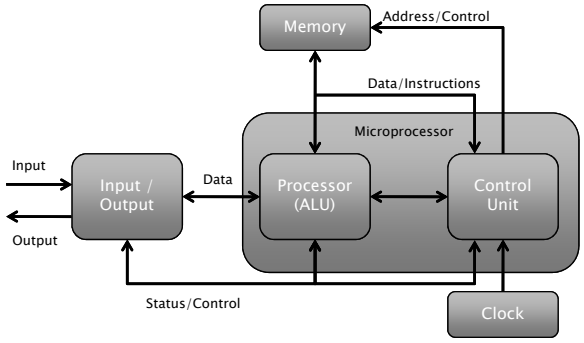
Lecture 1:
Introduction to Microcomputers

Today's Topics

- What is a microcomputers?
- Why do we study microcomputers?
- Two basic types of microcomputer architectures
- Internal components of a microcomputers

Microcomputer

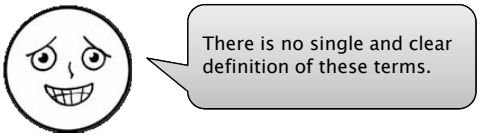
- Major components of the computer – the processor, the control unit, one or more memory ICs, one or more I/O ICs, and the clock
- A single printed circuit board usually connects the ICs, making a computer called a ***microcomputer***



Another definitions

Microcomputers, Microcontrollers, and Microprocessors

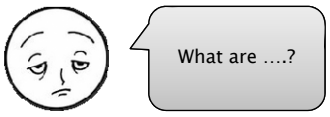
- Microcomputer
  - Relatively small and inexpensive computer that is contained on one or a few chips
- Microcontroller
  - A single-chip microcomputer
- Microprocessor
  - The processor and control unit part of the single-chip computer(=microcontroller) is called microprocessor.



Why do we study Microcomputers?

- Embedded systems use microcontrollers or microcomputers.
- Some interesting statistics (from a few years ago)
  - An average American interacts with 300 or more embedded systems every day.
  - 95% of all microprocessor will be sold each year for embedded systems.
  - IEEE estimated that over 700,000 people worldwide were employed writing code for embedded system in 2007.

Basic Architecture



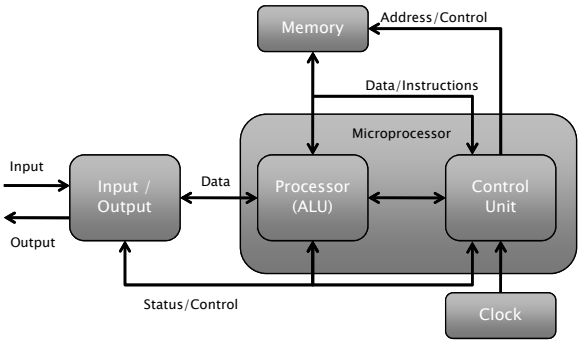
Princeton and Harvard

- There are many other architectures in use. They will be discussed in a computer architecture course.
- Here, we will cover two major architecture of microcomputers.
  - Princeton and Harvard architecture
  - The main difference is the memory structure
- Princeton Architecture*
  - Known as Von Neumann architecture
  - Single memory contains both the program code and the data.
- Harvard Architecture
  - Two separate memories. One contains only data while the other is containing only program code.

Princeton Architecture

Known as Von Neumann

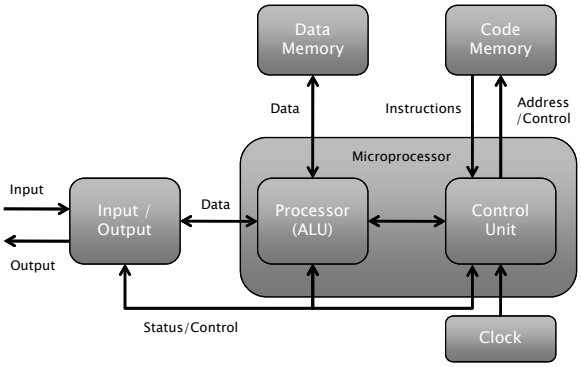
- No separate memory space for program code and data



Harvard Architecture

OK.. I see. One clear distinction of these two is whether two separate memory units exist or not.

- Two separate memory units
- The length of an instruction could be different from the data size
- Both data and a program instruction can be read at the same time



Major components

1. Processor

- Also called an arithmetic logic unit (ALU).
- Operations such as addition, subtraction, bit-wise AND and OR, shift operations.
- The processor has registers (groups of D flip-flops used to store binary values).
- Many microcontrollers perform operations on data that is located in a register. This requires the microcontroller to load the data from memory into a register in the processor, manipulate the data, then store the new value back to memory.
- The processor also generates signals that indicates when values are negative, zero, or when arithmetic overflow occurs.

Major components

2. Control Unit

- A synchronous sequential machine that coordinates the flow of data between the other units and operations of the other blocks.
- The sequence of states and control output of the unit depend on the inputs: the current program instruction, the status outputs of the other blocks, and the input/output block.
- Generally speaking, central processing unit (CPU) refers to not only the processor but also the control unit.

A Quick Introduction of HCS12 Microcontroller

HCS12 (=68HC12 or 9S12) family microprocessor

- The Motorola 68HC12 was introduced in 1996 as an upgrade for the 68HC11.
- Features
  - 16-bit CPU
  - Standard 64-KB address space support
  - Multiplexed (address and data) external bus.
  - 0 to 4 KB of on-chip EEPROM
  - 2 KB to 14 KB of on-chip SRAM
  - 10-bit A/D converter
  - 16 KB to 512 KB of on-chip flash memory (or ROM)
  - Etc. etc. etc.

Major components

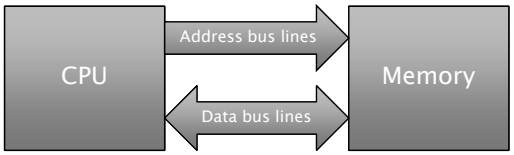
3. Memory

- Memory is the place where program code and data are stored.
- A sequence of directly addressable 'locations.'
- Therefore, the number of addresses available in a memory is limited by the number of bits used to represent the address.
- If 16 bits are used for the address, there are 65,536 ($=2^{16}$) different addresses available.

Major components

3. Memory – continued

- A memory location is referred to as an information unit which has two components: its ***address*** and its ***contents***.



- The content indicated by an address can be interpreted by the microprocessor as one of two things.
  - **Instruction code** are used as inputs into the control unit and determine how it operates. A group of instruction is called a program.
  - **Data** are the numbers to be processed or the results of operations in the processor.

Major components

4. Clock

- A periodic signal for the sequential machine in the control unit.
- Also used by other blocks to synchronize operations

Major components

5. Input/Output

- The Input/Output (I/O for short.) block represents the interface between the internals of the microcomputer and the outside world.
- Keyboard, LED and LCD display, printers for example.

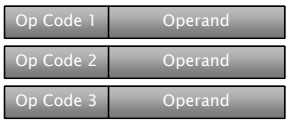
Instruction Codes

- Instruction codes consist of **Operation Code** and **Operand**
- Operation Code (Op Code for short)
  - This tells the microcomputer what action to perform and how to interpret the operand. All instructions must have an op code.
- Operand
  - The operand contains the data that microcontroller will perform the action on.
  - Some operands include several numbers for op codes that specify more complex actions.
  - Some operation codes that perform simple tasks do not need to have operands.

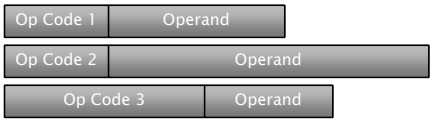
Instruction Length

Fixed and Variable-length

- Fixed length
  - Each instruction is the same number of bits as all others.



- Variable length*
  - The length of each instruction may be different.

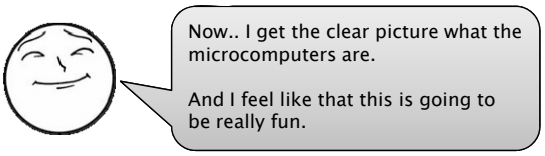


Questions?

Wrap-up

What we've learned

- The definitions of microcomputers, microcontroller, and microprocessor
- The importance of microcomputers in the real world
- Princeton* and Harvard architectures
- Processor, control unit, memory, clock, and I/O are the major components of microcomputers.



What to Come

- Review number systems
- Introduction to the HCS12/9S12