Computer Organization

605.204

Module Three

Part One

Assembly Language

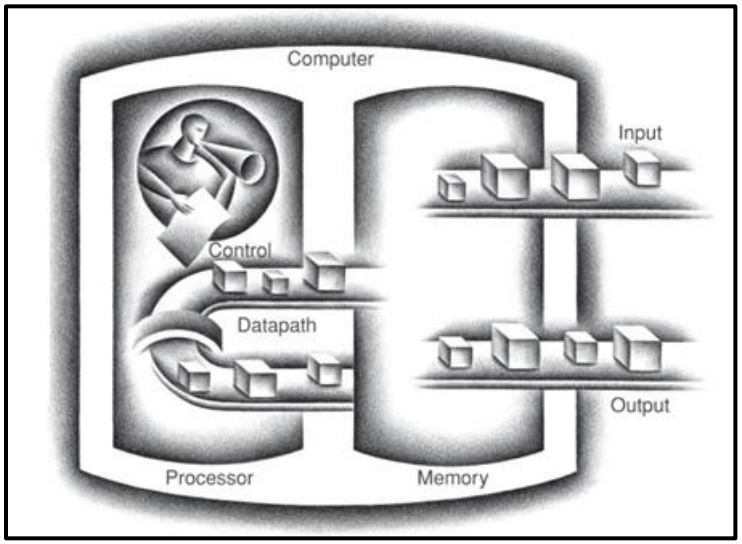
Module Three

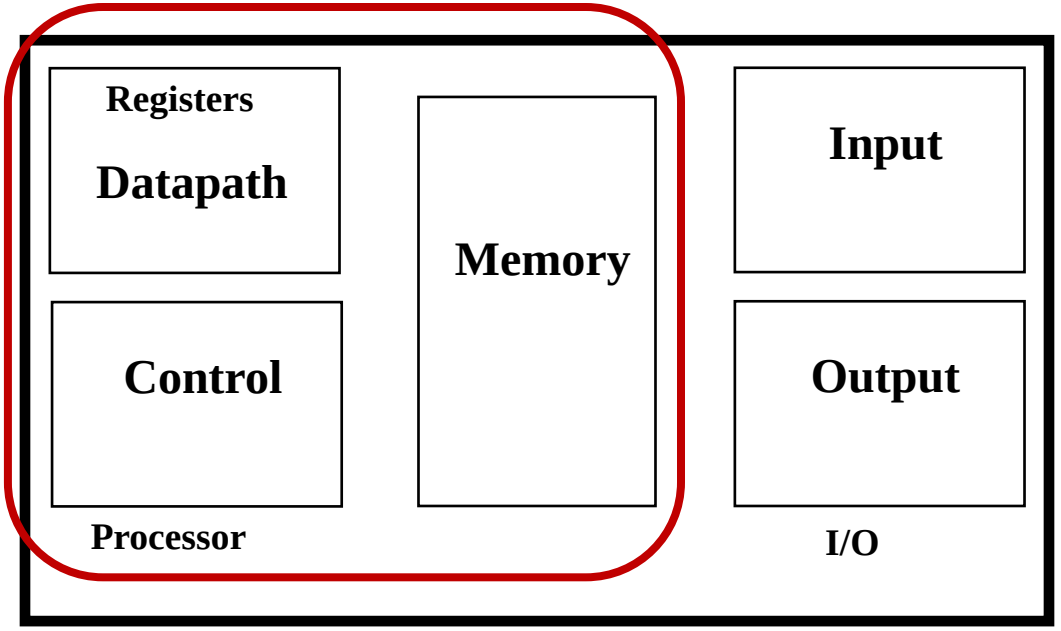
- Part One

- This week:
- A simple machine
- Language of the machine
- People Language
- Assembly Language
- MIPS Machine Code

A Simple Organization

- A Big Picture





A Program

```
swap:   muli    $v0, $a1, 4
        add     $v0, $a0, $v0
        lw      $t7, 0($v0)
        lw      $s0, 4($v0)
        sw      $s0, 0($v0)
        sw      $t7, 4($v0)
        jr      $ra
```

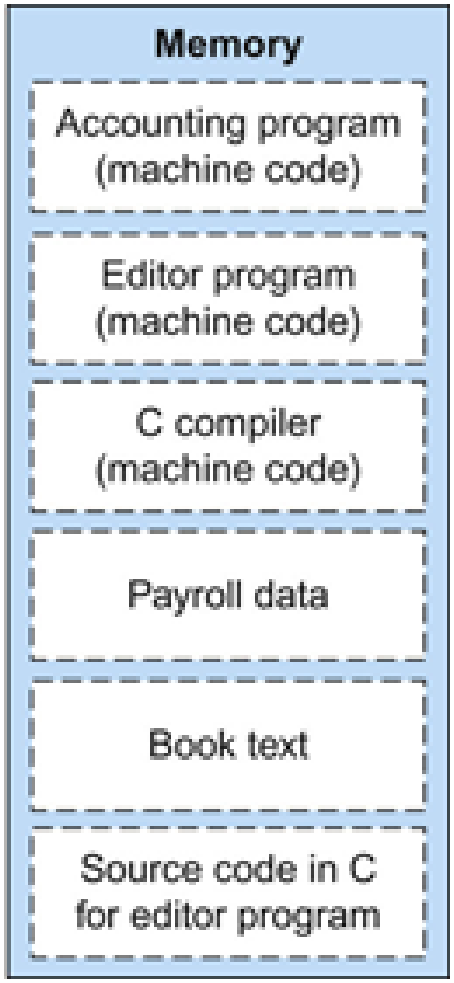
```
00000000101000010000000000011000
00000000000110000011000001000001
10001100011000100000000000000000
10001100111100100000000000000000
10101100111100100000000000000000
10101100011000100000000000000000
00000011110000000000000000001000
```

This program swaps data from one memory location to the next.

Stored Program Idea

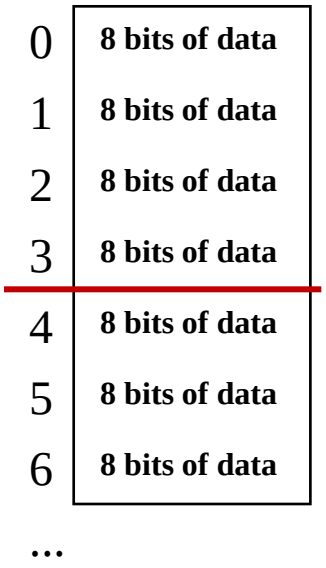
- Two key principals are the foundation of today's computers:
- **First**: Instructions are numbers.

  101011 00111 10010 0000000000000100
- **Second**: Programs can be stored in memory as numbers in the same way that data is stored in memory as numbers.
- The instructions are fetched from memory in the same way that data operands are retrieved from memory.
- Instructions are decoded by the processor to control the actions of the computer.



Memory Organization

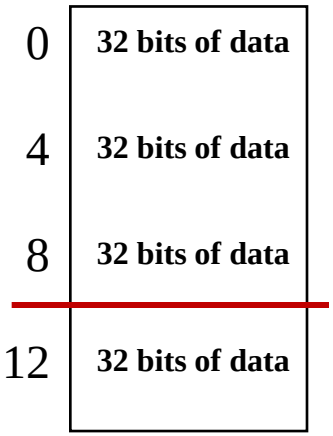
- Viewed as a large, single-dimension array, with an address.
- A memory address is an index into the array.
- "Byte addressing" means that the index points to a byte of memory.
- Bytes, 8 bits of data, are the smallest addressable unit.



Memory Organization

- Bytes are nice, but to be useful most data items use larger "words".
- For MIPS, a word is 4 bytes or 32 bits .

  2^{32} bytes with byte addresses from 0 to 2^{32}-1
- 2^{30} words with byte addresses 0, 4, 8, 12, 16, 20, ...

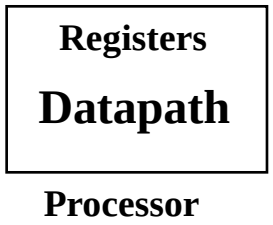


- Words are aligned:

  What are the values of the 2 least significant bits of a word address?

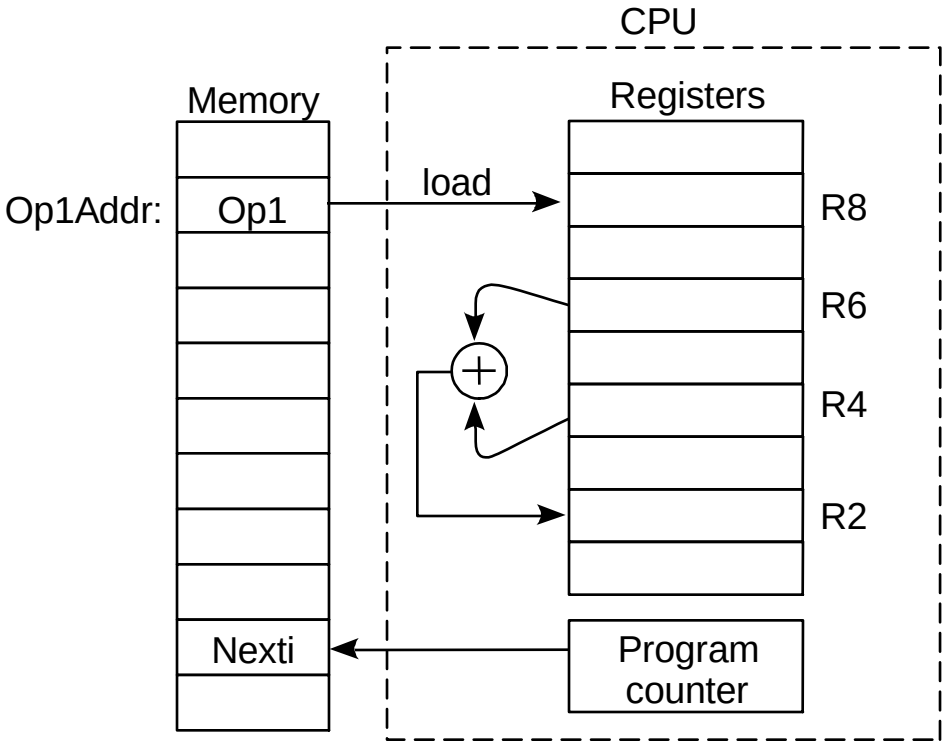
Registers

- Registers are small memory elements
- Special locations, within the Processor
- Registers hold 32 bits of data, 4 bytes, one word
- The MIPS processor has 32 registers.



The General Register Machine

- It is the most common choice in today's general-purpose computers.



Instruction formats

load R8, Op1 (R8 ← Op1)

load	R8	Op1Addr

add R2, R4, R6 (R2 ← R4 + R6)

add	R2	R4	R6

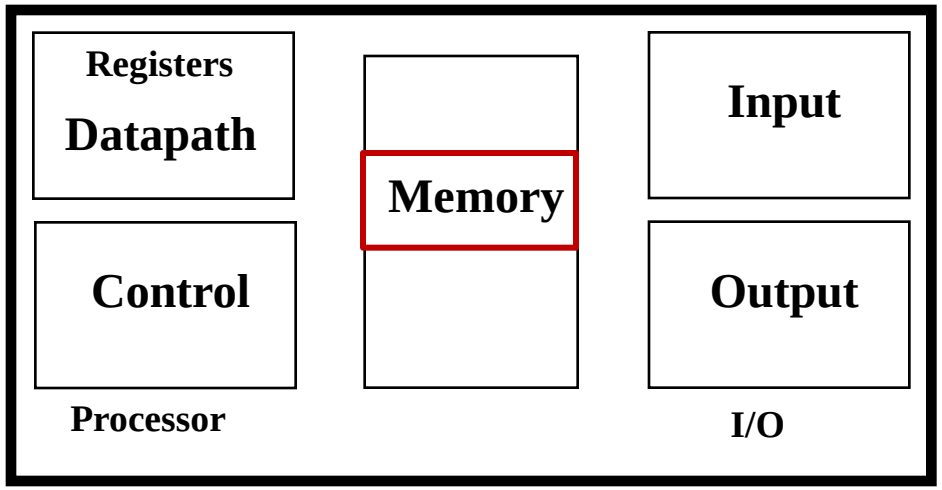
Operands: Memory or Registers

- MIPS is a general register machine.
- MIPS Arithmetic instruction requires that the operands be in registers,

  However,

  only 32 registers

  are provided



- What about programs with lots of variables ?

Summary

- A Simple Machine Organization
- Stored Program Idea
- General Register Machine
- Next: Machine Code