer Architecture: A quantitative approach**

  By:

  John L. Hennessy and David A. Patterson

- **Research papers on Computer Design and Architecture**

  By:

  IEEE and ACM conferences, transactions and journals

Architecture & Organization

- **Architecture is those attributes visible to the programmer**
  - **Instruction set, number of bits used for data representation, I/O mechanisms, addressing techniques.**
  - **e.g. Is there a multiply instruction?**
- **Organization is how features are implemented**
  - **Control signals, interfaces, memory technology.**
  - **e.g. Is there a hardware multiply unit or is it done by repeated addition?**

Structure & Function

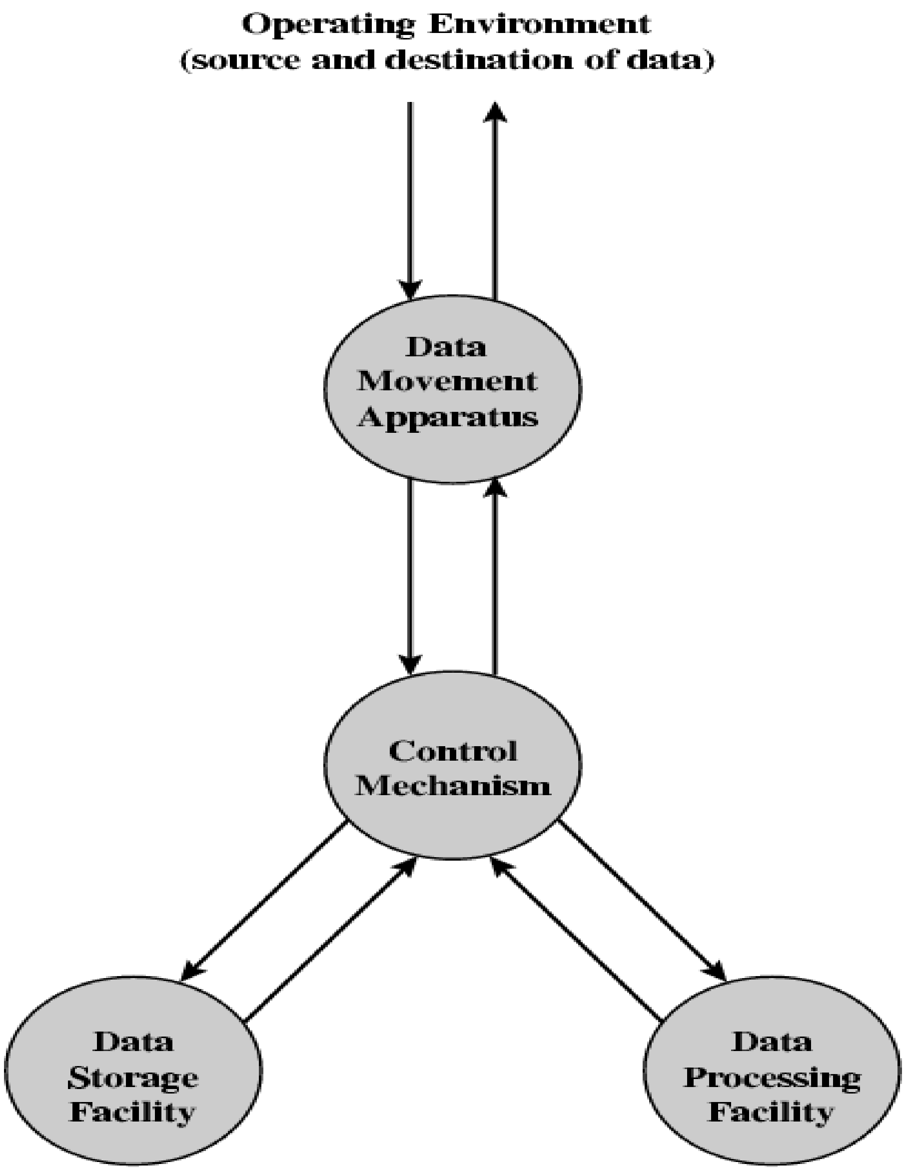
- **Structure is the way in which components relate to each other.**

- **Function is the operation of individual components as part of the structure.**

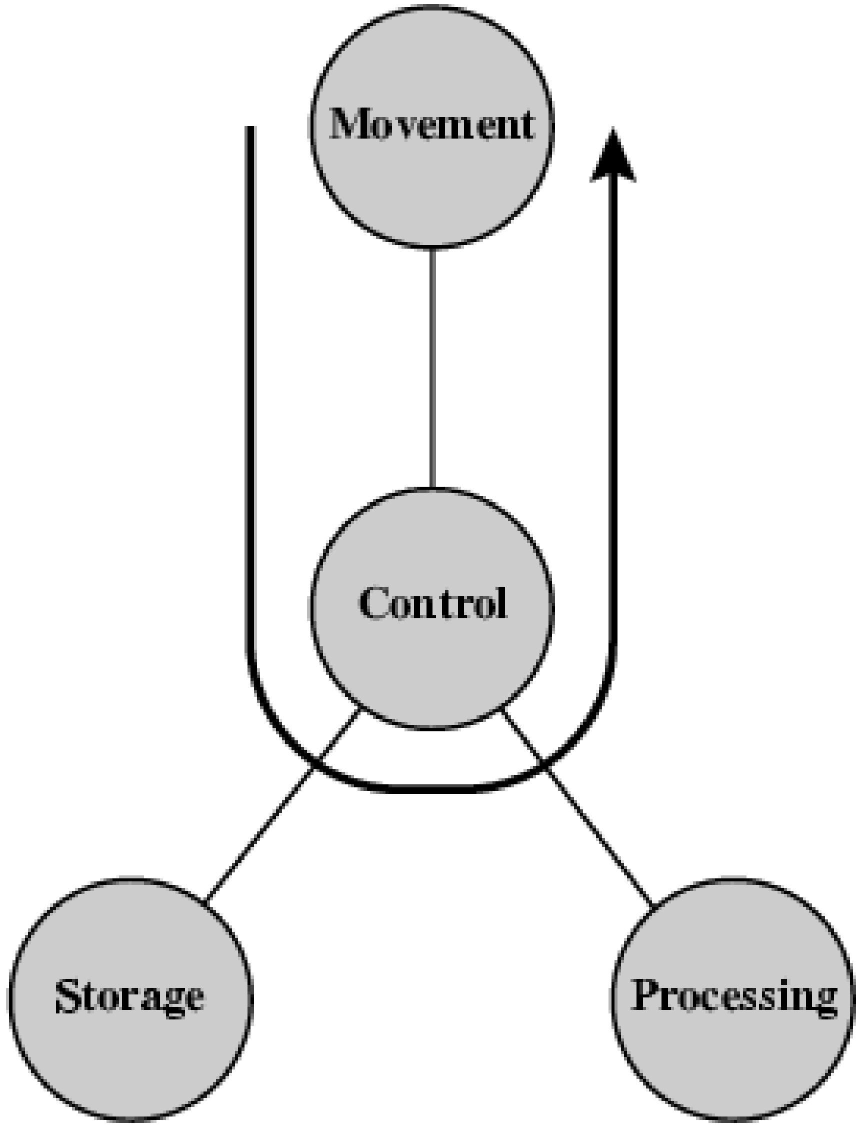
Function

- **All computer functions are:**
  - **Data processing**
  - **Data storage**
  - **Data movement**
  - **Control**

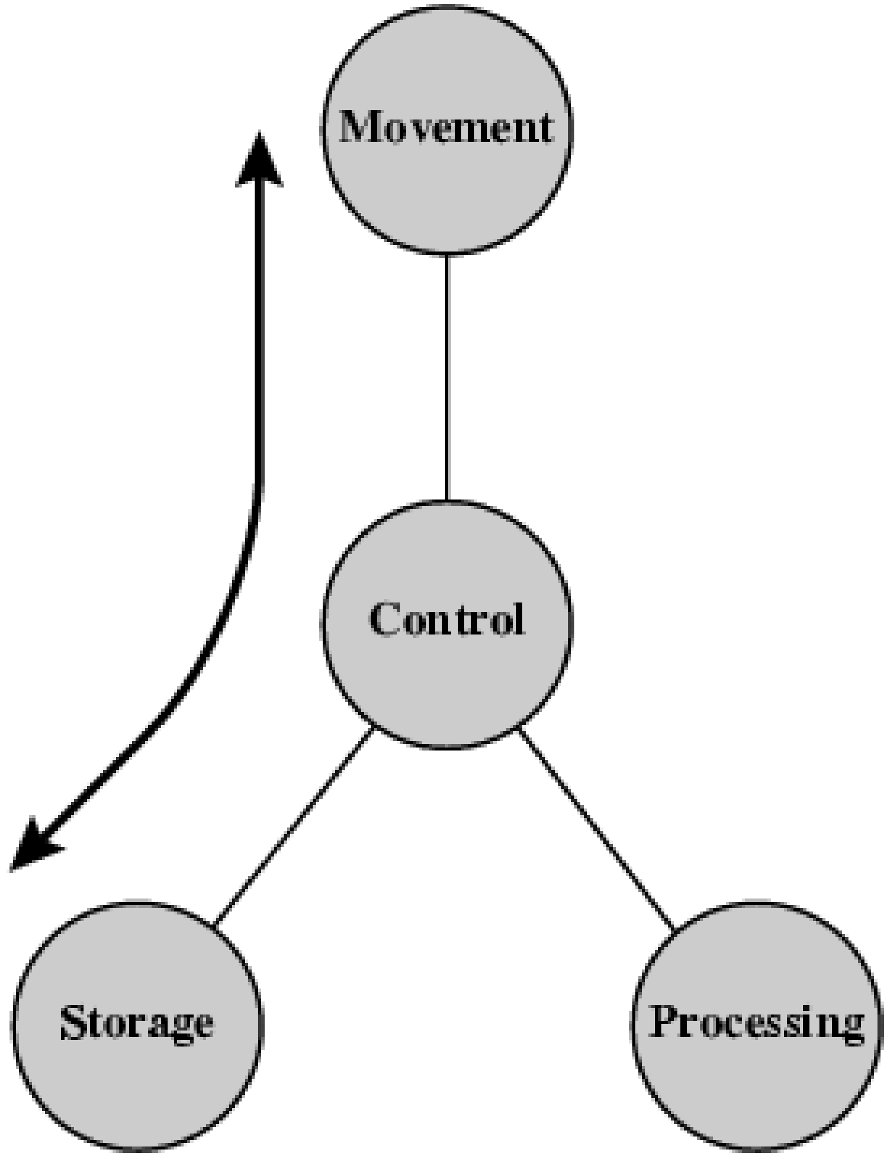
Functional view



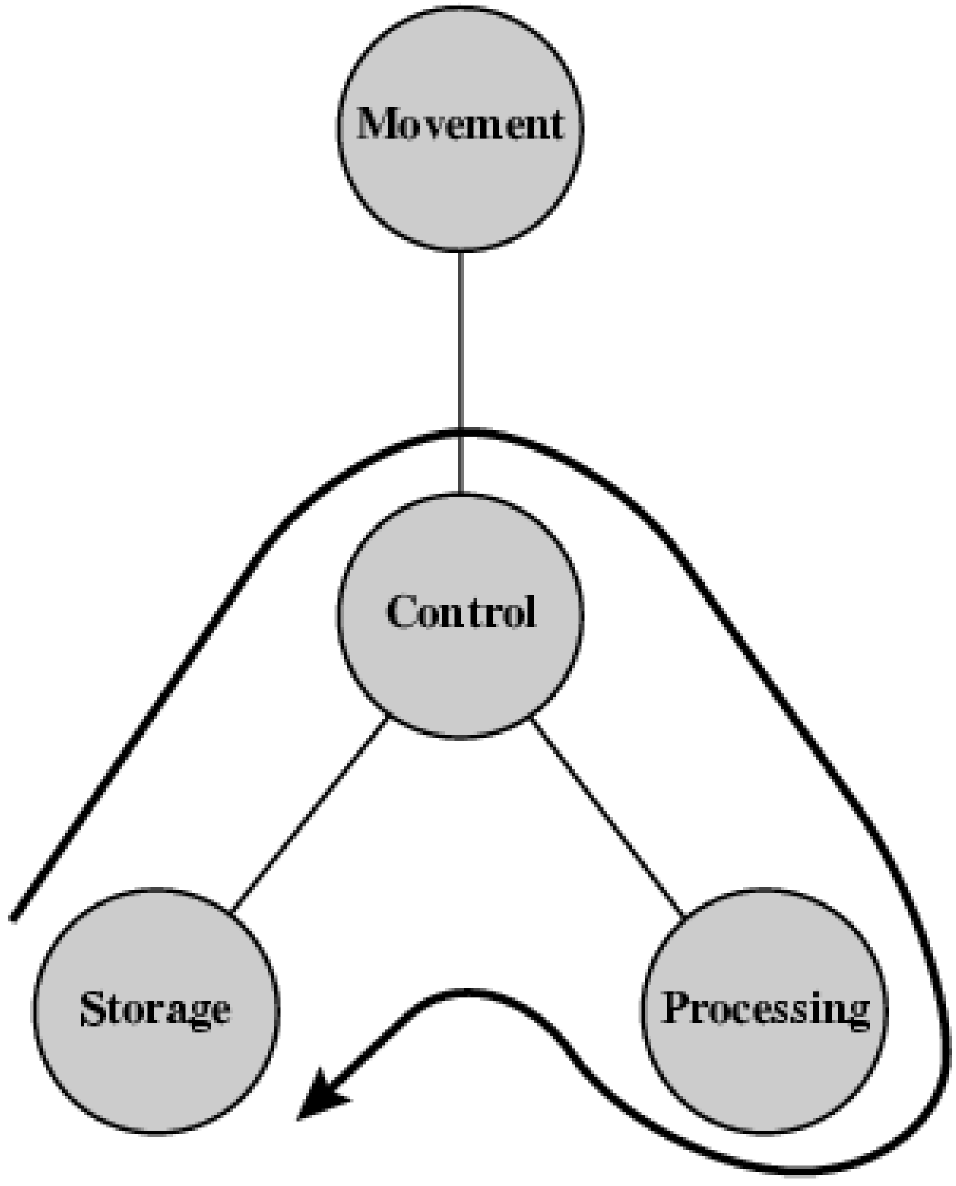
Operations (1) Data movement



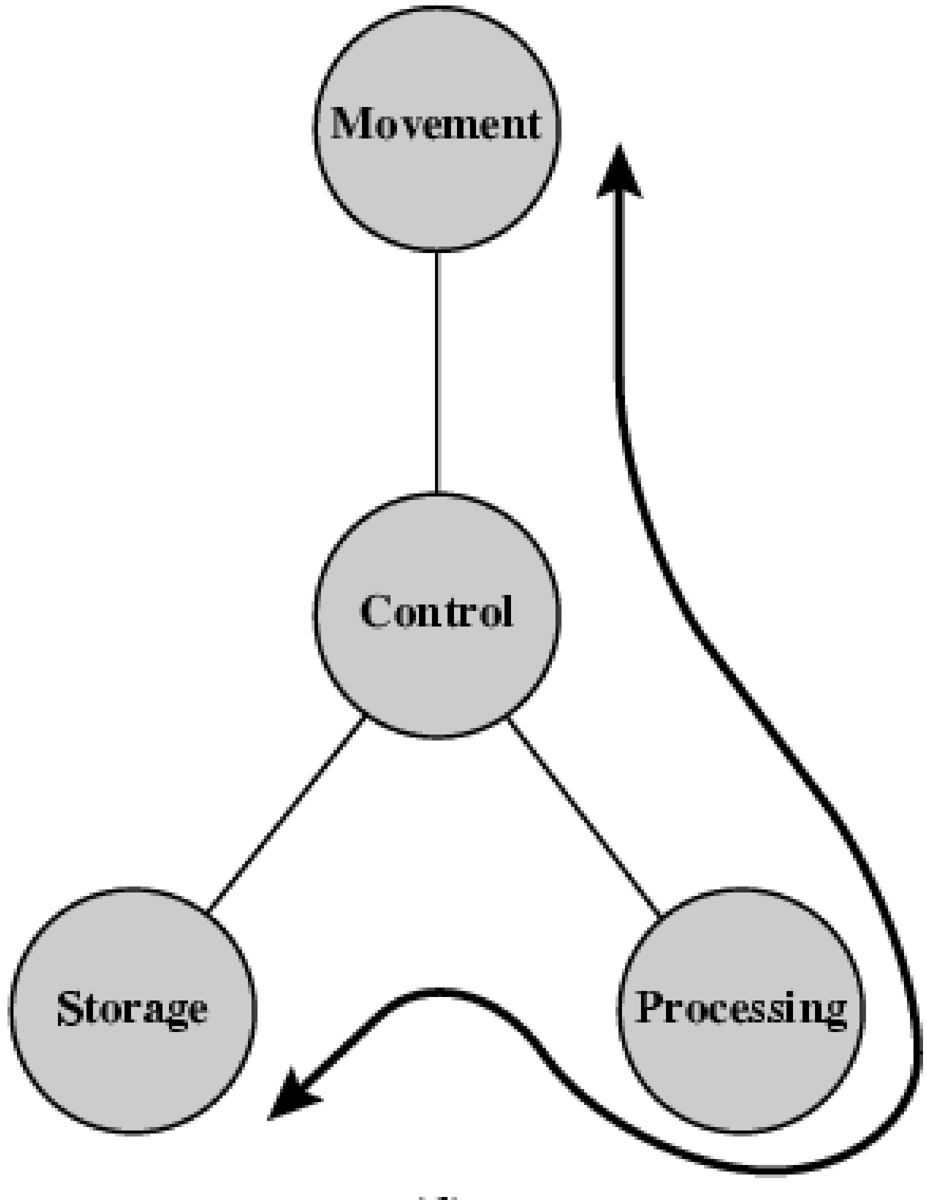
Operations (2) Storage



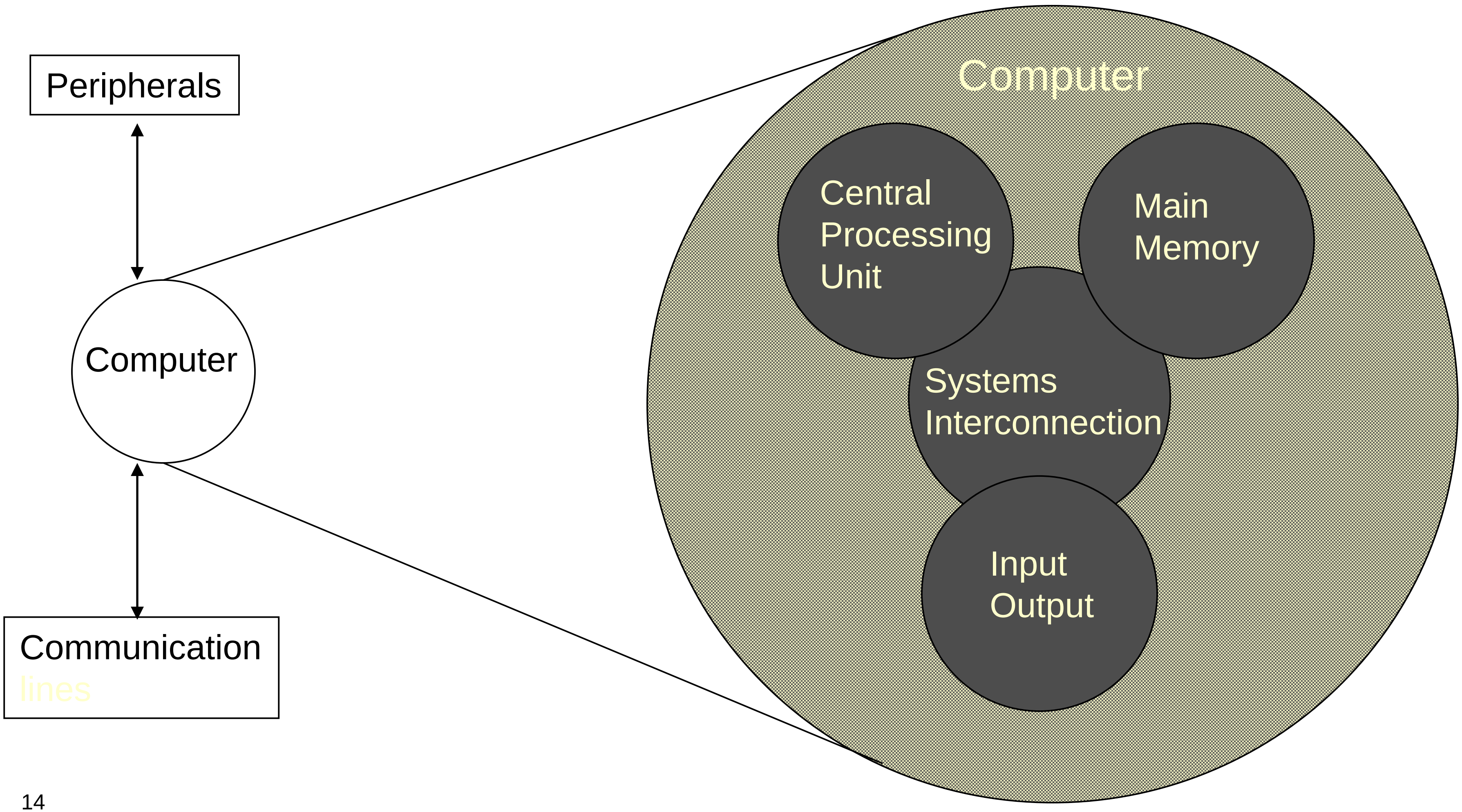
Operation (3) Processing from/to storage



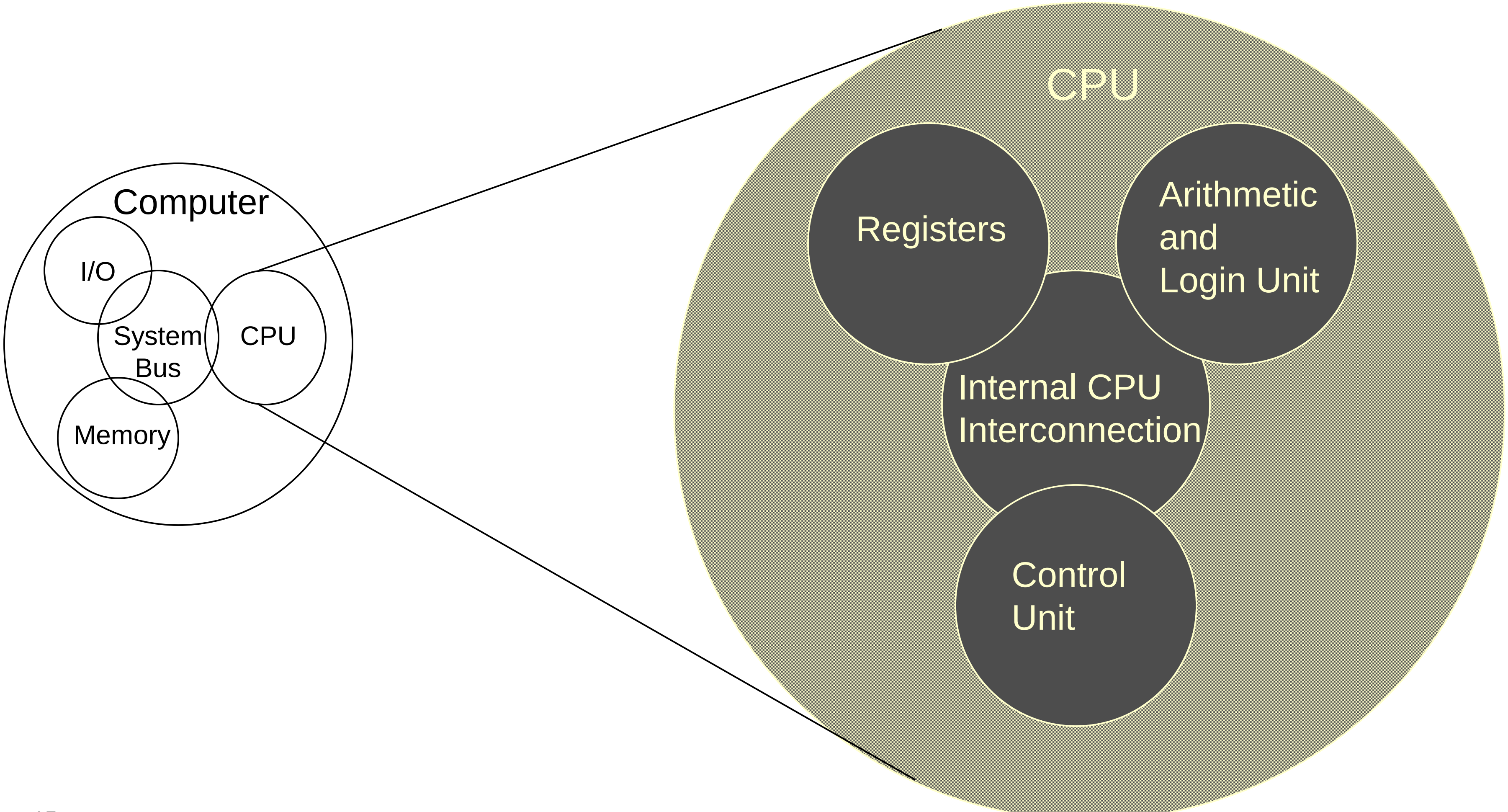
Operation (4) Processing from storage to I/O



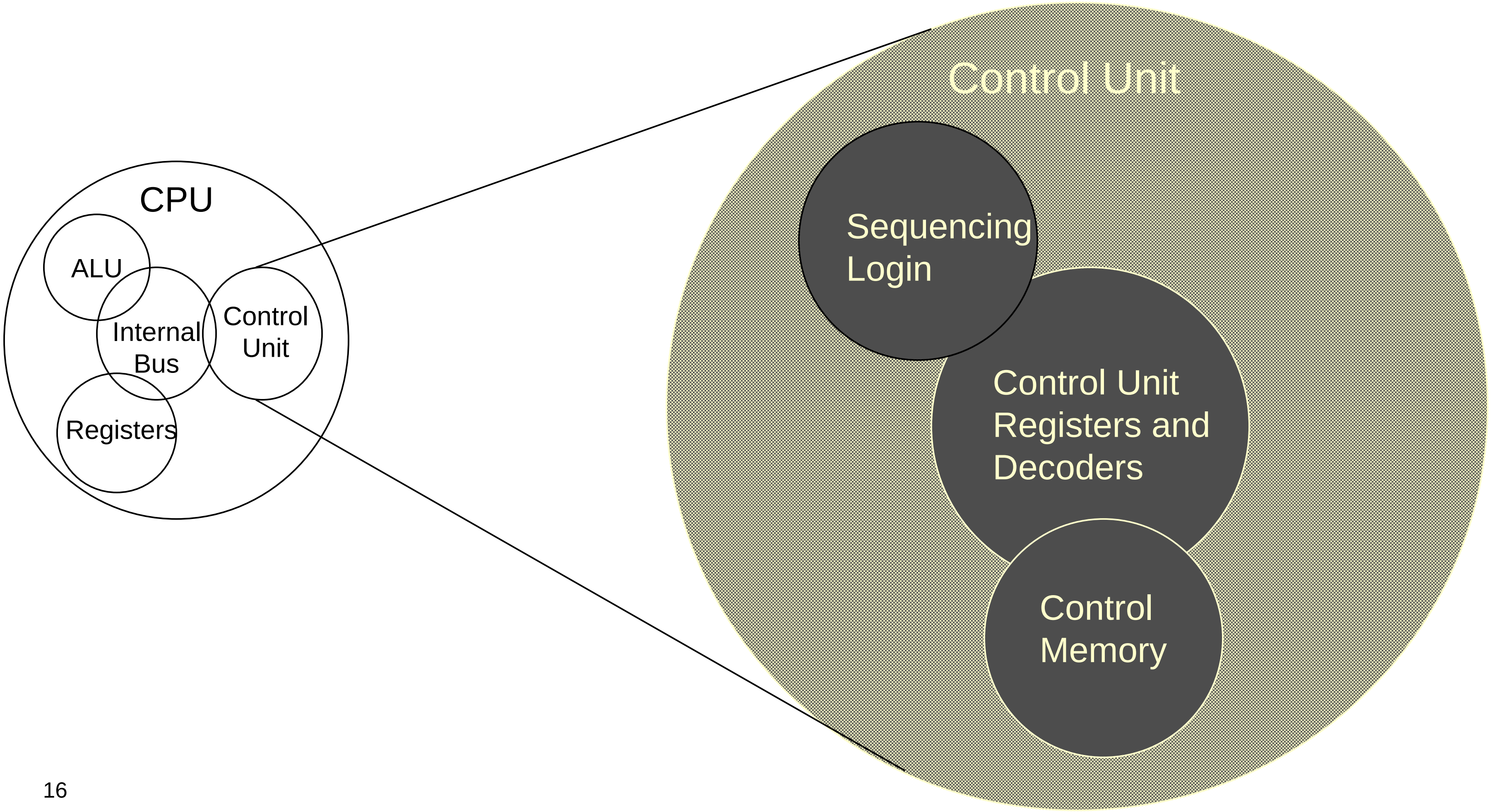
Structure - Top Level



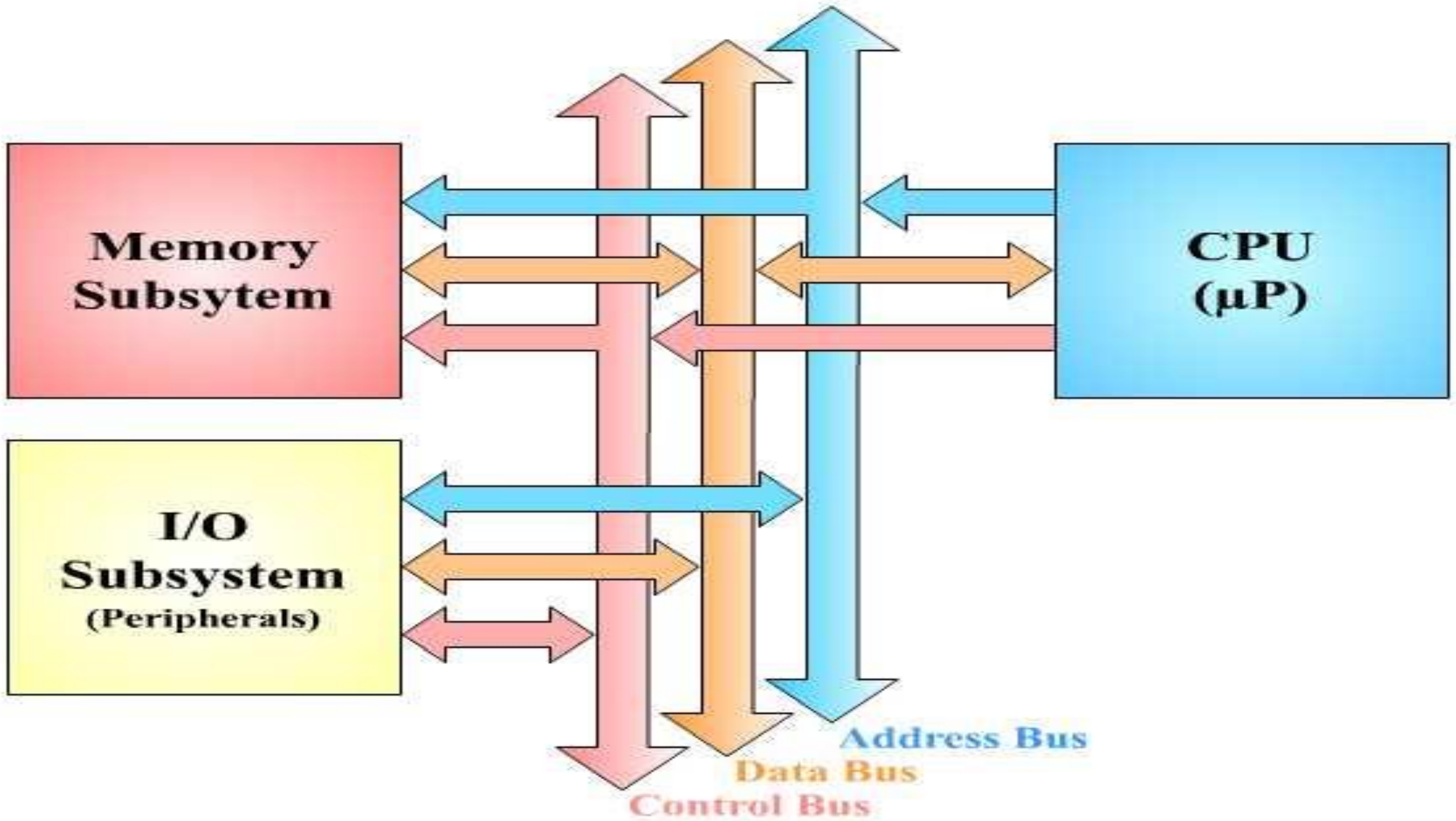
Structure - The CPU



Structure - The Control Unit



Computer System



History

ENIAC - background

- **Electronic Numerical Integrator And Computer**
- **John Presper Eckert and John Mauchly**
- **University of Pennsylvania**
- **World first general purpose electronic digital computer**
- **Army Ballistic Research Laboratory (BRL)**
- **Started 1943**
- **Finished 1946**
- **Used until 1955**

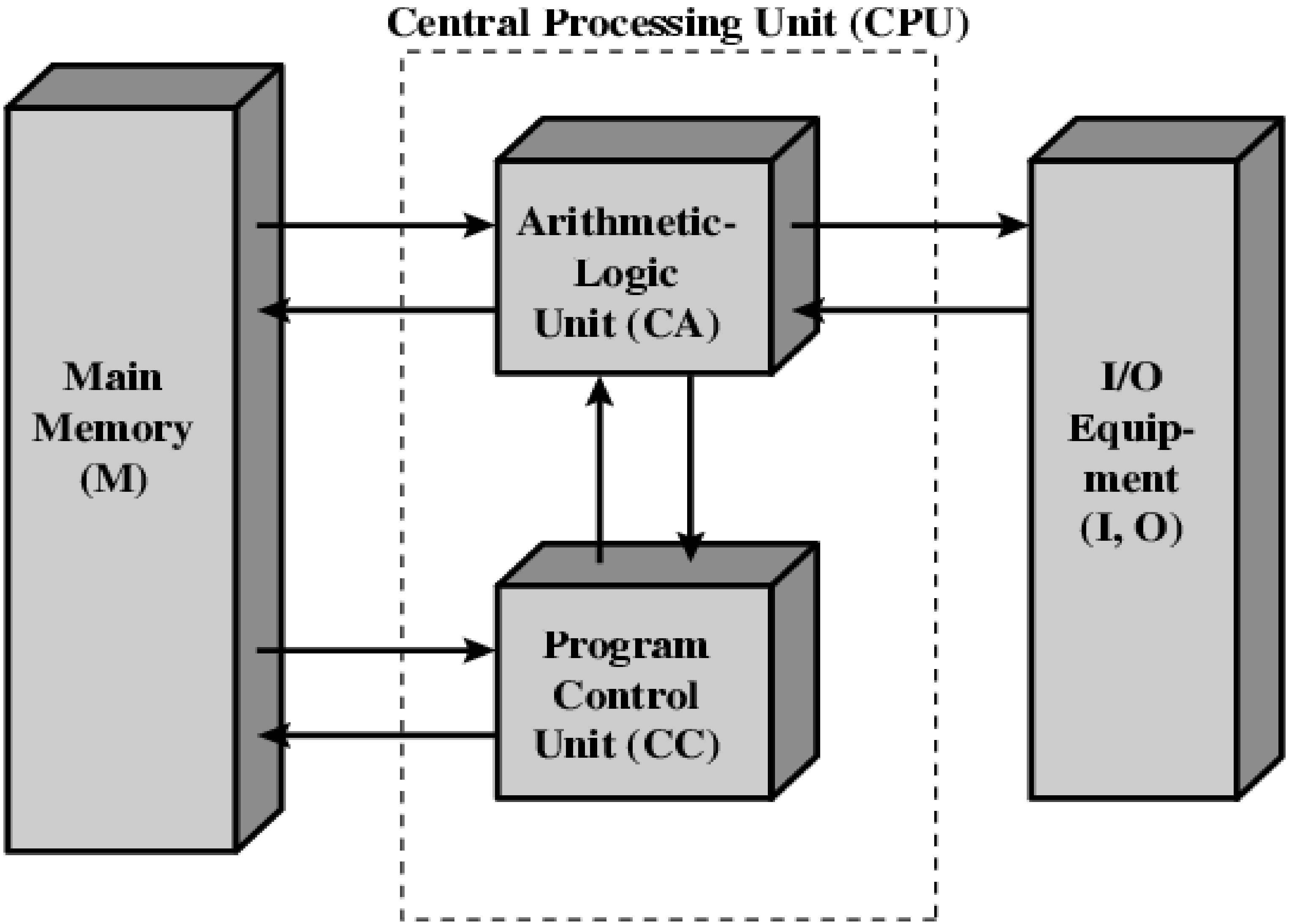
ENIAC - details

- **Decimal (not binary)**
- **Programmed manually by switches**
- **18,000 vacuum tubes**
- **30 tons**
- **15,000 square feet**
- **140 kW power consumption**
- **5,000 additions per second**
- **The task of entering and altering programs for the ENIAC was extremely tedious.**

John von Neumann/Alan Turing

- **Stored program concept**
- **In 1945 gave idea of EDVAC (Electronic Discrete Variable Computer)**
- **In 1946, they started working on IAS (Institute of Advance Study) computer at Princeton Institute for Advanced Studies.**
- **Main memory storing programs and data**
- **ALU operating on binary data**
- **Control unit interpreting instructions from memory and executing**
- **Input and output equipment operated by control unit**
- **Completed 1952**
- **Used the term “organ” to describe devices**

Structure of von Neumann machine



Commercial Computers

- **1947 - Eckert-Mauchly Computer Corporation**
- **UNIVAC I (Universal Automatic Computer)**
- **US Bureau of Census**
- **Late 1950s - UNIVAC II**
    - **Faster**
    - **More memory**

IBM

- **Punched-card processing equipment**
- **1953 - the 701**
  - **IBM’s first stored program computer**
  - **Used for scientific calculations**
- **1955 - the 702**
  - **It had number of hardware features**
  - **Suited for business applications**
- **Lead to 700/7000 series**

Transistors (The Second Generation)

- **Replaced vacuum tubes**
- **Smaller**
- **Cheaper**
- **Less heat dissipation**
- **Made from Silicon**
- **Invented 1947 at Bell Labs**

Transistor Based Computers

- **Second generation machines**
- **NCR & RCA produced small transistor machines**
- **IBM 7000 was the first transistor machine from IBM**
- **Digital equipment corporation (DEC) - 1957**
  - **Produced, PDP-1 (Programmed Data Processor)**
  - **This company developed the mini-computer phenomenon**

Computer Generations

- **Vacuum tube** 1946-1957 **1st Gen.**
- **Transistor -** 1958-1964 **2nd Gen.**
- **Small scale integration** 1965-1968
  - Up to 100 devices/chip
- **Medium scale integration** 1969-1971 **3rd Gen.**
  - 100-3,000 devices/chip
- **Large scale integration** 1972-1977
  - 3,000 - 100,000 devices/chip
- **Very large scale integration** 1978 on.. **4th Gen.**
  - 100,000 - 100,000,000 devices/chip
- **Ultra large scale integration**
  - Over 100,000,000 devices/chip

Third Generation: Integrated Circuits Moore's Law

- **Increased density of components on chip**
- **Gordon Moore - cofounder of Intel**
- **Number of transistors on a chip will double every year**
- **Cost of a chip has remained almost unchanged as the cost of computer logic and memory circuitry has fallen.**
- **Higher packing density means shorter electrical paths, giving higher performance**
- **Smaller size gives increased flexibility**
- **Reduced power and cooling requirements**
- **Fewer interconnections increases reliability**

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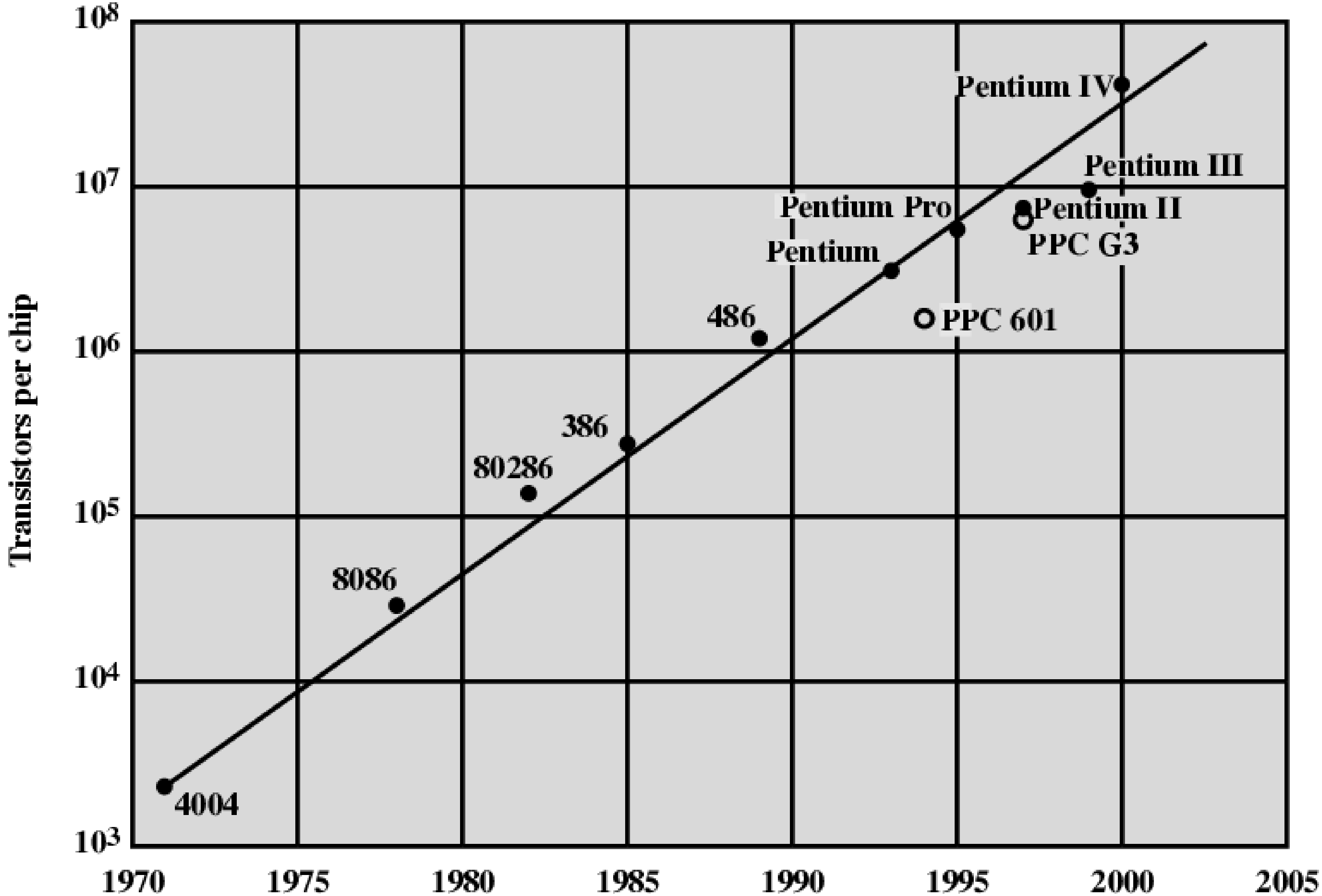
Growth in CPU Transistor Count



IBM 360 series

- **1964**
- **Replaced (& not compatible with) 7000 series**
- **First planned "family" of computers.**
    - **Similar or identical instruction set**
    - **Similar or identical operating system**
    - **Increasing speed**
    - **Increasing number of I/O ports (i.e. more terminals)**
    - **Increased memory size**
    - **Increased cost**

Digital Equipment Corporation (DEC) PDP-8

- **1964**
- **First minicomputer**
- **Did not need air conditioned room**
- **Small enough to sit on a lab bench**
- **Cheap**
- **Other equipment manufacturer can integrated PDP-8 it into a big system.**
- **Bus Structure**

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Intel

- **1971 - 4004**
    - **First microprocessor**
    - **All CPU components on a single chip**
    - **4 bit**
- **Followed in 1972 by 8008**
    - **8 bit**
    - **Both designed for specific applications**

Pentium Evolution (1)

- **1974 - 8080**
  - **First general purpose microprocessor**
  - **8 bit data path**
  - **Used in first personal computer – Altair**
- **8086**
  - **much more powerful**
  - **16 bit machine**
  - **instruction cache, prefetch few instructions**
  - **8088 (8 bit external bus) used in first IBM PC**
- **80286**
  - **16 bit**
  - **16 Mbyte memory addressable**
- **80386**
  - **32 bit**
  - **Support for multitasking**

Pentium Evolution (2)

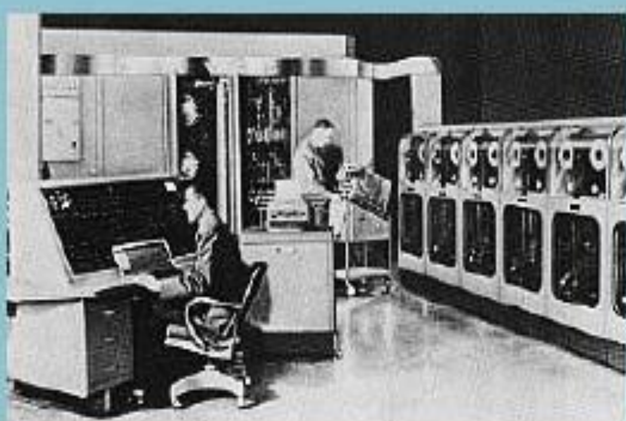
- **80486**
  - **Sophisticated powerful cache and instruction pipelining**
  - **Built in maths co-processor**
- **Pentium**
  - **Superscalar**
  - **Multiple instructions executed in parallel**
- **Pentium Pro**
  - **Increased superscalar organization**
  - **Aggressive register renaming**
  - **Branch prediction**
  - **Data flow analysis**
  - **Speculative execution**

Pentium Evolution (3)

- **Pentium II**
  - **MMX (SIMD, Single instruction multiple data) technology (in 1996)**
  - **graphics, video & audio processing**
- **Pentium III**
  - **Additional floating point instructions for 3D graphics**
- **Pentium 4**
  - **Further floating point and multimedia enhancements**
- **Itanium**
  - **64 bit**
- **Xeon (400 MHz to 3.8 GHz)**
- **Core i7 (4 cores), Core i5 (4 cores), Core i3 (2 cores) (1.06 GHz to 3.33 GH)**
- **Intel Atom (800 MHz to 2 GHz)**

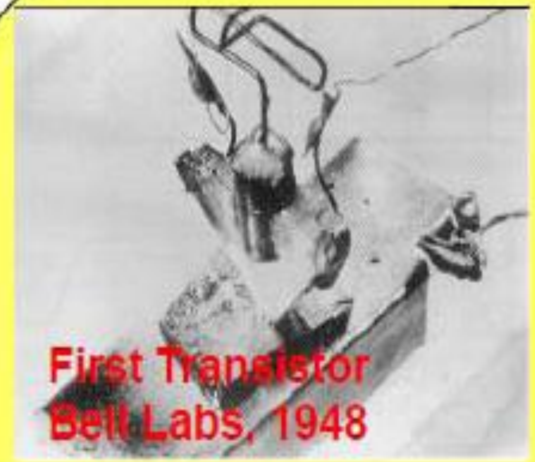
Evolution of digital electronics

Vacuum Tubes	Transistors	VLSI Circuits



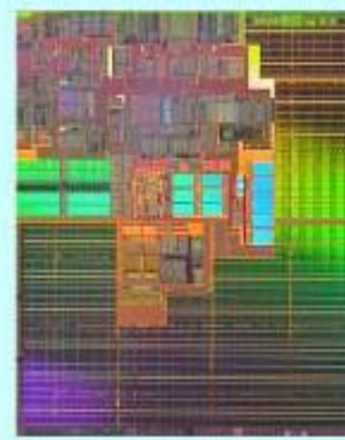
UNIVAC, 1951

1900 adds/sec



IBM System/360, 1964

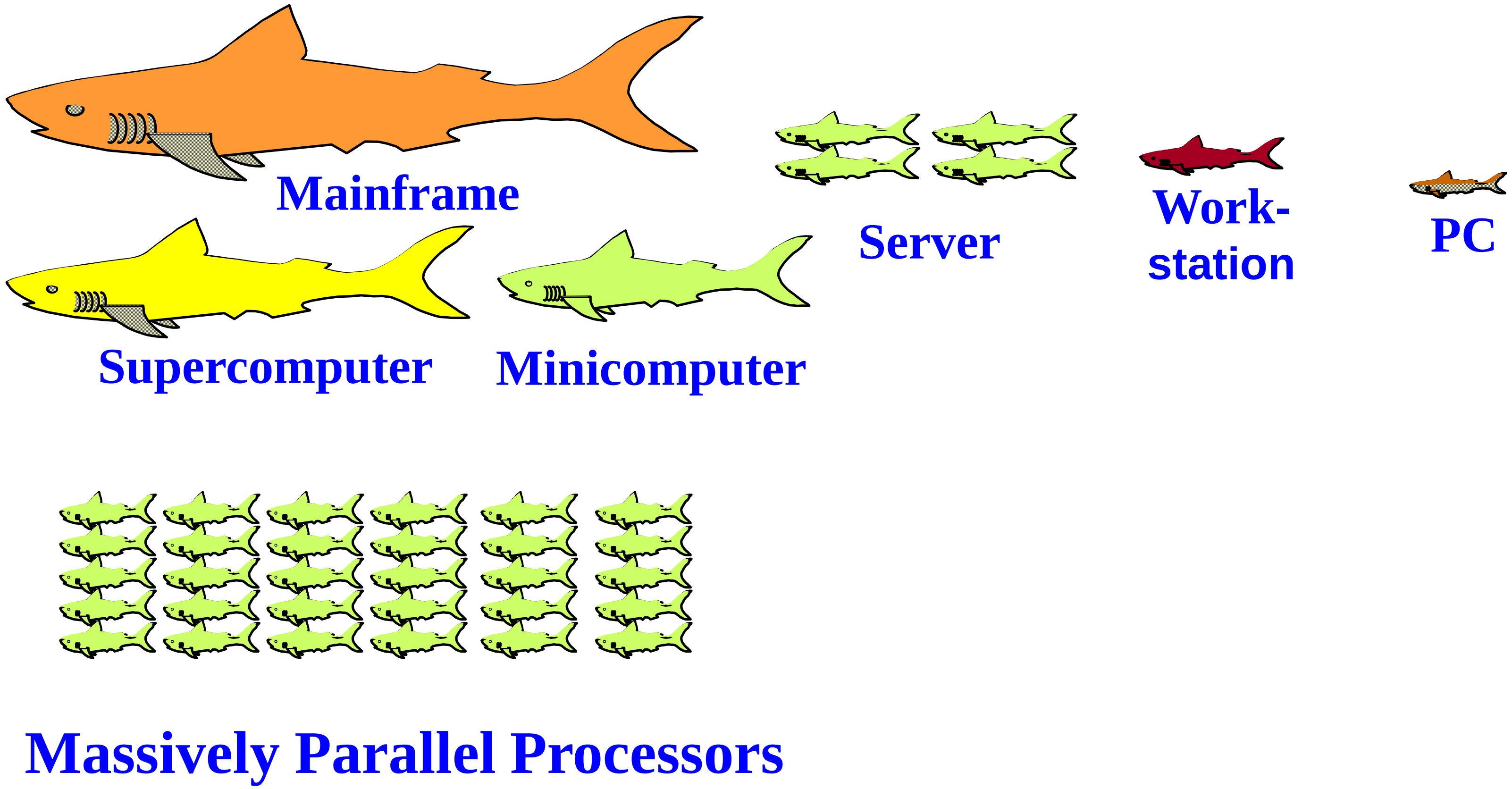
500,000 adds/sec



Intel Itanium, 2003

2,000,000,000
adds/sec

Evolution of Microprocessors



Summary

- **Studied about basics of computer organization and architecture.**

- **Looked at the history of computer architectures.**
    - **Vacuum tube.**
    - **Transistors.**
    - **Integrated circuits.**