



CSARCH Lecture Series: Introduction to Computer Organization and Architecture

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Overview

Reflect on the following questions:

- Is there a difference between Computer Organization and Computer Architecture?
- What is Von Neumann Architecture?
- What are some technologies that lead to the growth of computer system?

Overview

- This sub-module presents a general introduction to the course Computer Organization and Architecture
- The objective are as follows:
 - ✓ Explain the difference between Computer Organization and Computer Architecture
 - ✓ Explain Von Neumann Architecture
 - ✓ Describe the brief history of computer technology

Computer Architecture

Computer Architecture involves computer design based on these aspects:

- Instruction Set Architecture
- Organization or microarchitecture
- Hardware implementation

CSARCH2+CEPARCO/CSC612M

- LBYARCH
- CSARCH2
- CSARCH1

Computer Architecture

Issues involving Computer Architecture (i.e., Architectural attributes):

- Representation of data types – is integer defined as 32-bit or 64-bit?
- Class of ISA – load-store or register-memory architecture?
- Instruction set – whether to support MUL instruction or not?
- Memory addressing – byte-size? Endianness?
- Addressing modes – support complicated addressing such as autoincrement?

Computer Architecture involves **computer design** based on these aspects:

- Instruction Set Architecture
- Organization or microarchitecture
- Hardware implementation

Instruction Set Architecture

- Refers to those attributes of a system visible to a programmer
- Attributes that have a direct impact on the logical execution of a program
- “Assembly language”

Computer Architecture involves computer design based on these aspects:

- **Instruction Set Architecture**
- Organization or microarchitecture
- Hardware implementation

Computer Organization

- Also refers to the term “microarchitecture”
- Refers to the operational units and their interconnections that realize the architectural specifications.

Computer Architecture involves computer design based on these aspects:

- Instruction Set Architecture
- Organization or microarchitecture
- Hardware implementation

Computer Organization

Issues involving Computer Organization (i.e., Organizational attributes):

- Arithmetic unit – Sequential circuit binary multiplier
- Control signals – hardwired vs. microprogramming
- Cache memory

Example:

If MUL instruction is to be used, the question is whether to use a special multiply unit or use existing add unit?

Hardware

- Refers to the specific of a computer:
 - logic design
 - Combinational circuit
 - sequential circuit
 - Packaging technology of the computer

Computer Architecture involves computer design based on these aspects:

- Instruction Set Architecture
- Organization or microarchitecture
- Hardware implementation

Von Neumann Architecture

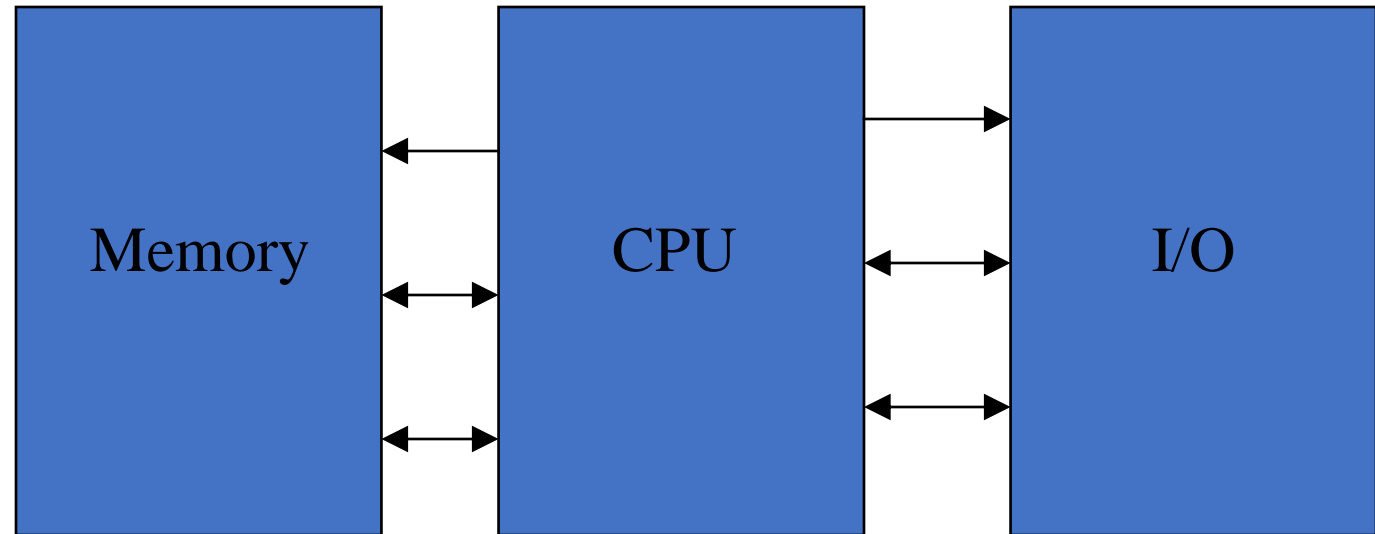
Whether it is a desktop computer (old or new), laptop computer, or tablet, all uses Von Neumann Architecture



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Von Neumann Architecture

- Store Program Architecture – program & data are stored in the main memory and **not** in the CPU
- Instructions in the main memory are **Fetch**, **Decoded** and **Executed** sequentially (or at least it appears to be)



The Technology

- Vacuum Tubes
 - Invented: Dr. Lee De Forest, 1906
 - Used by computer: in the late 30's, early 40's
 - Mainframe: ENIAC, EDVAC, UNIVAC1



The Technology

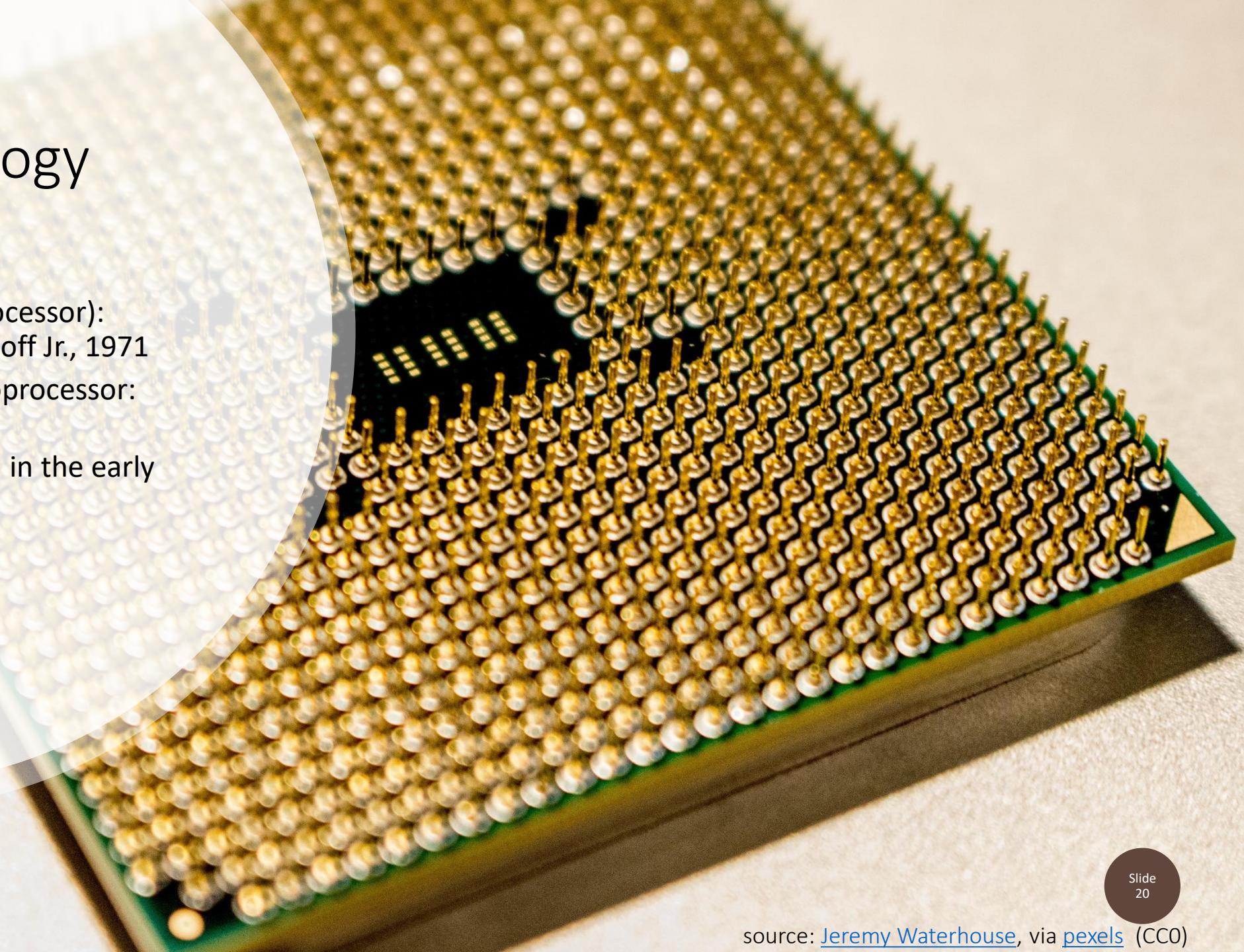
- Transistor
 - Invented: William Shockley, John Bardeen, Walter H. Brattain, 1947 (BELL LABS)
 - Used by computer: in 1957
 - Minicomputer: DEC PDP (TX-0), IBM 7090 series, IBM 1401

The Technology

- Integrated Circuit
 - Invented: Jack S. Kilby (TI), Robert S. Noyce (Fairchild), 1958
 - Used by computer: in 1964
 - DEC PDP-8, System/360

The Technology

- VLSI & Microprocessor
 - Invented (microprocessor):
Marcian E. “Ted” Hoff Jr., 1971
 - Industry’s 1st microprocessor:
INTEL 4004
 - Used by computer: in the early
70’s
 - Microcomputers



The Technology

- TeraHertz Transistor

- Transistor size to shrink from 10um ($10000 \times 10^{-9}\text{m}$) to 2nm (internally: 45nm)
- Marketing term: 2nm (internally: 45nm).
- Currently: Intel desktop – “Raptor Lake” (13th gen Intel core processor). Based on Intel7 process (“7nm”, internally: 54nm gate pitch using FINFet). Example: Core i7-13700 (16-core, 1.5GHz→5.2GHz) / Core i5-13600 (2.0GHz→5.0GHz)
- Currently: Intel mobile – “Raptor Lake-P” (13th gen Intel core processor). Based on Intel7 process (54nm gate pitch using FINFet). Example: Core i7-1370P (16-core, 1.4GHz→5.2GHz)
- Future works: Intel – Meteor Lake (Intel4 process, or “5nm”, internally: 50nm, 2024/2025). Mobile only. Intel Core 5 processor (letter “i” will be dropped).
- Future future works: Intel 20a processor (or “2nm”, internally: 45nm based on Gate-All-Around Field Effect Transistor (GAAFET).

The Technology

- Micron (μ)

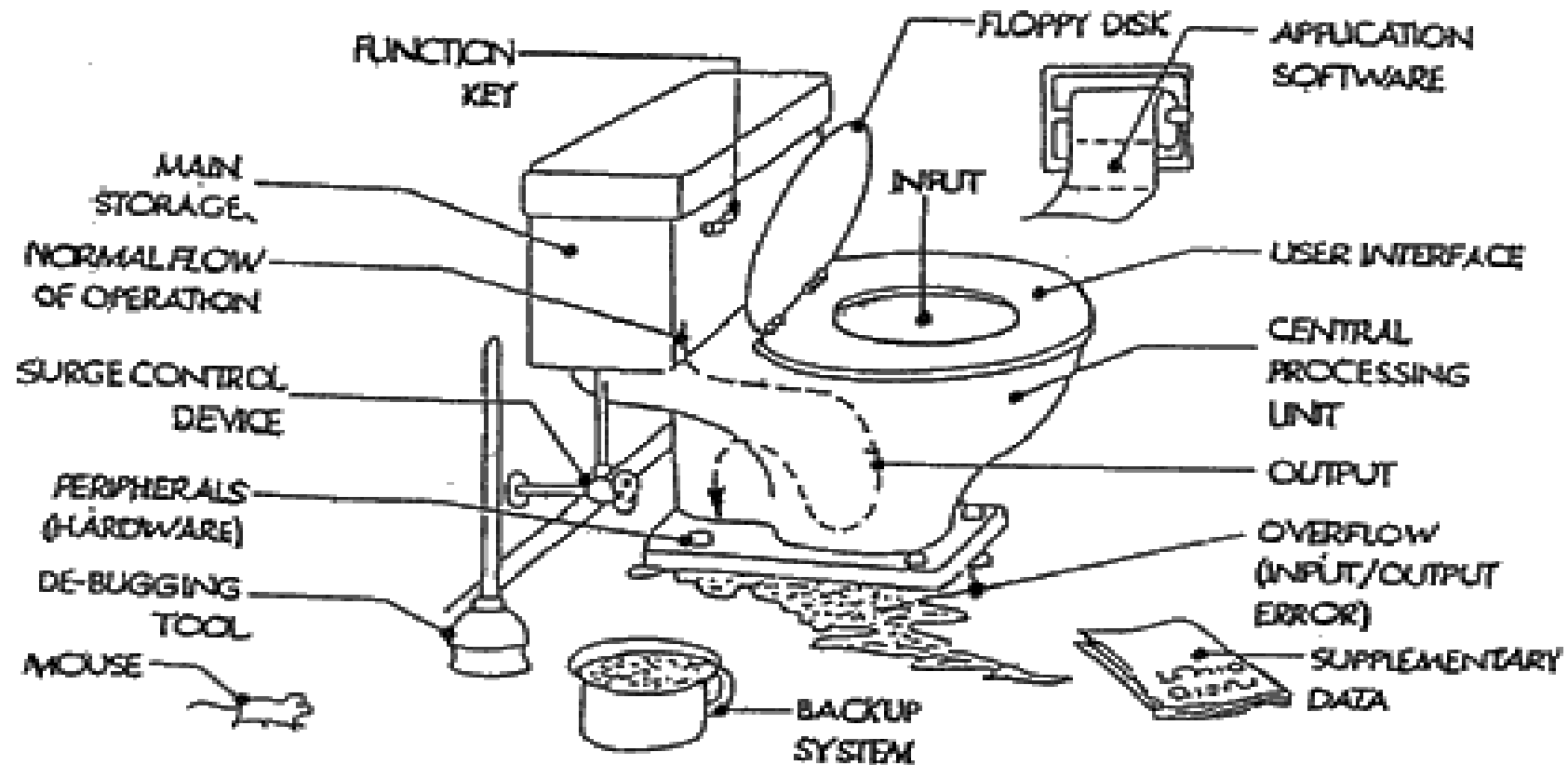
- Micrometer or one millionth of a meter ($1 \times 10^{-6} \text{m}$)
- Strand of human hair is about 100μ wide
- Red blood cells $\sim 8 \mu$ in diameter
- Upper size for airborne virus particle $\sim 50 \text{nm}$ (0.05μ)

The Technology

- Angstrom (Å)
 - Equal to 0.1nanometer (0.1×10^{-9} meter)
 - Visible light ranges from 4000 to 7000 Å
 - Some atom radii is ~ 1 to 2 Å

Another look at a computer system

Understanding Computer Technology



Quote ...

- *Where... the ENIAC is equipped with 18000 vacuum tubes and weighs 30 tons, computers in the future may have 1000 vacuum tubes and perhaps weigh just 1.5 tons.*
 - *Popular Mechanics, 1949*

Quote ...

- *I thought computers would be a universally applicable idea, like a book is. But I didn't think it would develop as fast as it did, because I didn't envision we'd be able to get as many parts on a chip as we finally got. The transistor came along unexpectedly. It all happened much faster than we expected.*
 - J. Presper Eckert, co-inventor of ENIAC, speaking in 1991

Quote ...

- *Science must begin with myths, and the criticism of myths*
 - Sir Karl Popper, *The Philosophy of Science*, 1957

To recall ...

- What have we learned:
 - ✓ Explain the difference between Computer Organization and Computer Architecture
 - ✓ Explain Von Neumann Architecture
 - ✓ Describe the brief history of computer technology