CZ1006
CE1006

Introduction

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Introduction

Classes of Computers and Early History of Computing

Learning Objectives (1a)

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

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**

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, etc.

The Titan Supercomputer
at Oak Ridge National Laboratory, USA

The world's fastest supercomputer at 20 petaflops (as of Nov 2012)

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

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

Classes of computers

Embedded Systems

- Compact devices that use 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

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

Typical Ballistic Computation

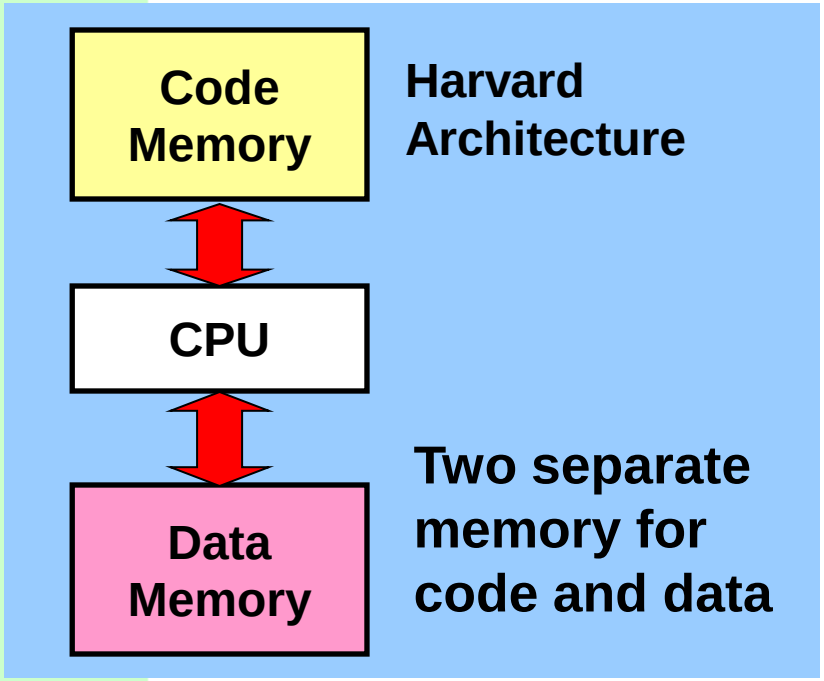
Analog gear-based computer

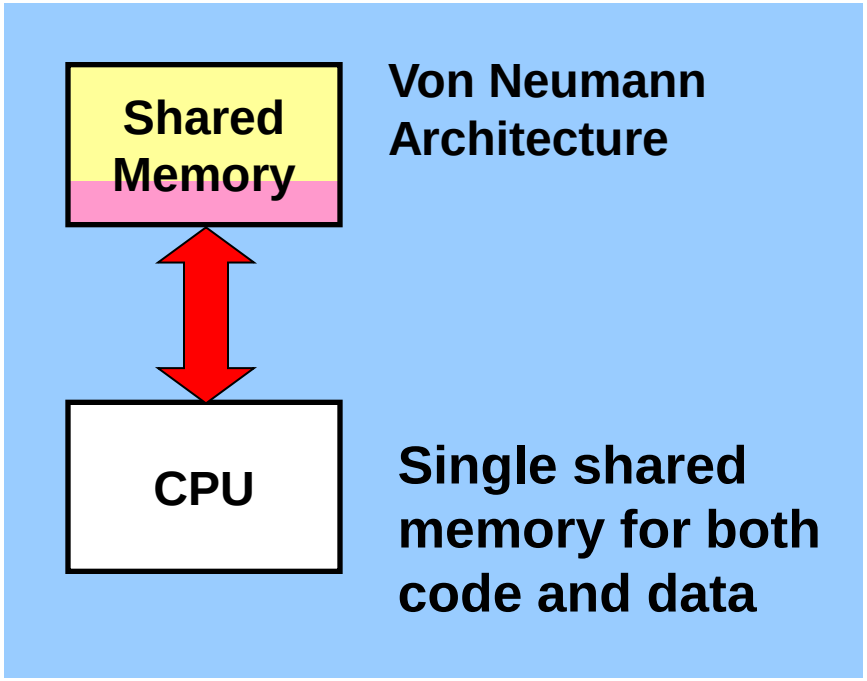
- Knobs input numbers such as target speed and course, range to target, wind speed, wind direction, own speed, own course, etc.

  The outputs controlled the motors of the gun.

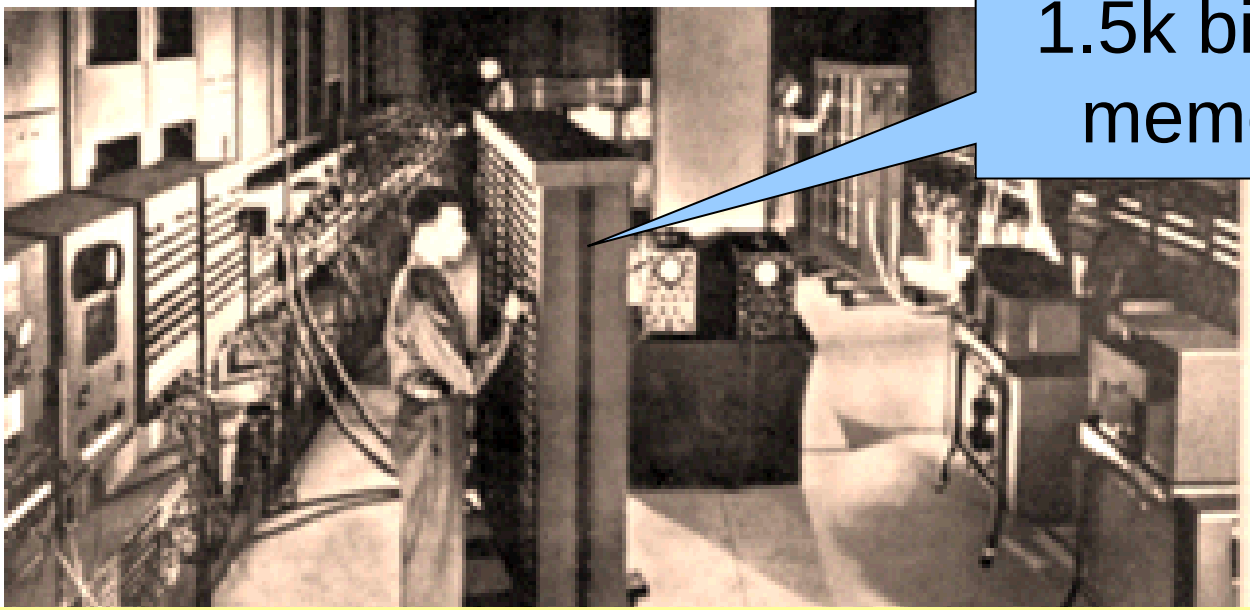
Harvard and Von Neumann

- 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 – the first digital computer

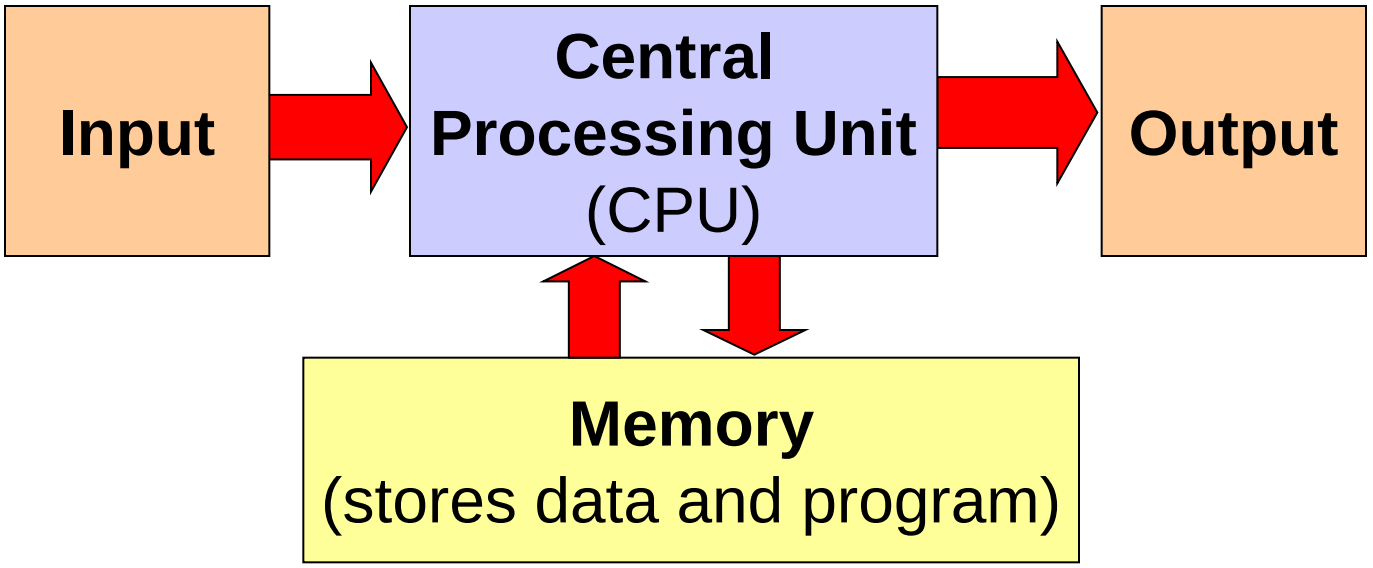


Specifications:
Weighed 30 tons, contained 19,000 vacuum tubes, 1,500 relays and consumed 200kW of power.

Electronic Numerical Integrator and Calculator

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

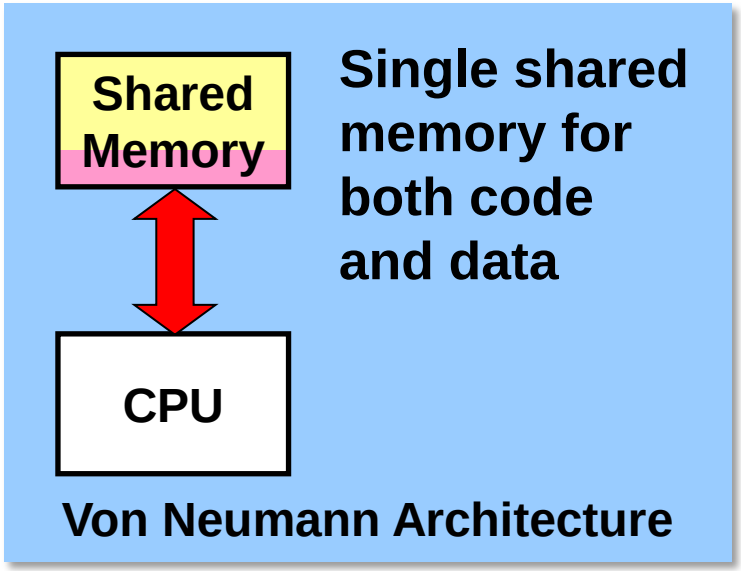
The von Neumann Architecture



- Many modern day computers are still based on von Neumann's design, which consist of:
  - Central Processing Unit (CPU)
  - Memory
  - Input and Output

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.



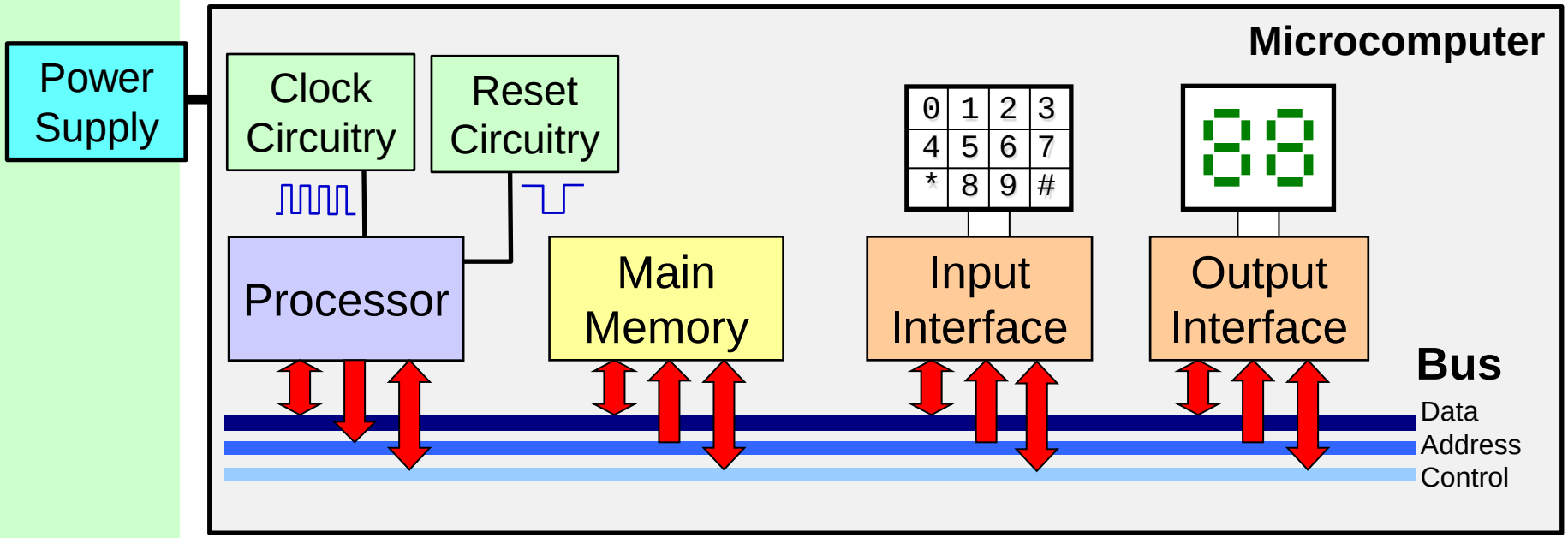
Introduction

Basic Components of a Microcomputer

Learning Objectives (1b)

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

Components of a Microcomputer



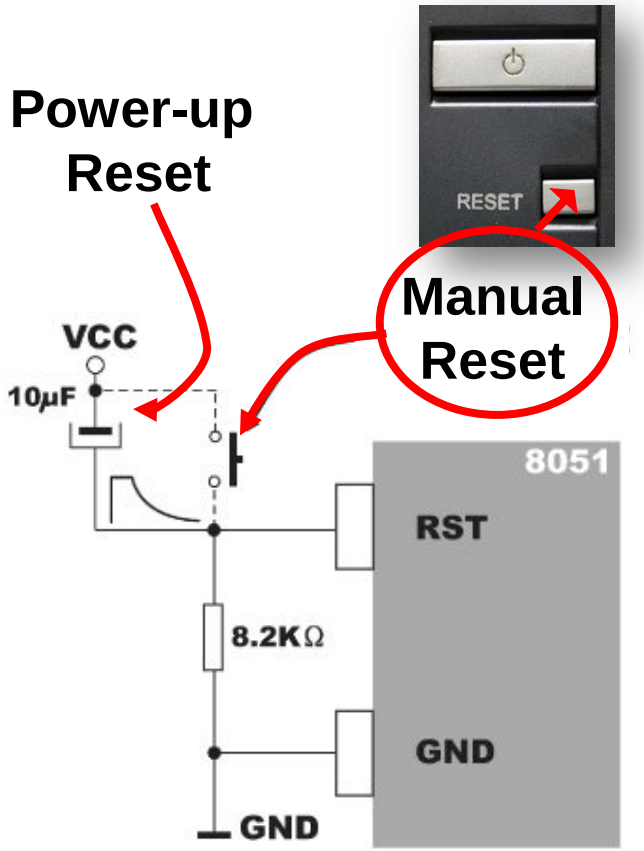
- Consist of three main components: **processor**, main **memory** and **I/O** interfaces.
  - They are interconnected by a **bus** structure, which consist of a collection of wires through which binary information can be transferred in parallel.
  - Other important components include the **power** supply,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

Clock

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

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 executed.



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**.

Introduction

Desktop PC and Tablet PC Examples

Learning Objectives (1c)

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

Computer Hardware Decomposition

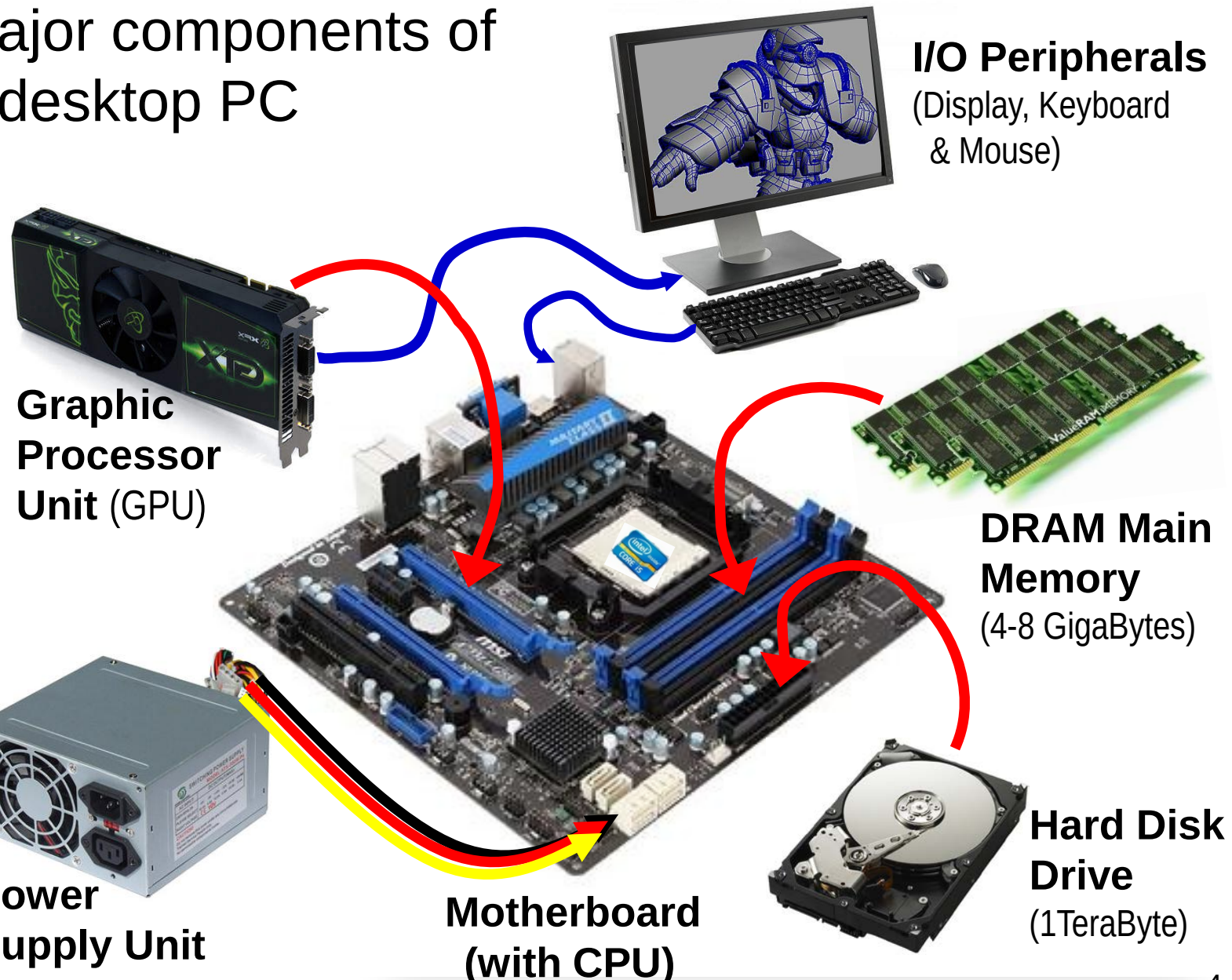
- What are the major components within the typical computers that we use?

Desktop Personal Computer

Tablet Computer

Inside the Desktop Personal Computer

- Major components of a desktop PC

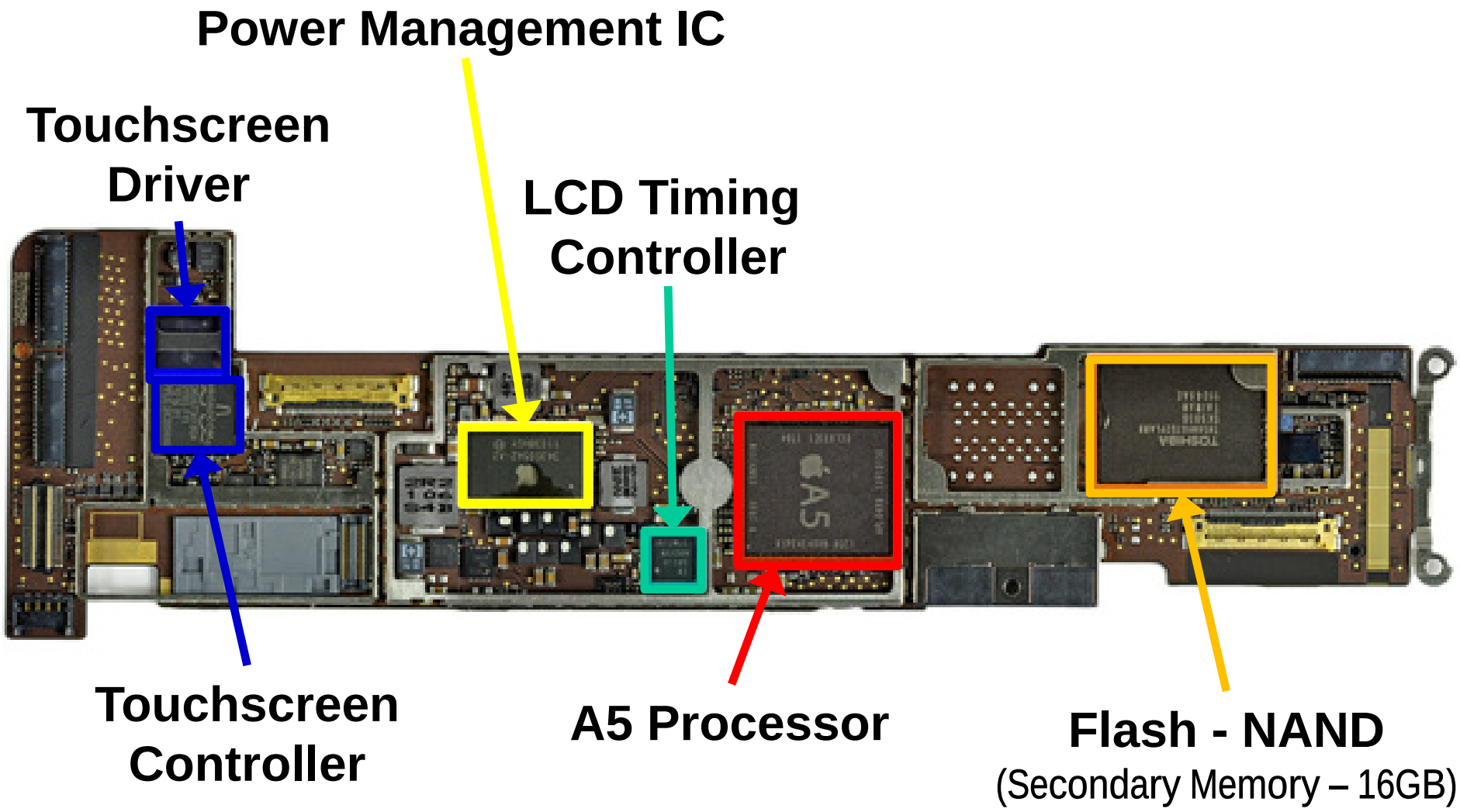


Inside the Tablet Computer

- Major components of the iPad2

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

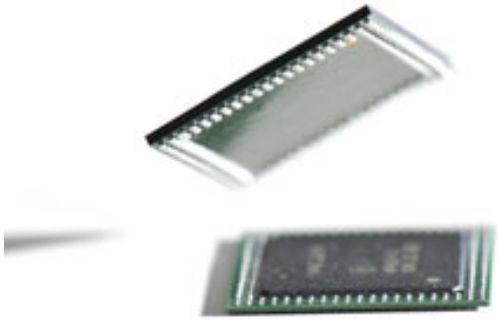
Inside the iPad 2

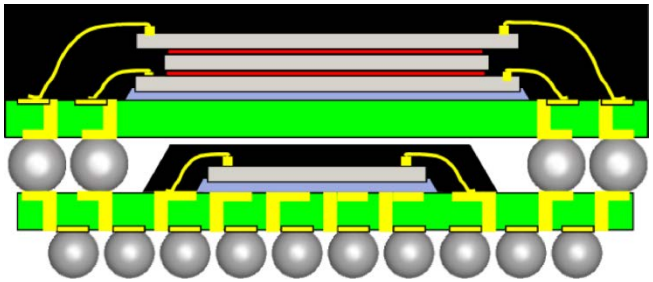


Source: http://www.appleinsider.com/articles/11/03/11/live_teardown_of_apples_ipad_2_currently_underway.html

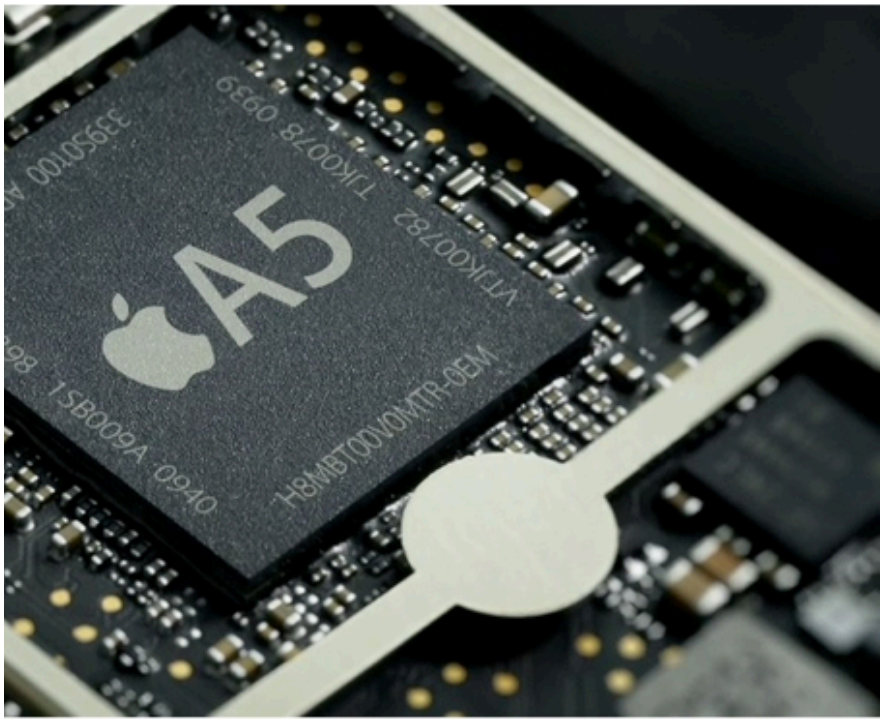
Apple A5 Processor

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





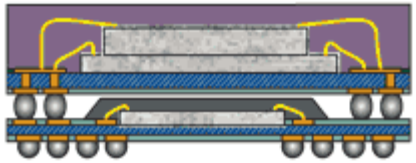
Package on package



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

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”

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

Summary

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