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Chapter 1

Introduction

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Chapter 1

Introduction

Classes of Computers and Early History of Computing

Learning Objectives (1.1)

1. Describe the following classes of computers:
   - Supercomputers
   - Microcomputers
   - Embedded systems
2. Describe two early computer architecture designs.

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What is a Computer?

- From supercomputer → server → PC → tablet → mobile phone → watch.
  - All these devices contain some form of computational elements.
  - No definitive way to classify computers. But we review three broad categories:

    Supercomputer, microcomputers and embedded systems.



Supercomputer → Microcomputer → Embedded

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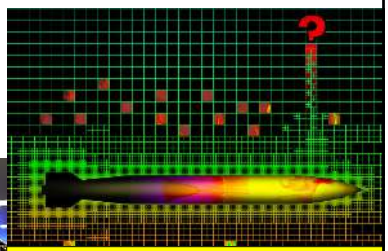
Classes of computers

Supercomputers

- Very large, powerful and expensive computers.
  - High computational performance and can operate on large data sizes (for high precision calculations).
  - Generally scalable by adding more processors.
  - Applications - weather forecasting, simulation of complex physical systems and sub-atomic structures.



Assess Health of Nuclear Bombs

The Titan Supercomputer
at Oak Ridge National Laboratory, USA

Computational peak performance is around 17-27 petaFLOPS.

Titan consist of
•18,000+ Nvidia Tesla K20 GPUs
•700 terabytes of memory

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Classes of computers

Microcomputers

- Microcomputers contain a microprocessor as a processing unit and external memory and peripheral chip support.
  - More powerful **workstations** are used as servers and the more common variety such as desktop **PC** and **notebooks** are for home-office computing applications.

High-end Server

Personal Computer

Notebook

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Classes of computers

Embedded Systems

- Compact devices that usually employ a single-chip (**microcontroller**) containing the processing unit, memory and relevant peripheral support.
  - They are called **embedded** systems as the presence of the microprocessor is non-obvious. Such devices are all around us.

Examples of embedded systems

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Early Days of the Digital Computer

- Major progress made during World War II (1940's)
- Computer research funded mainly by the War Department
- To solve problems related to ballistics

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Typical Ballistic Computation

Analog gear-based computer

- Knobs input numbers such as target speed and course, range to target, wind speed, wind direction, own speed, own course, etc.

  The outputs controlled the motors of the gun.

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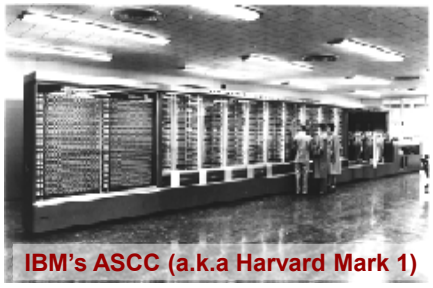
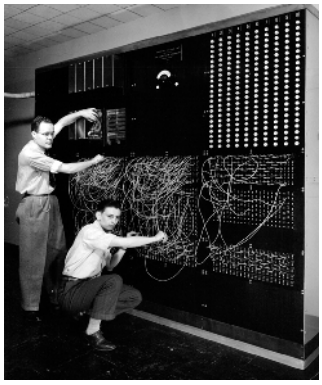
Harvard and Von Neumann

- Two major classes of computer architecture emerged.
- **Harvard architecture**, named after Harvard series of relay calculators developed by Howard Aiken at Harvard Univ.

Howard Aiken



IBM's ASCC (a.k.a Harvard Mark 1)



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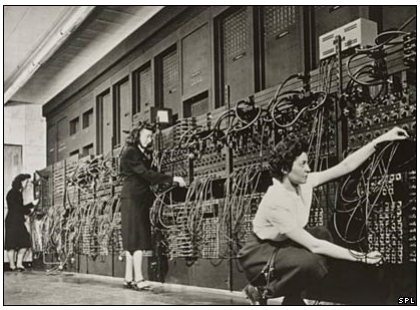
Harvard and Von Neumann

- Two major classes of computer architecture emerged.
- **Harvard architecture**, named after Harvard series of relay calculators developed by Howard Aiken at Harvard Univ.
- **Von Neumann architecture**, developed by John Von Neumann at Princeton University. Influenced ENIAC's design.

ENIAC

John von Neumann



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Harvard and Von Neumann

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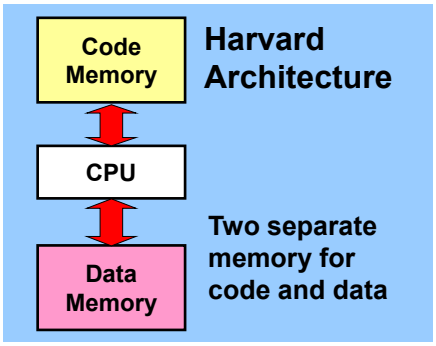

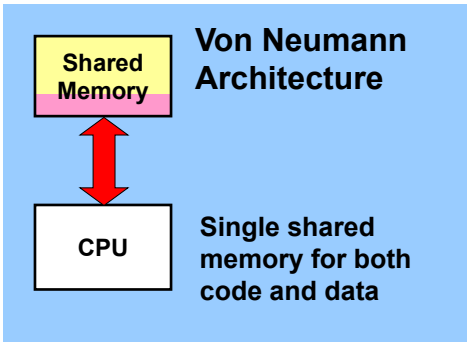

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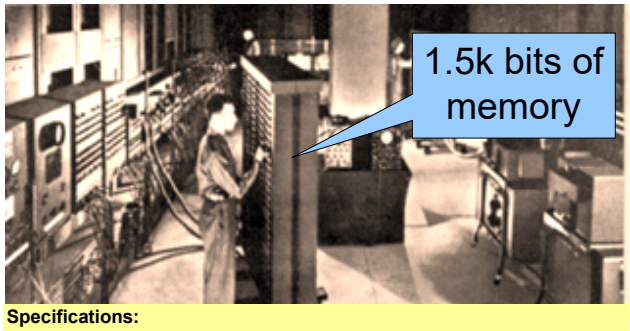
ENIAC – the first digital computer



Specifications:
Weighed 30 tons, contained 19,000 vacuum tubes, 1,500 relays and consumed 200kW of power.

Electronic Numerical Integrator and Calculator

- In 1943, the US army funded Presper Eckert and John Mauchly at Univ. of Pennsylvania to build ENIAC, based on **von Neumann's architecture**.

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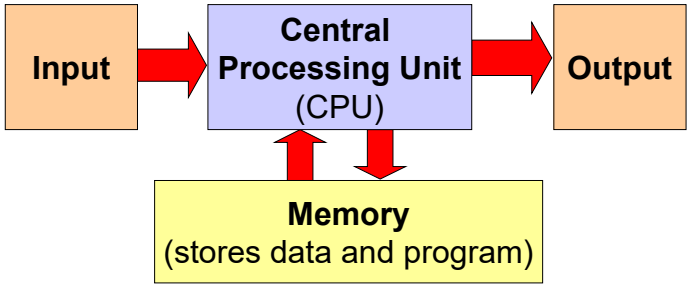
The von Neumann Architecture



- Many modern day computers are still based on von Neumann's design, which consist of:
  - Central Processing Unit (CPU)
  - Memory - very critical component ; stores both data and instructions
  - Input and Output

→ the access speed of the memory usually determines the performance of computer
→ A fast processor with a fast clock that is coupled with slow memory will still execute instructions slowly.

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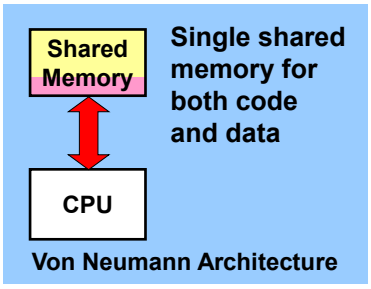
Summary

- Computers can be classified in many ways, e.g. by function, size, general design, etc.
- We looked at three classes, namely supercomputers, microcomputers and embedded systems.
- Two early rivals in computer architecture designs, the **Harvard** and **von Neumann** architectures.
- In part, due to the high cost of memory in the early days of computing, the shared memory design of the von Neumann design became the preferred architecture.



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Chapter 1

Introduction

Basic Components of a Microcomputer

Learning Objectives (1.2)

1. Describe the basic components of a microcomputer.
2. Describe the purpose of the CPU clock and reset circuitry.

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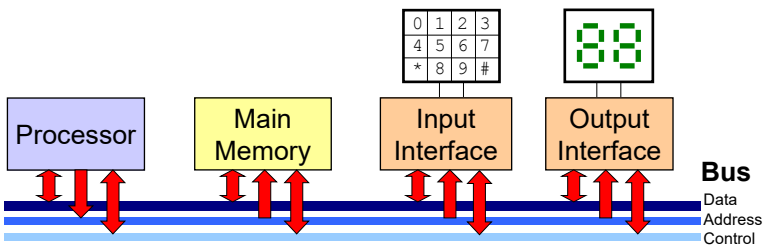
Components of a Microcomputer



- Consist of three main components: **processor**, main **memory** and **I/O** interfaces.
- They are interconnected by a **bus** structure, which consist of a collection of wires through which binary information can be transferred in parallel.

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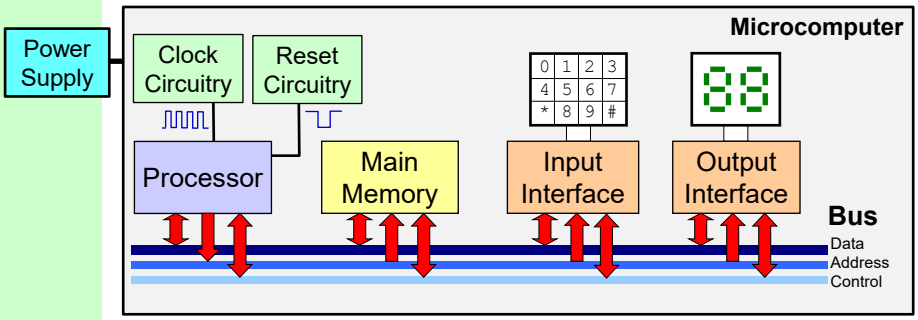
Components of a Microcomputer



- Consist of three main components: **processor**, main **memory** and **I/O** interfaces.
  - They are interconnected by a **bus** structure, which consist of a collection of wires through which binary information can be transferred in parallel.
  - Other important components include the **power** supply, CPU **clock** and **reset** circuitries.

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Clock

- Most computers are **synchronous** and are driven by a master or system **clock**.

higher clock rate, faster execution

  - The **speed performance** of the computer is governed by the frequency of the clock.
  - The CPU requires a fixed number of clock ticks (**cycles**) to execute each instruction.
  - Many **different clock** frequencies are derived from the one master clock.
  - Operation closer to the CPU core (e.g. registers and arithmetic & logic units) are **clocked faster** and those involving external components (e.g. memory or peripheral access) are **clocked slower**.

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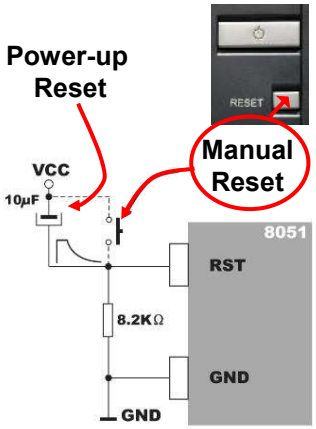
Reset Circuitry

- The CPU is put into a known state on power up. The **reset circuitry** provides an external signal that asserts the Reset pin when power is applied.
  - An active-low signal on the reset pin for a **substantial duration** (several clock cycles) is required to reset the CPU.
  - Most computer system provide an additional **manual reset** button to reset the CPU without switching off the power.
  - On reset, the CPU is put into a known initial state where the boot-up code can then execute.



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Summary

- The basic components within a computer consist of the CPU, memory and I/O interfaces.
- The **memory** is a very critical component in a computer as it stores both data and instructions.
  - The access speed of the memory usually determines the performance of the computer.
  - A fast processor with a fast clock that is coupled with slow memory will still execute instructions slowly.
- Understanding how data and instructions are organised in memory can help programmers write more **efficient programs**.

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1 MB (Megabyte) = 1048576 bytes = 2^{20}

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Chapter 1

Introduction

Desktop PC and Tablet PC Examples

Learning Objectives (1.3)

1. Describe the hardware composition of a desktop PC.
2. Describe the hardware composition of a tablet computer.

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Computer Hardware Decomposition

- What are the major components within the typical computers that we use?

Desktop Personal Computer

Tablet Computer

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Inside a Desktop Personal Computer

- Major components of a desktop PC

A Gamer's PC

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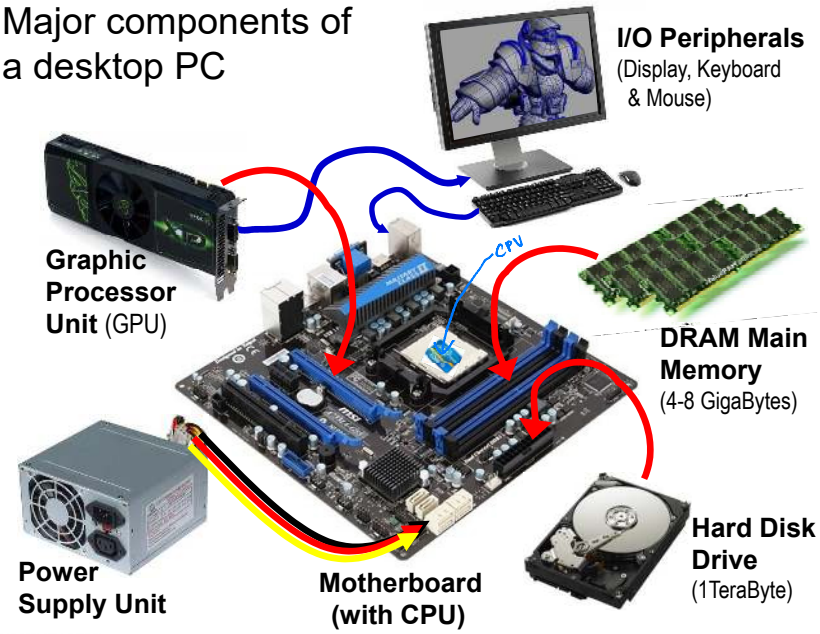
Inside a Desktop Personal Computer

- Major components of a desktop PC



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Inside a Tablet Computer

- Major components of the iPad2

Source: http://www.appleinsider.com/articles/11/03/11/live_teardown_of_apples_ipad_2_currently_underway.html

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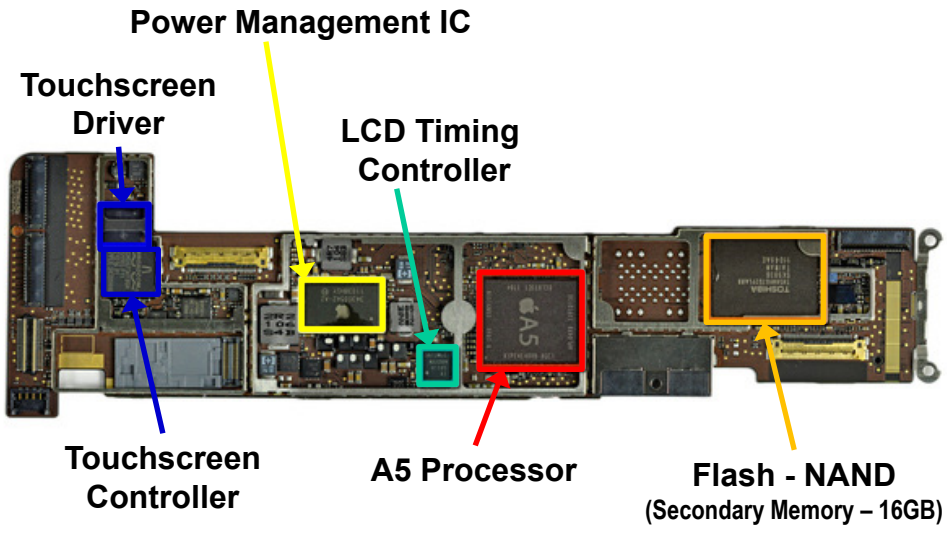
Inside the iPad 2



Source: http://www.appleinsider.com/articles/11/03/11/live_teardown_of_apples_ipad_2_currently_underway.html

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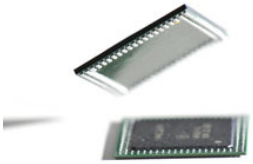
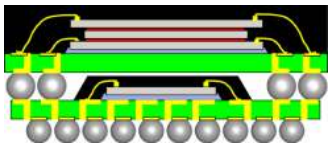
Apple A5 Processor

- The A5 is a **package on package** (PoP) **system-on-a-chip** (SoC) that was designed by Apple and made by Samsung.





Package on package

Source:..http://www.appleinsider.com/articles/11/03/15/x_ray_of_apples_a5_cpu_in_ipad_2_confirms_manufacturing_by_samsung.html

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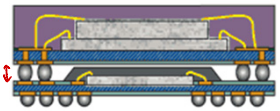
Benefit of PoP Packaging

- Package on package (PoP) is an IC packaging technique that vertically stacks and interconnect separate packages (e.g. CPU and memory) via ball grid array (BGA) connections.
- Some benefits of PoP packaging:



  - **Save space** on motherboard - reduce size of product.
  - **Minimize track length** between CPU and memory - faster signal propagation and reduced electrical noise.
  - Memory units can be **tested separately** before combining with CPU units - improve manufacturing yield and supports multiple memory suppliers.
  - **Different-sized memory** can be coupled with CPU based on user requirements - simplifies inventory control.

Try: Google Search "Benefits of Package on Package"

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A5 Processor (System-on-a Chip)

- The A5 processor is with its built in I/O interfaces and support is considered a system-on-a-chip (SoC).
- A dual-core **ARM Cortex-A9** CPU with 4.5MB cache memory.
- 1GHz CPU clock, can be dynamically reduced to save battery life.
- 512MB low-power DDR SDRAM (@533MHz).
- Dual core PowerVX SGX543MP2 GPU to speed up graphics.

Source:http://www.appleinsider.com/articles/11/03/15/x_ray_of_apples_a5_cpu_in_ipad_2_confirms_manufacturing_by_samsung.html

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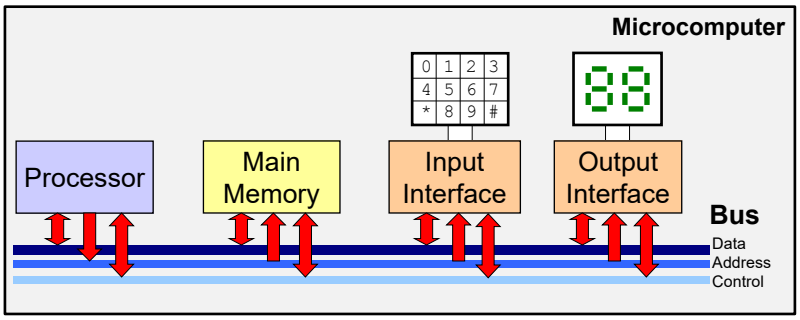
Summary

- Whether a desktop or tablet PC, the basic components of a computer remains the same.
- These basic components are essentially the **CPU**, **memory** and the various **I/O interfaces** that permit peripherals to be connected to the computer.



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Two's Complement Numbers

Give the decimal value of the 8-bit hexadecimal 2's complement number **0x80**?

Computing 2's Complement value:

$1000\ 0000_2$ - negative number – (?)

$0111\ 1111_2$ - complement

$1000\ 0000_2$ - add 1 to give –(128)

A. 80

B. 128

C. - 0

✓ D. -128