CS2100 COMPUTER ORGANISATION

http://www.comp.nus.edu.sg/~cs2100/

Lecture #1

Introduction

From High-Level Languages to Computer Organisation
(AY2020/21 Semester 2)

Lecture #1: Introduction

1. Programming Languages
2. C Programming Language
3. Abstraction
4. So, What is a Computer?
5. Why Study Computer Organisation?

1. Programming Languages (1/5)

Programming language: a formal language that specifies a set of instructions for a computer to implement specific algorithms to solve problems.

1. Programming Languages (2/5)

High-level program

Eg: C (CS1010), Java (CS1010J), Python (CS1010S), ECMAScript (CS1101S)

```
int i, a = 0;
for (i=1; i<=10; i++) {
        a = a + i*i;
}
```

```
a = 0
for i in range(1,11):
  a = a + i*i
```

Low-level program

Eg: MIPS (CS2100)

Assembly = intermediate language (simplified version)

```
      addi $t1, $zero, 10
      add  $t1, $t1, $t1
      addi $t2, $zero, 10
Loop: addi $t2, $t2, 10
      addi $t1, $t1, -1
      beq  $t1, $zero, Loop
```

Machine code

Computers can execute only machine code directly.

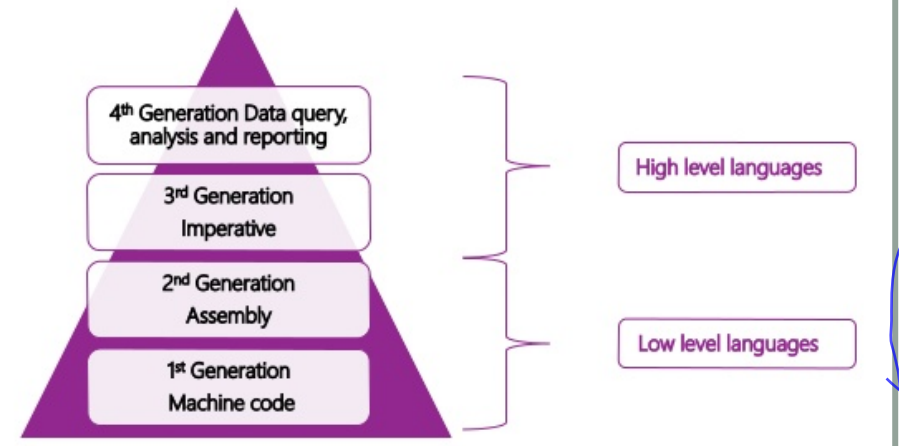
```
00100000000010010000000000001010
00000001001010010100100000100000
. . .
```

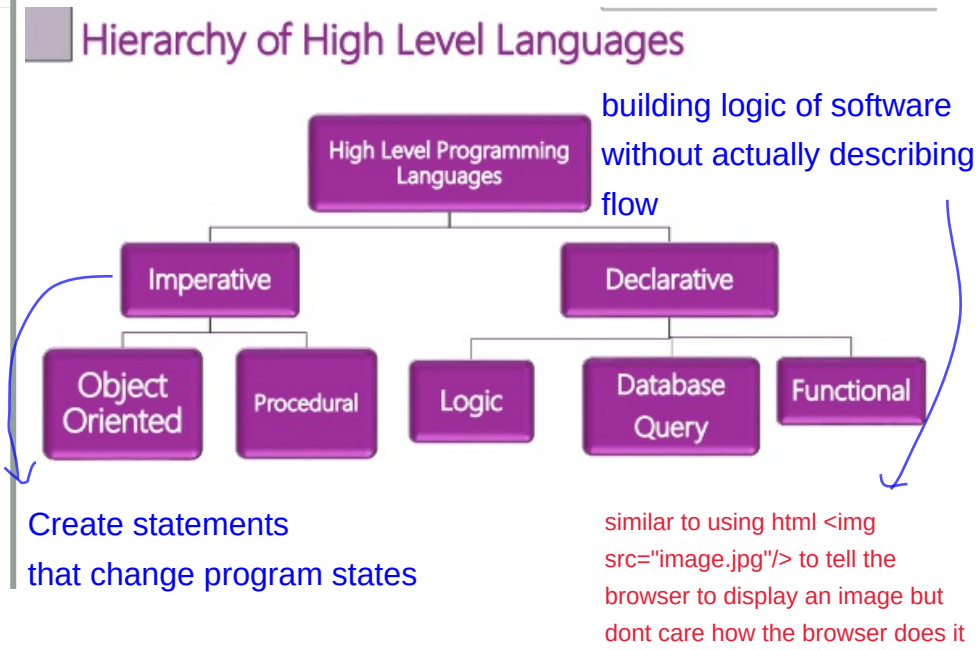
1. Programming Languages (3/5)

- 1st Generation Languages
  - Machine language.
    Directly executable by machine.
    Machine dependent.
    Efficient code but difficult to write.
- 2nd Generation Languages
  - Assembly language.
    Need to be translated (assembled) into machine code for execution.
    Efficient code, easier to write than machine code.
- 3rd Generation Languages
  - Closer to English.
    Need to be translated (compiled or interpreted) into machine code for execution.
    Eg: FORTRAN, COBOL, C, BASIC
- 4th Generation Languages
  - Require fewer instructions than 3GL.
    Used with databases (query languages, report generators, forms designers)
    Eg: SQL, PostScript, Mathematica
- 5th Generation Languages
  - Used mainly in A.I. research.
    Declarative languages
    Functional languages (eg: Lisp, Scheme, SML)
    Logic programming (eg: Prolog)

1. Programming Languages (4/5)

- "Generational" classification of high level languages (3GL and later) was never fully precise.
- A different classification is based on paradigm.





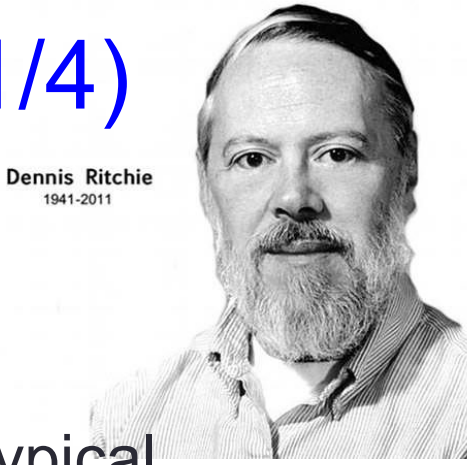
1. Programming Languages (5/5)

- Difference between scripting languages and programming languages

Scripting languages	Programming languages
Eg: JavaScript, PHP, Python	Eg: C, C++, Java
Interpreted; do not require compilation	Compiled
Generally slower	Generally faster

- However, the environment is more important than the language in the classification.
  - We can write a C interpreter and use it as a scripting language
  - We can compile JavaScript to machine code
- The distinction is getting blurred due to improved hardware capabilities and coding practices
  - Eg: Python is widely used without compilation, but the main implementation (CPython) does that by compiling to bytecode on-the-fly and then running the bytecode in a VM (virtual machine)
  - Eg: Java is compiled to bytecode, which is then interpreted/recompiled at runtime

2. C Programming Language (1/4)



- Created by Dennis Ritchie (1941 – 2011) at Bell Laboratories in the early 1970s.
- C is an imperative procedural language.
- C provides constructs that map efficiently to typical machine instructions.
- C is a high-level language very close to the machine level, hence sometimes it is called “mid-level”.
- UNIX is written in C.

HelloWorld.c

```c
#include <stdio.h>

int main(void) {
   printf("Hello, world\n");
   return 0;
}
```

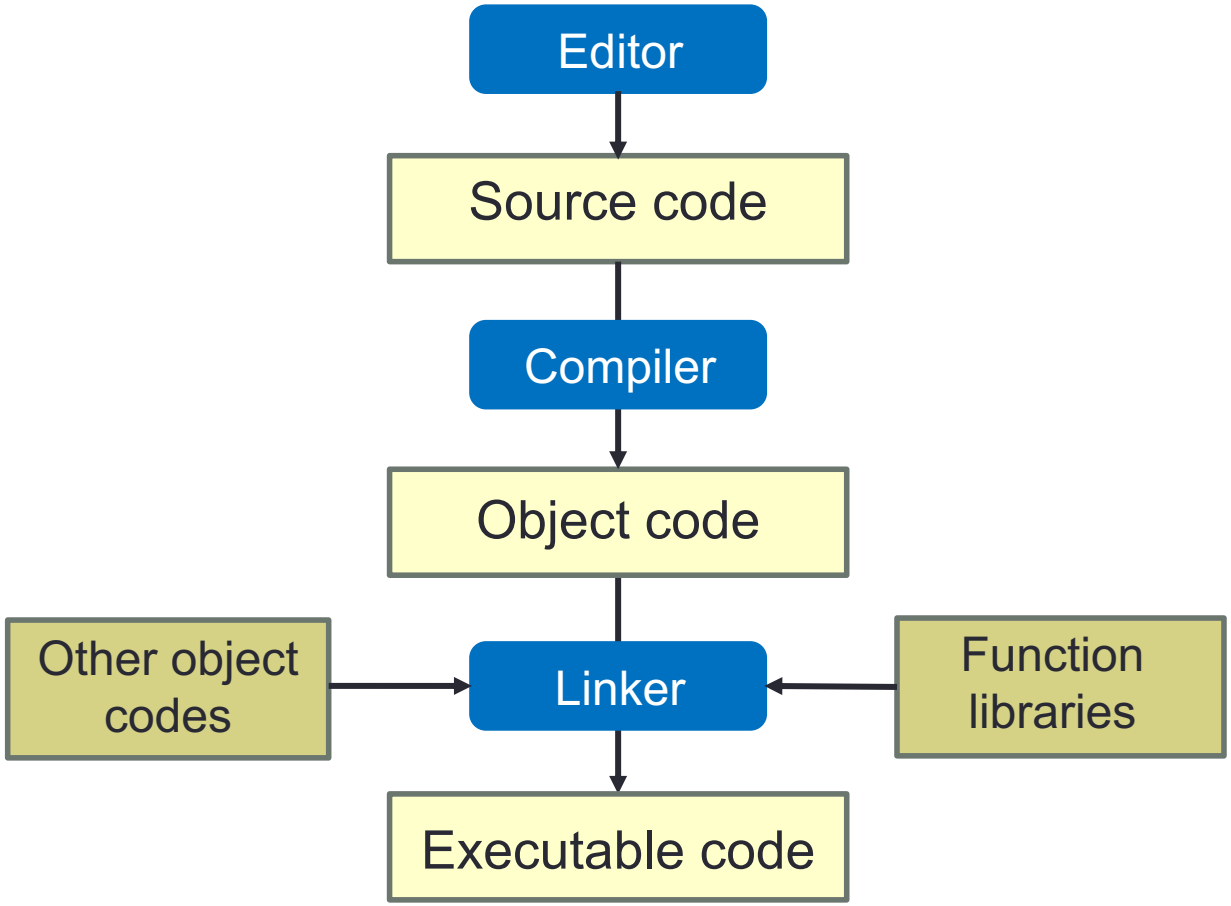
HelloWorld.py

```
print("Hello, world")
```

(Note: All C programs in the lectures are available on the CS2100 website.)

2. C Programming Language (2/4)

- Creating a C program



2. C Programming Language (3/4)

Edit

```
tantc@suna0:~/cs2100/lect/prog/lect1[40]: vim HelloWorld.c
```

Illustration on SoC UNIX server

```
1 // HelloWorld.c
2 #include <stdio.h>
3
4 int main(void) {
5     printf("Hello, world\n");
6     return 0;
7 }
8
~
~
```

Compile and link

```
tantc@suna0:~/cs2100/lect/prog/lect1[42]: ls
HelloWorld.c
tantc@suna0:~/cs2100/lect/prog/lect1[43]: gcc HelloWorld.c
tantc@suna0:~/cs2100/lect/prog/lect1[44]: ls
a.out          HelloWorld.c
tantc@suna0:~/cs2100/lect/prog/lect1[45]:
```

Execute

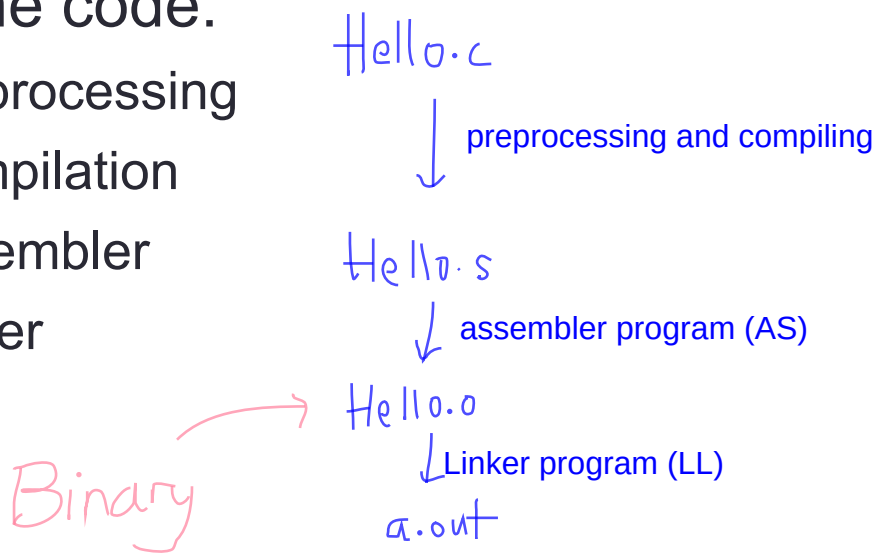
```
tantc@suna0:~/cs2100/lect/prog/lect1[46]: a.out
Hello, world
tantc@suna0:~/cs2100/lect/prog/lect1[47]:
```

2. C Programming Language (4/4)

```
tantc@suna0:~/cs2100/lect/prog/lect1[43]: gcc HelloWorld.c
tantc@suna0:~/cs2100/lect/prog/lect1[44]: ls
a.out          HelloWorld.c
tantc@suna0:~/cs2100/lect/prog/lect1[45]:
```

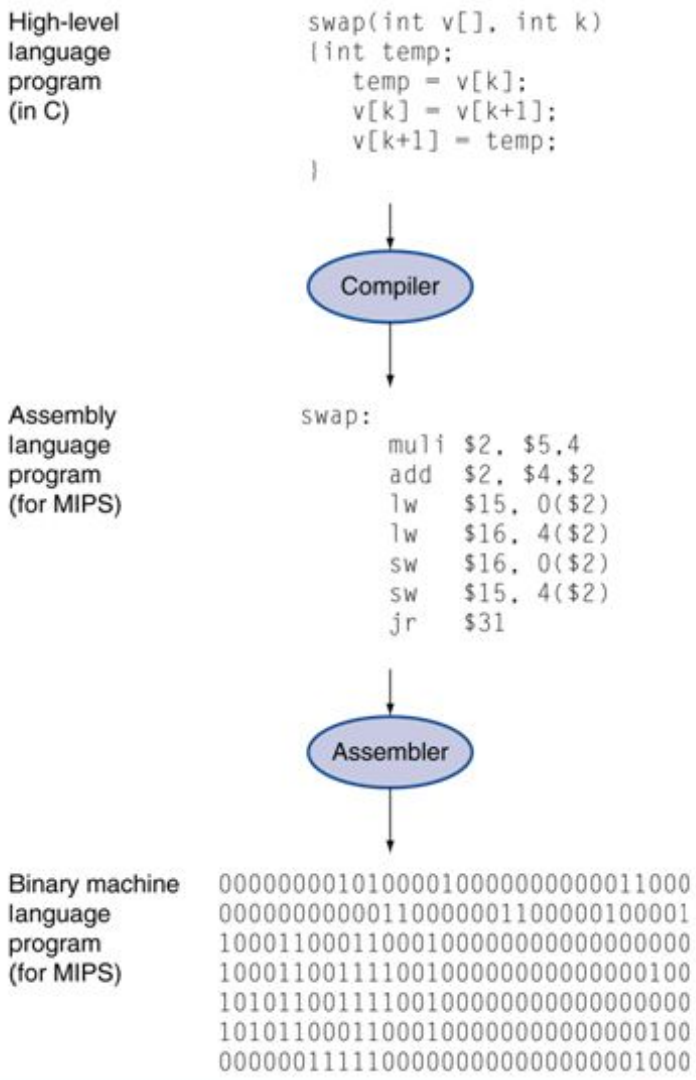
Compile and link

- The command gcc hides all the details
- Using gcc –v HelloWorld.c will display all the details
- The process goes through the following steps to generate machine code:
  - Preprocessing
  - Compilation
  - Assembler
  - Linker



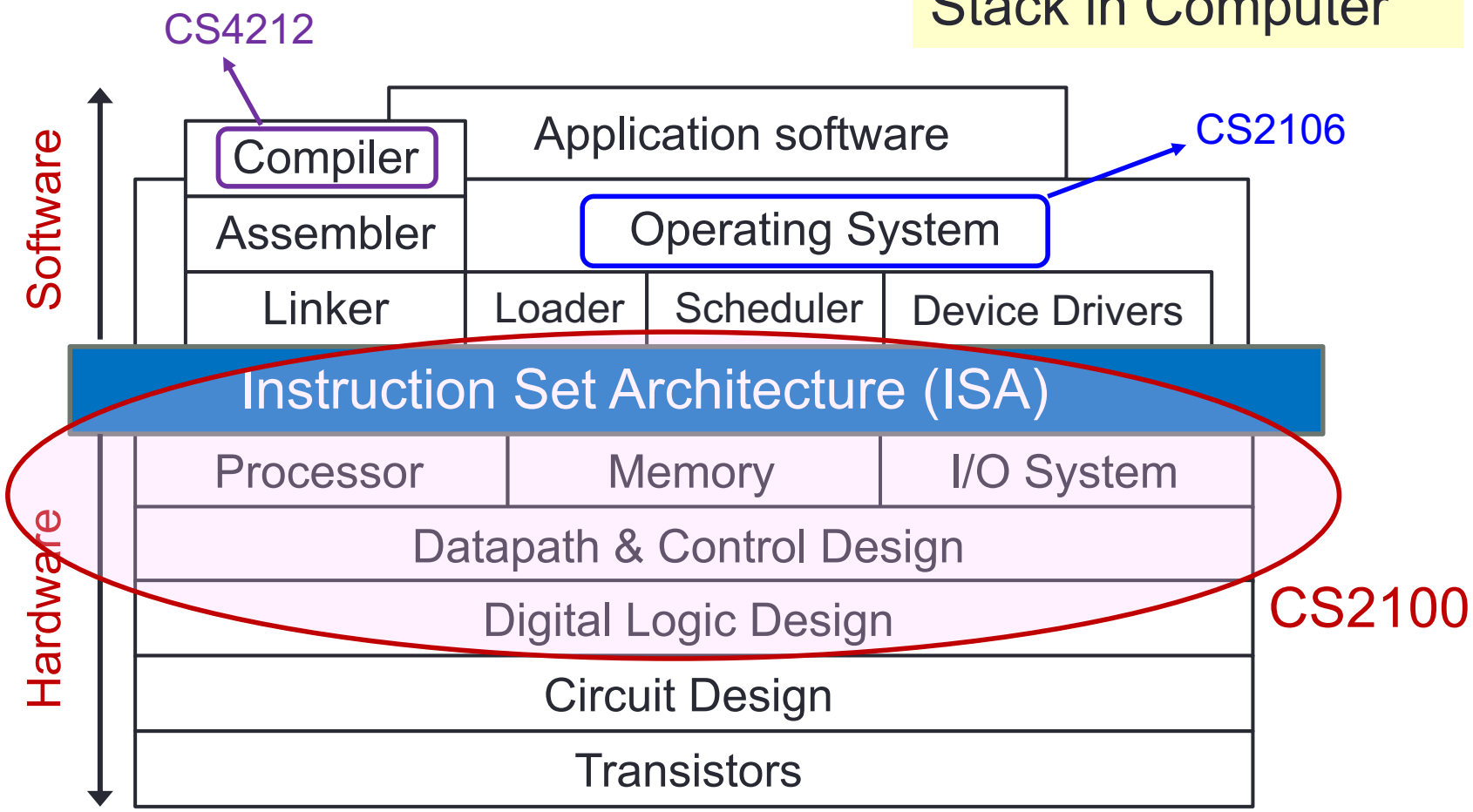
3. Abstraction (1/3)

- High-level language
  - Level of abstraction closer to problem domain
  - Provides productivity and portability
- Assembly language
  - Textual and symbolic representation of instructions
- Machine code (object code or binary)
  - Binary bits of instructions and data



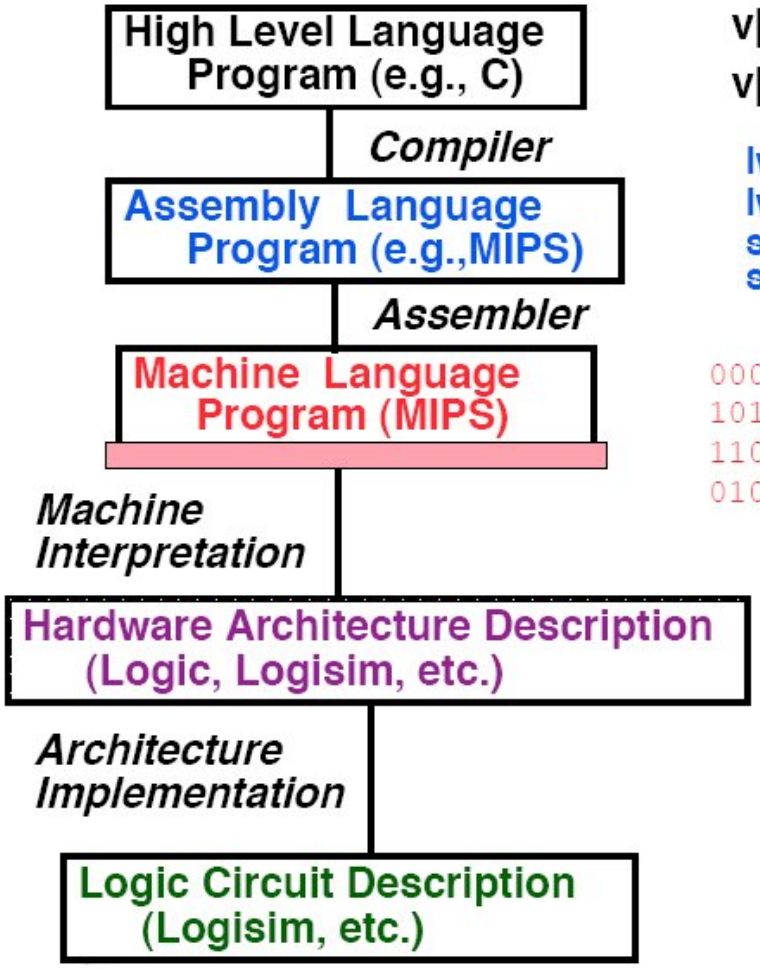
3. Abstraction Layers (2/3)

Hardware/Software Stack in Computer



3. Abstraction (3/3)

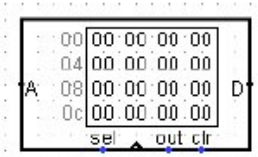
Level of Representation

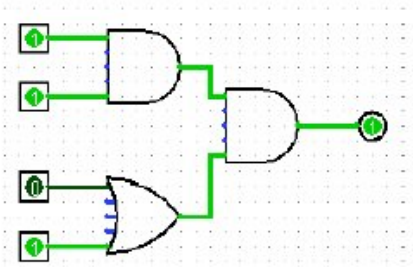



```
temp = v[k];
v[k] = v[k+1];
v[k+1] = temp;
```

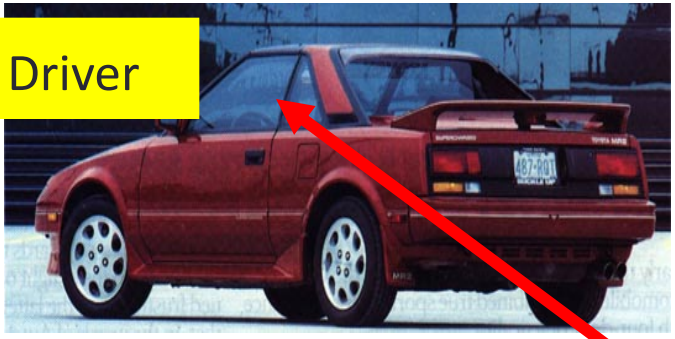
```
lw   $t0, 0($2)
lw   $t1, 4($2)
sw   $t1, 0($2)
sw   $t0, 4($2)
```

```
0000 1001 1100 0110 1010 1111 0101 1000
1010 1111 0101 1000 0000 1001 1100 0110
1100 0110 1010 1111 0101 1000 0000 1001
0101 1000 0000 1001 1100 0110 1010 1111
```



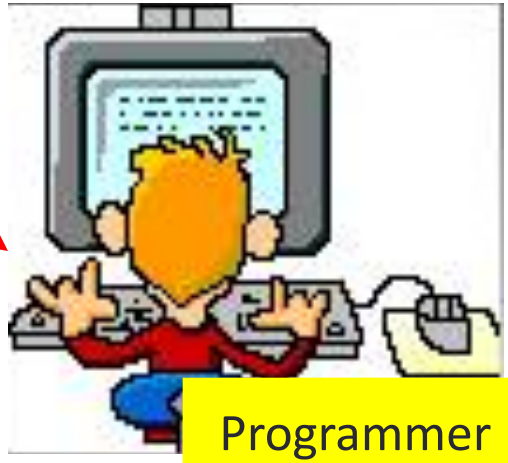


4. So, What is a Computer? (1/6)



Example: An automobile augments our power of locomotion.

A computer is a device capable of solving problems according to designed programs. It simply augments our power of storage and speed of calculation.



4. So, What is a Computer? (2/6)

- From computer organisation perspective, we study the components and how they work together
  - Processor, memory, input/output devices, networks, …

Credit: http://tech4abc.blogspot.sg/2010/08/latest-technology-in-computer-hardwares.html

4. So, What is a Computer? (3/6)

MOST RECENT July 8th, 2012 1 COMMENT »

Most Recent Computer Technology

Written by: admin
Tags: breaking

Do you know what is in your computer? Maybe you peeked when the repair technician was installing amazing for you. When you primary open up the CPU and seem inside, a computer is a very intimidating machine. But once you are acquainted with about the dissimilar parts that make up a total computer it gets a lot easier. Today's computer consists of around eight main devices; some of the advanced computers might have a few additional mechanisms. What are these eight main components and what are they used for? We will start with beginner level facts to get you in progress.

First is the Power Supply. The authority provides is used to provide electrical

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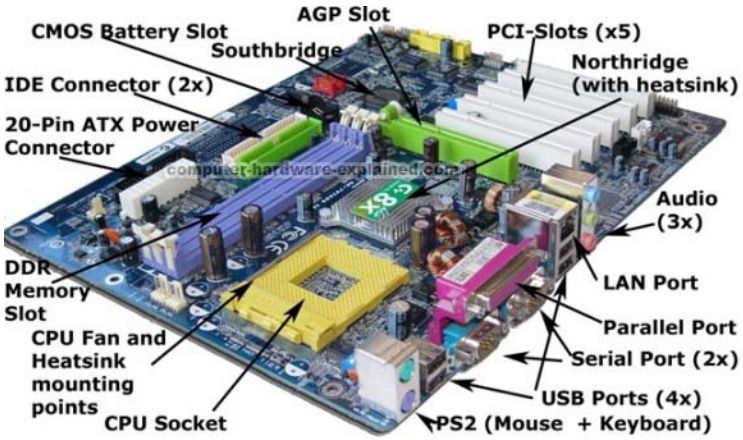
Credit: http://tech3news.com/most-recent-computer-technology/

1. Power supply
2. Motherboard
3. Central Processing Unit (CPU)
4. Random Access Memory (RAM)
5. Hard drive
6. Cooling fan
7. I/O devices

Credit: http://www.overclock3d.net/reviews/cpu_mainboard/the_computer_council_-_clocked_gamer_quad/1

4. So, What is a Computer? (4/6)

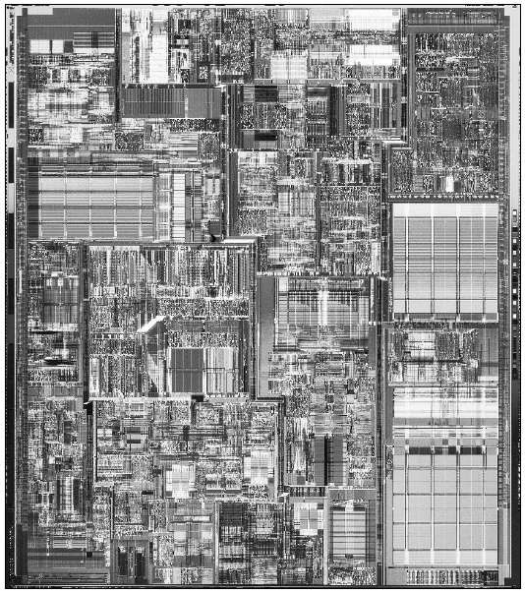
- PC motherboard

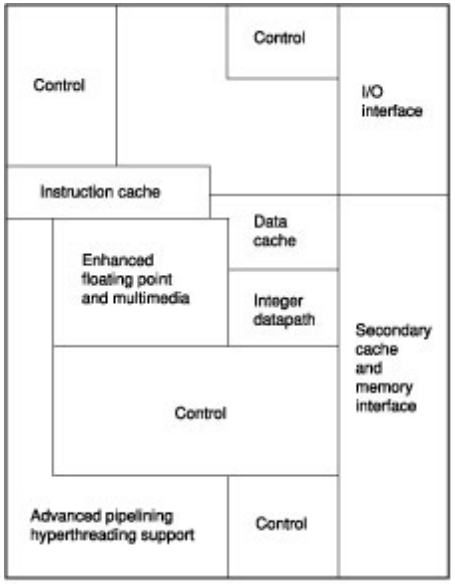


Credit: http://www.computer-hardware-explained.com/what-is-a-motherboard.html

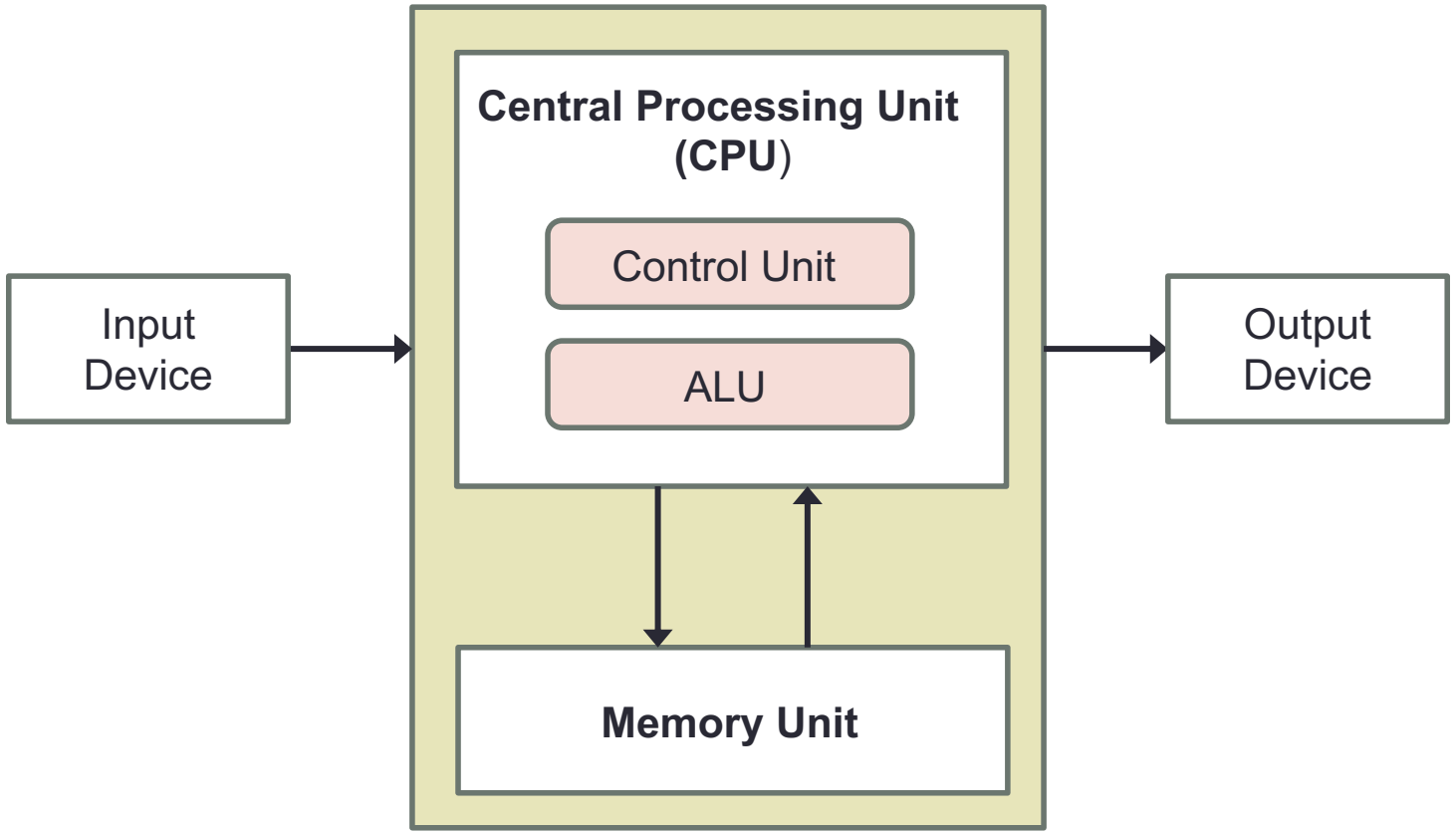
- Pentium processor

Inside a Pentium chip





4. So, What is a Computer? (5/6)



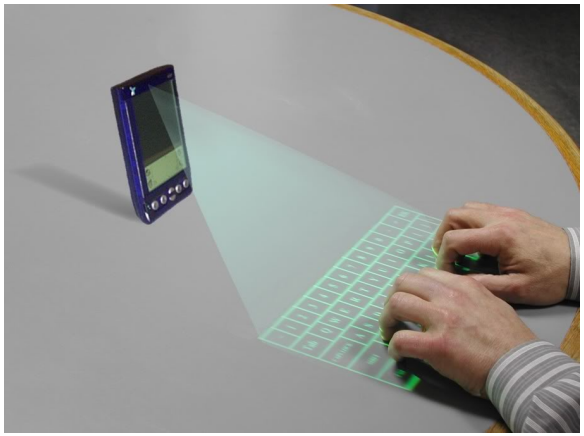
ALU: Arithmetic/Logic Unit

4. So, What is a Computer? (6/6)

Next generation…

Credit: http://www.custom-build-computers.com/Latest-Computer-Hardware.html

Credit: http://www.prabhanjamindiaits.com/blogdetailedpage.aspx?id=66



Credit: http://new-techpc.blogspot.sg/2012/10/latest-in-computer-technology.html

6th January 2014

www.theverge.com/2014/1/6/5282472/intel-announces-edison-a-computer-the-size-of-an-sd-card

LONGFORM VIDEO REVIEWS TECH SCIENCE CULTURE DESIGN BUSINESS US & WORLD FOR

CES 2014 TECH BREAKING

Intel announces Edison, a computer the size of an SD card

By Sean Hollister on January 6, 2014 10:01 pm Email

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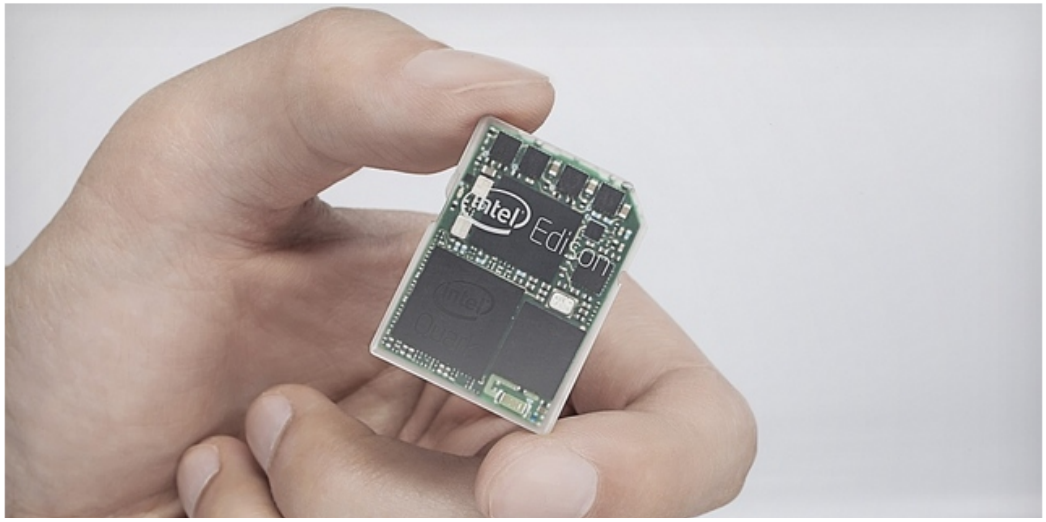
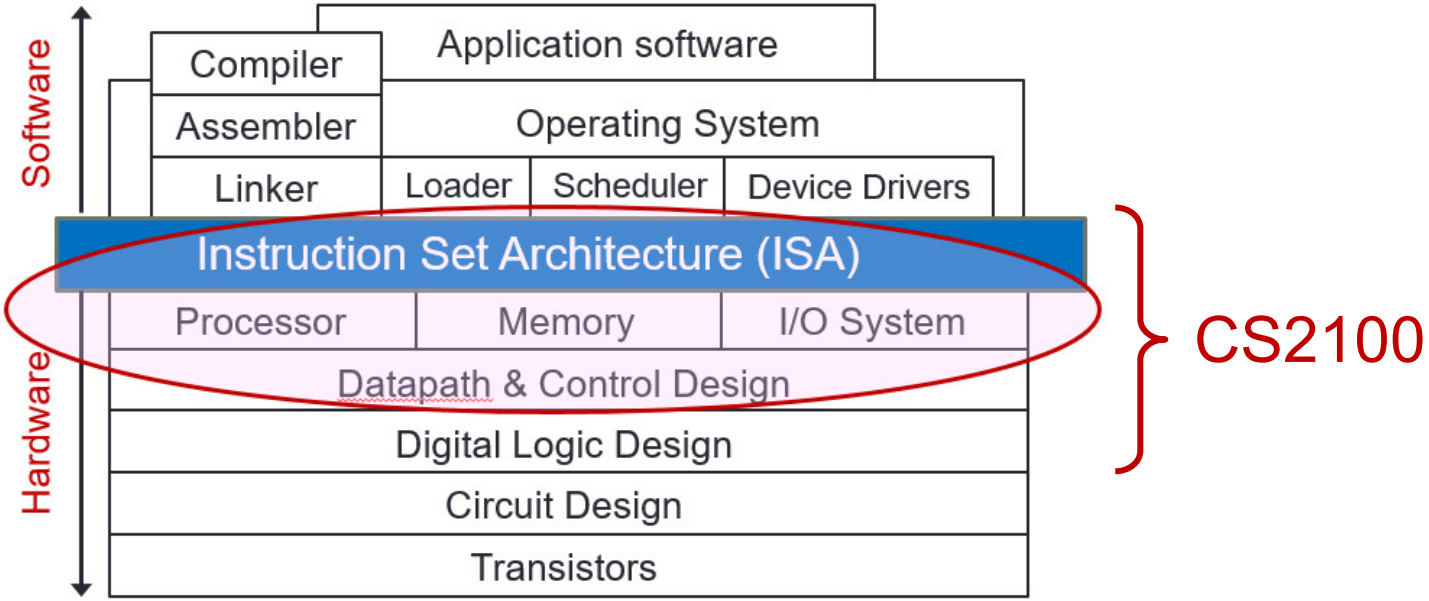


http://www.theverge.com/2014/1/6/5282472/intel-announces-edison-a-computer-the-size-of-an-sd-card

PART OF THIS STORYSTREAM

5. Why Study Computer Organisation?

- Computer organisation is the study of internal working, structuring and implementation of a computer system.
- It refers to the level of abstraction above the digital logic level, but below the operating system level.



5. Why Study Computer Organisation?

(From user to builder)

- You want to call yourself a computer scientist/specialist.
- You want to build software people use.
- You need to make purchasing decisions.
- You need to offer “expert” advice.
- Hardware and software affect performance
  - Algorithm determines number of source-level statements (eg: CS1010, CS2030, CS2040, CS3230)
  - Language, compiler, and architecture determine machine instructions (COD chapters 2 and 3)
  - Processor and memory determine how fast instructions are executed (COD chapters 5, 6 and 7)
- Understanding performance (COD chapter 4)

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