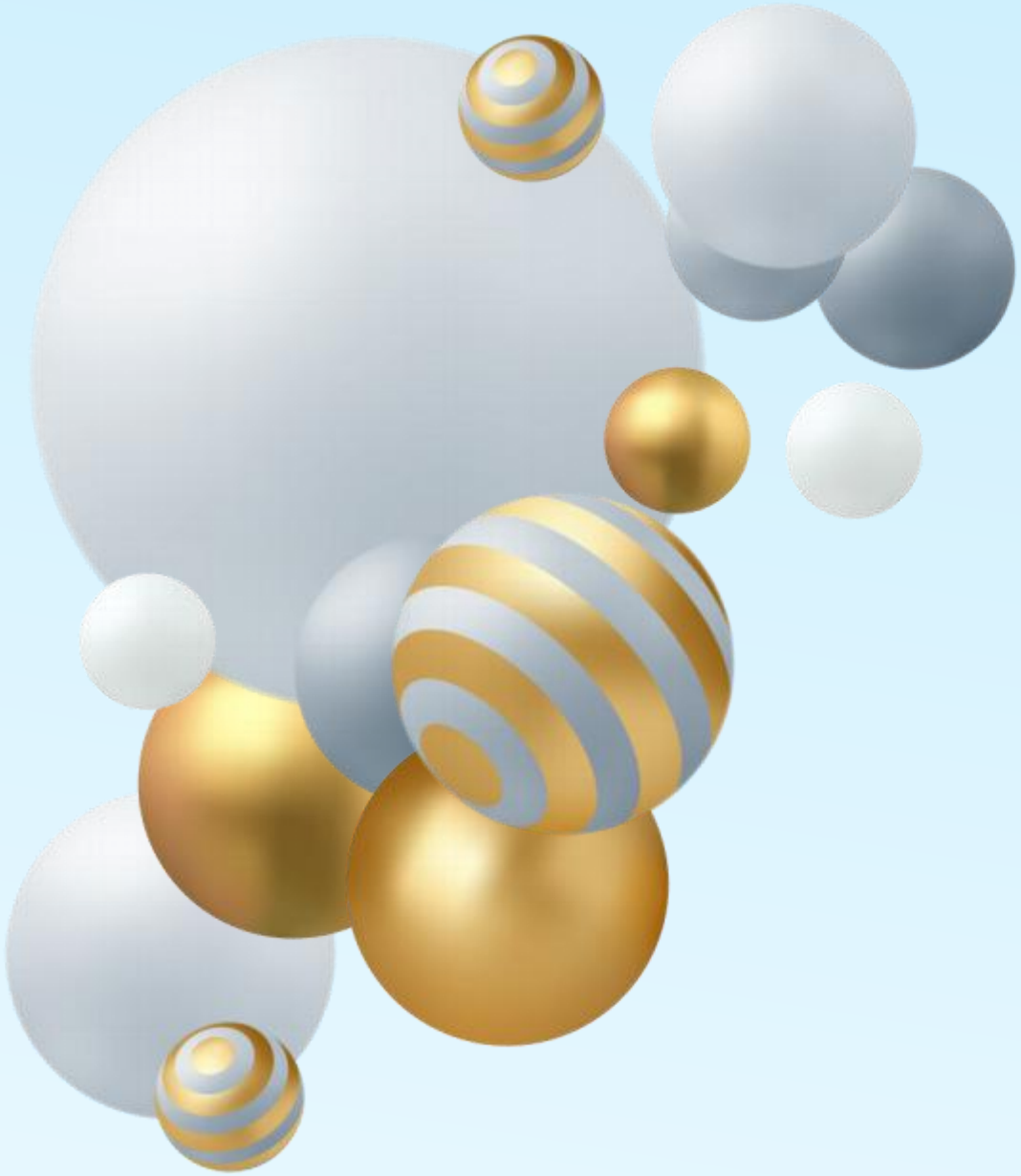
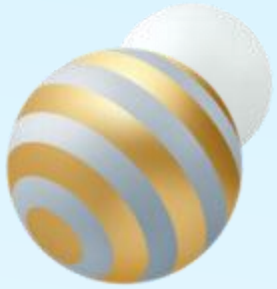


Computer Orgnization

Lab1

Simulator of MIPS



Contact

- BlackBoard site:
  - 计算机组成原理（H）2022春季
- QQ group:
  - 813120411

Assignments Submission Rules

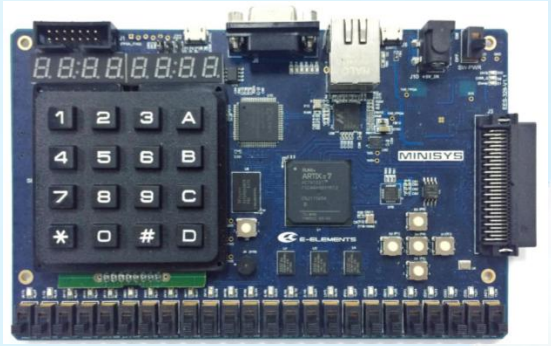
- All assignments **MUST be submitted to BlackBoard site**, any other forms of submission are NOT accepted.
- If the submission is delayed **for one day, 20% discount** on the total score. If it is **delayed for more than a week, any submission is NOT ACCEPTABLE**! This assignment is 0 point.
- In the case of plagiarism: at the 1st time, the assignment was 0 for all concerned students and at the 2nd time, the grade of the experimental course is 0 for all concerned students.
- Reminder:
  - Assignment scoring and the score publication would be completed within two weeks after the publication of assignment. **If you have any question about the score, please email the relevant reviewer in one week after the score publication.**

Experimental tool kits

- Learn and practice **MIPS (QtSpim / Mars)**

- Design and implement an **CPU**

  (vivado + FPGA based Development Board)



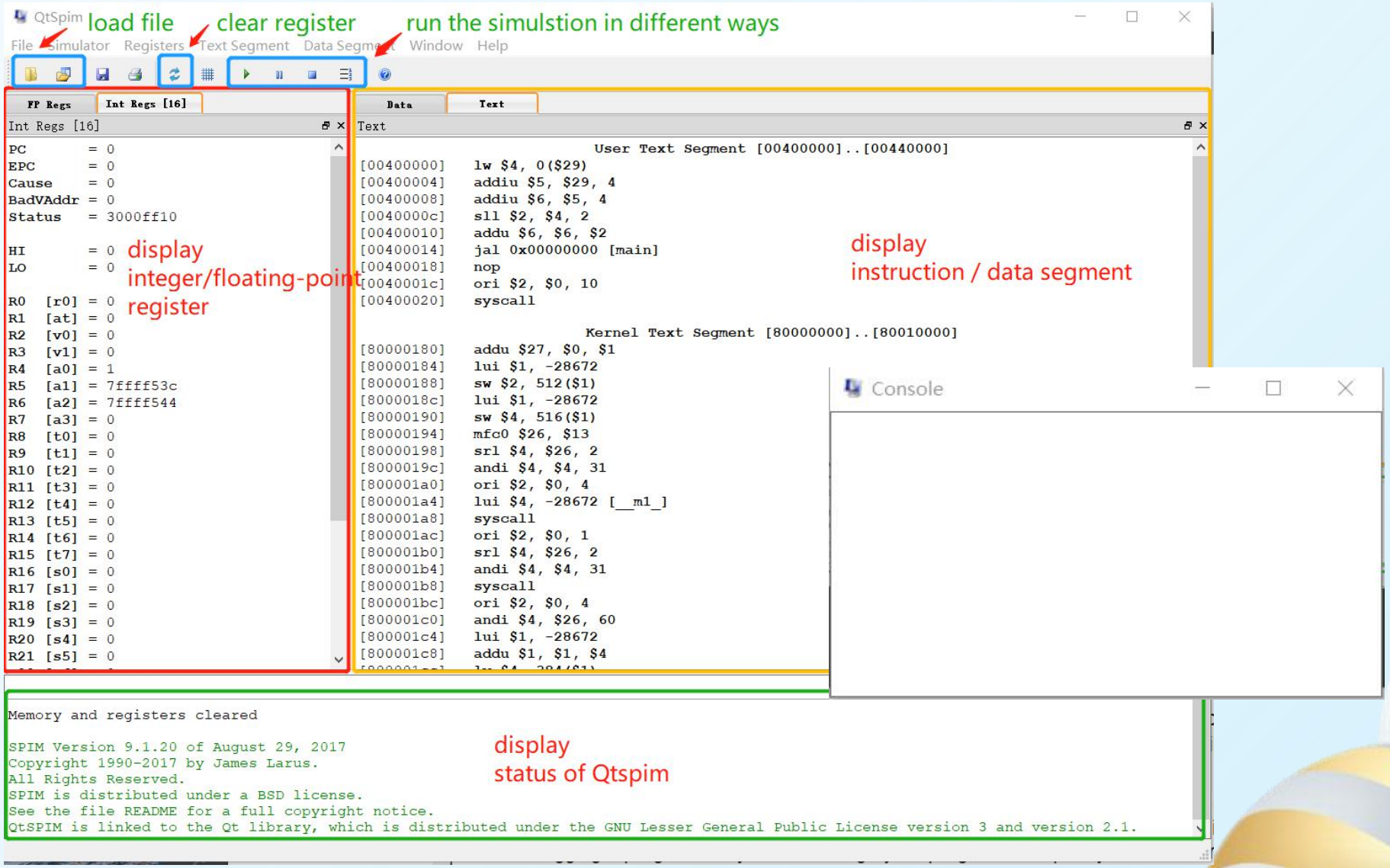
QtSpim（1）

http://spimsimulator.sourceforge.net/

- QtSpim
  - **QtSpim is the newest version of Spim that currently being actively maintained, runs on Microsoft Windows, Mac OS X, and Linux.**
    - Spim, A self-contained simulator that runs MIPS32 program developed by Prof. James Larus from University of Wisconsin-Madison
  - **QtSpim reads and executes programs written in assembly language（汇编语言） for a MIPS computer. QtSpim does not execute binary (compiled) programs.** To simplify programming, QtSpim provides a simple debugger and small set of operating system services
  - **QtSpim implements MOST of the MIPS32 assembler-extended instruction set. (**It omits the floating point comparisons and rounding modes and the memory system page tables.**)** which means that QtSpim will **NOT run programs for ALL MIPS processors.**

Name	Modified	Size
QtSpim_9.1.23_Windows.msi	2021-12-06	21.5 MB
qtspim_9.1.23_linux64.deb	2021-12-06	18.5 MB
QtSpim_9.1.23_mac.mpkg.zip	2021-12-06	22.2 MB

QtSpim (2)


QtSpim
load file
clear register
run the simulstion in different ways
File Simulator Registers Text Segment Data Segment Window Help
FP Regs
Int Regs [16]
Int Regs [16]
PC = 0
EPC = 0
Cause = 0
BadVAddr = 0
Status = 3000ff10
HI = 0
LO = 0
R0 [r0] = 0
R1 [at] = 0
R2 [v0] = 0
R3 [v1] = 0
R4 [a0] = 1
R5 [a1] = 7ffff53c
R6 [a2] = 7ffff544
R7 [a3] = 0
R8 [t0] = 0
R9 [t1] = 0
R10 [t2] = 0
R11 [t3] = 0
R12 [t4] = 0
R13 [t5] = 0
R14 [t6] = 0
R15 [t7] = 0
R16 [s0] = 0
R17 [s1] = 0
R18 [s2] = 0
R19 [s3] = 0
R20 [s4] = 0
R21 [s5] = 0
display integer/floating-point register
Data
Text
Text
User Text Segment [00400000]..[00440000]
[00400000] lw $4, 0($29)
[00400004] addiu $5, $29, 4
[00400008] addiu $6, $5, 4
[0040000c] sll $2, $4, 2
[00400010] addu $6, $6, $2
[00400014] jal 0x00000000 [main]
[00400018] nop
[0040001c] ori $2, $0, 10
[00400020] syscall
Kernel Text Segment [80000000]..[80010000]
[80000180] addu $27, $0, $1
[80000184] lui $1, -28672
[80000188] sw $2, 512($1)
[8000018c] lui $1, -28672
[80000190] sw $4, 516($1)
[80000194] mfc0 $26, $13
[80000198] srl $4, $26, 2
[8000019c] andi $4, $4, 31
[800001a0] ori $2, $0, 4
[800001a4] lui $4, -28672 [__m1_]
[800001a8] syscall
[800001ac] ori $2, $0, 1
[800001b0] srl $4, $26, 2
[800001b4] andi $4, $4, 31
[800001b8] syscall
[800001bc] ori $2, $0, 4
[800001c0] andi $4, $26, 60
[800001c4] lui $1, -28672
[800001c8] addu $1, $1, $4
display instruction / data segment
Console
Memory and registers cleared
SPIM Version 9.1.20 of August 29, 2017
Copyright 1990-2017 by James Larus.
All Rights Reserved.
SPIM is distributed under a BSD license.
See the file README for a full copyright notice.
QtSPIM is linked to the Qt library, which is distributed under the GNU Lesser General Public License version 3 and version 2.1.
display status of Qtspim

QtSpim (3)

Load file and Do the **simulation**

Step1: loading a file (assembly code file usually have the extension "**.s**")

- Open file : **File->Load File** or **File ->Reinitialize and Load File**
- Tips:
  - **Reinitialize and Load File** : **Clears** all the changes made by a program, deleting all of its instructions, then **reload** the last file
  - **Before doing the simulation, make sure clear registers**, you can do it by :

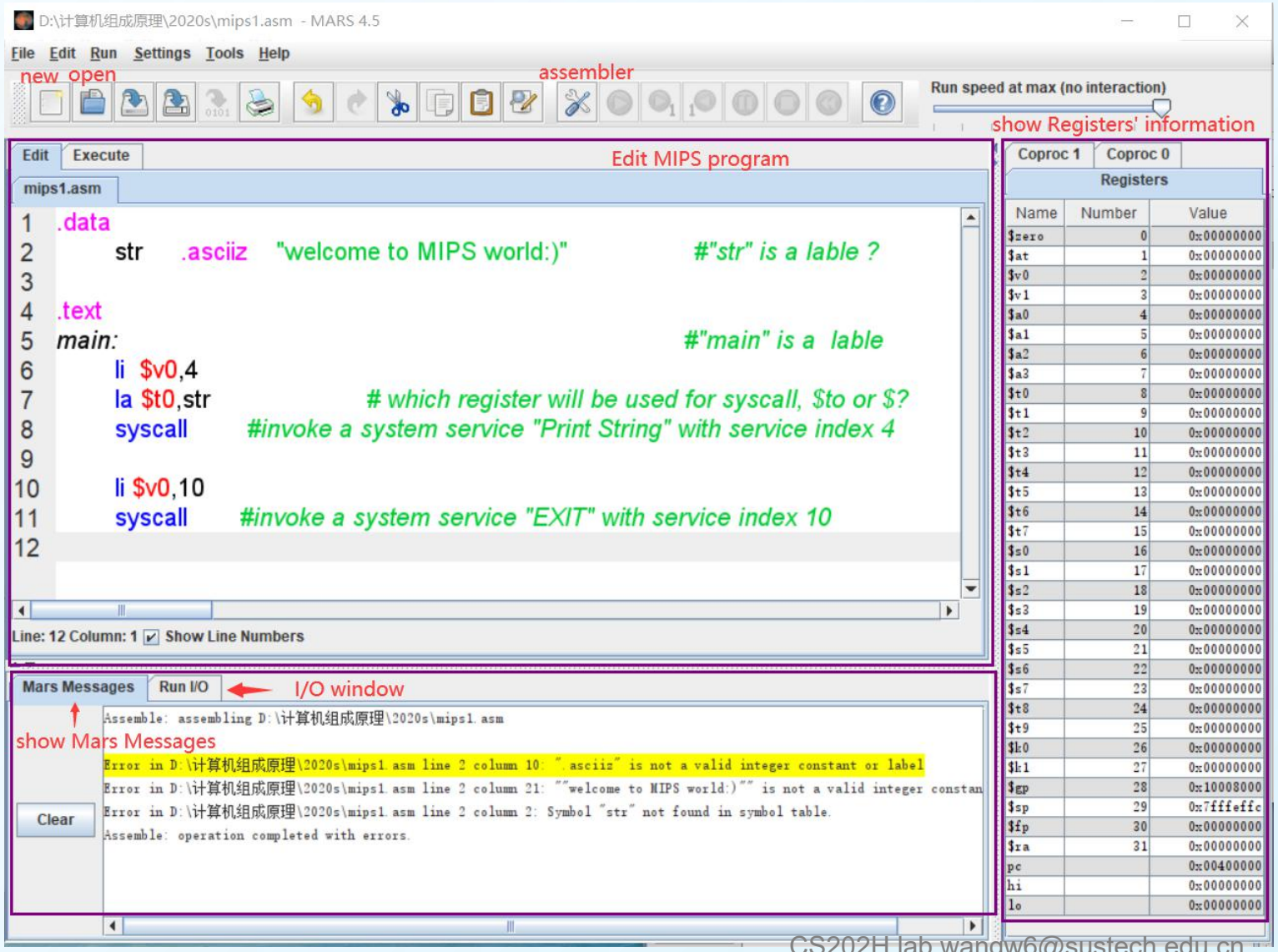
    Simulator->Clear Registers or by related tools.

Step2:

- **Run** file : **Simulator->Run / Continue**
- The value of register in left window will be refreshed, the program's output will appear in the Console window.

Mars(1)

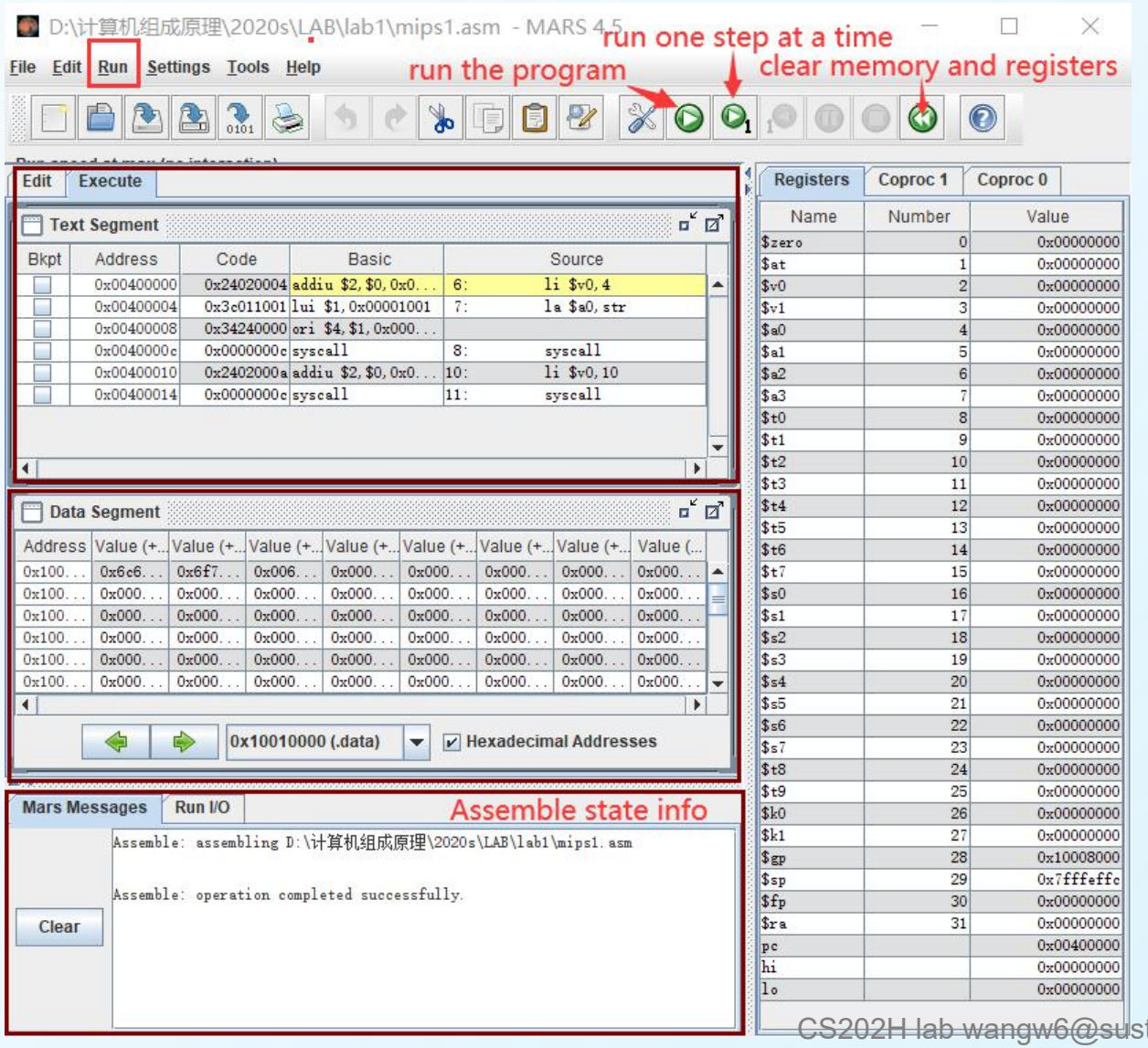
http://courses.missouristate.edu/kenvollmar/mars/download.htm

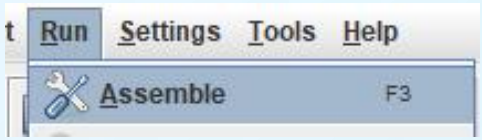


MARS is a **lightweight** interactive development environment (**IDE**) for programming in **MIPS** assembly language, intended for educational-level use with Patterson and Hennessy's Computer Organization and Design.

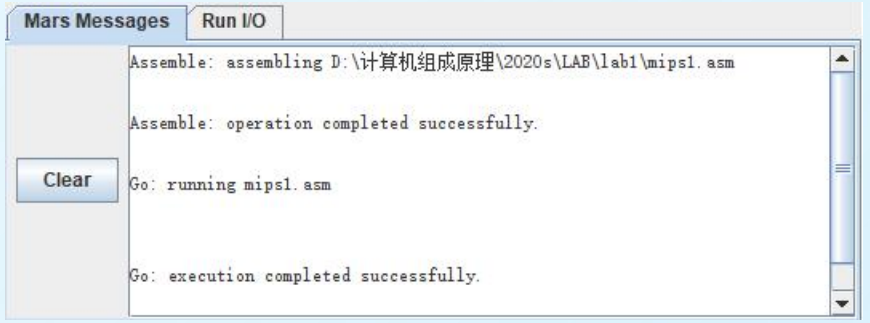
MARS requires Java J2SE 1.5 (or later) SDK installed on your computer.

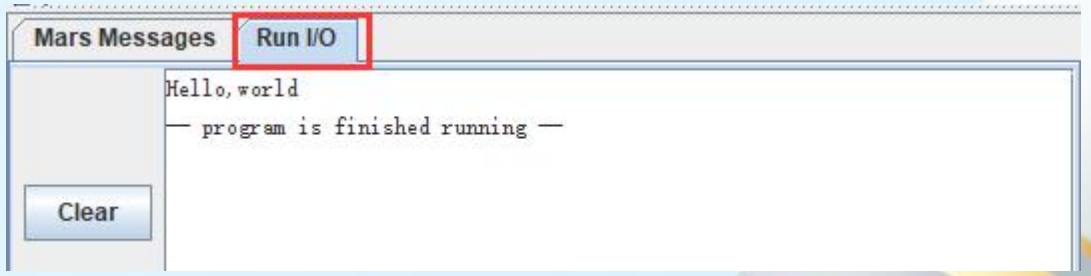
Mars(2)


D:\计算机组成原理\2020s\LAB\lab1\mips1.asm - MARS 4.5
File Edit Run Settings Tools Help
run the program
run one step at a time
clear memory and registers
Edit Execute
Text Segment
Bkpt Address Code Basic Source
0x00400000 0x24020004 addiu $2, $0, 0x0... 6: li $v0, 4
0x00400004 0x3c011001 lui $1, 0x00001001 7: la $a0, str
0x00400008 0x34240000 ori $4, $1, 0x000...
0x0040000c 0x0000000c syscall 8: syscall
0x00400010 0x2402000a addiu $2, $0, 0x0... 10: li $v0, 10
0x00400014 0x0000000c syscall 11: syscall
Data Segment
Address Value (+...
0x10010000 (.data)
Hexadecimal Addresses
Mars Messages
Run I/O
Assemble state info
Assemble: assembling D:\计算机组成原理\2020s\LAB\lab1\mips1.asm
Assemble: operation completed successfully.
Clear
Registers
Coproc 1
Coproc 0
Name Number Value
$zero 0 0x00000000
$at 1 0x00000000
$v0 2 0x00000000
$v1 3 0x00000000
$a0 4 0x00000000
$a1 5 0x00000000
$a2 6 0x00000000
$a3 7 0x00000000
$t0 8 0x00000000
$t1 9 0x00000000
$t2 10 0x00000000
$t3 11 0x00000000
$t4 12 0x00000000
$t5 13 0x00000000
$t6 14 0x00000000
$t7 15 0x00000000
$s0 16 0x00000000
$s1 17 0x00000000
$s2 18 0x00000000
$s3 19 0x00000000
$s4 20 0x00000000
$s5 21 0x00000000
$s6 22 0x00000000
$s7 23 0x00000000
$t8 24 0x00000000
$t9 25 0x00000000
$k0 26 0x00000000
$k1 27 0x00000000
$gp 28 0x10008000
$sp 29 0x7fffeffc
$fp 30 0x00000000
$ra 31 0x00000000
pc 0x00400000
hi 0x00000000
lo 0x00000000


Run Settings Tools Help
Assemble F3

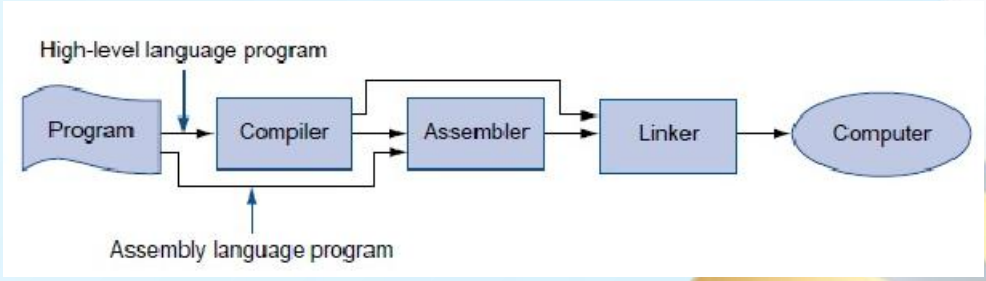

Run Settings Tools Help
Assemble F3
Go F5


Mars Messages
Run I/O
Clear
Assemble: assembling D:\计算机组成原理\2020s\LAB\lab1\mips1.asm
Assemble: operation completed successfully.
Go: running mips1.asm
Go: execution completed successfully.


Mars Messages
Run I/O
Clear
Hello, world
-- program is finished running --

Assembly Language(汇编语言) Overview

- Assembly language
  - **The main body of assembly language（汇编语言） is assembly instruction（汇编指令）.**
    - **Assembly instructions(汇编指令)** and **Machine instructions(机器指令)** differ in instruction expression. **Assembly instruction is a human-friendly writing format of machine instruction.** Assembly language is the mnemonic of machine language.For example
      - machine instruction “1000100111011000” means that send the contents of register BX to AX.
      - The assembly instructions are written as “mov ax, bx”. Such writing is similar to human language and easy to read and remember.
  - Feature：programs written in assembly language are inherently machine-specific and must be totally rewritten to run on another computer architecture
  - CISC (intel x86) vs **RISC** (ARM, **MIPS**, RISC-V)



Assembly Program Structure

data declarations + program code

- **part1: Data Declarations**
  - placed in section of program identified with assembler directive(汇编说明/汇编器指示符): **.data**
  - **declare** variable names used in program; storage allocated in main **memory** (RAM)
- **part2: Program Code**
  - placed in section of text identified with assembler directive: **.text**
  - contains program code (instructions)
  - starting point of code e.g. ecution given label main:
  - ending point of code should use exit system call (see below in “System Calls” part)
- **part3: Comments (suggested)**
  - anything following # on a line
    # This stuff would be consideredd as comment

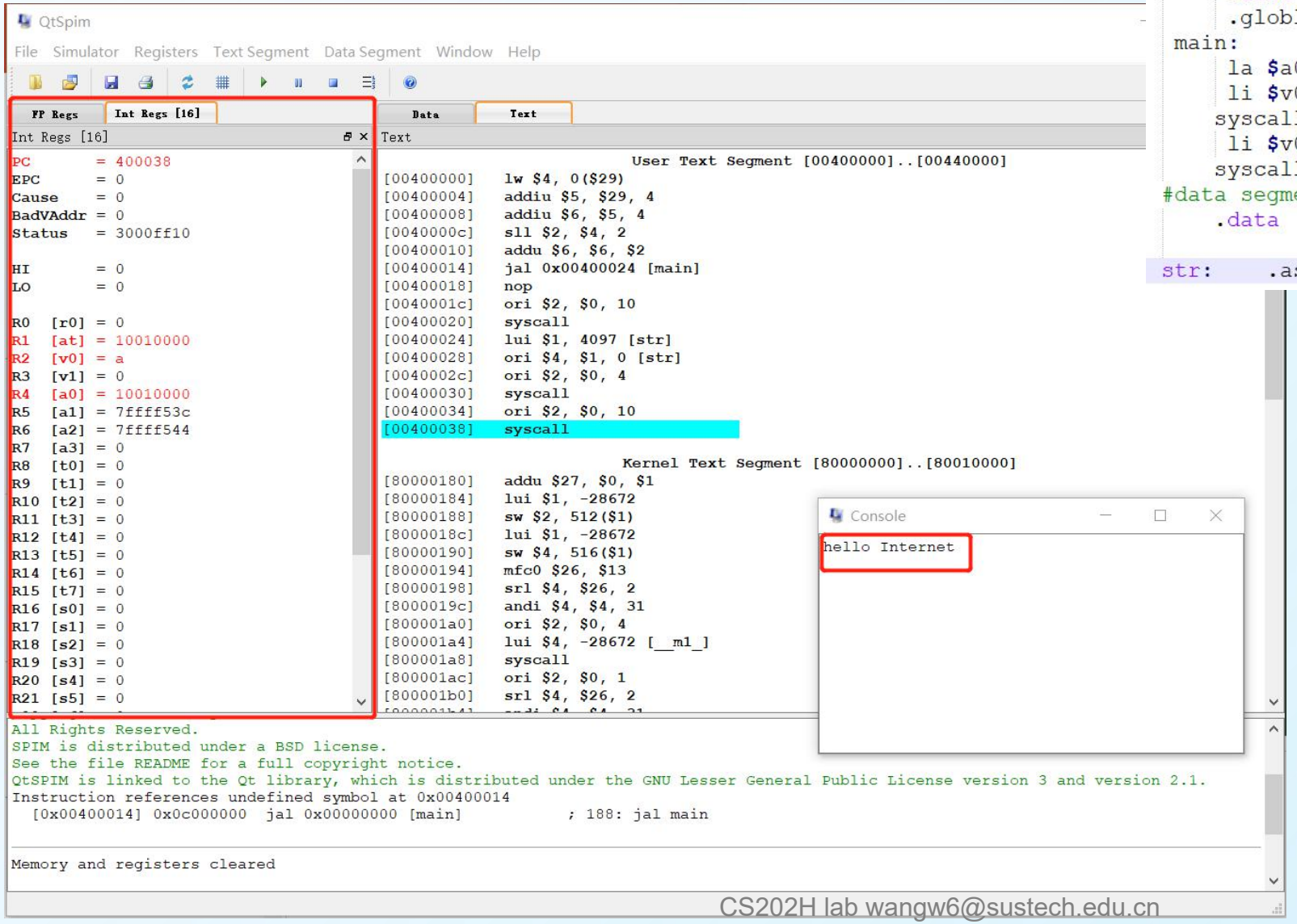
```
# Comment giving name of program and description of function
# Template.s
# Bare-bones outline of MIPS assembly language program

            .data       # variable declarations follow this line
                        # ...

            .text       # instructions follow this line

main:                   # indicates start of code (first instruction to execute)
                        # ...

# End of program, leave a blank line afterwards to make SPIM happy
```

System Calls

- **System Calls**
  - **SPIM** provides a small set of **operating-system-like services** through the system call (**syscall**) instruction.
  - To request a service, a program **loads the system call code into register $v0** and **arguments into registers $a0~$a3** (or $f12 for floating-point values).
  - **System calls that return values put their results in register $v0** (or $f0 for floating-point results).

Service	System call code	Arguments	Result
print_int	1	$a0 = integer	
print_float	2	$f12 = float	
print_double	3	$f12 = double	
print_string	4	$a0 = string	
read_int	5		integer (in $v0)
read_float	6		float (in $f0)
read_double	7		double (in $f0)
read_string	8	$a0 = buffer, $a1 = length	
sbrk	9	$a0 = amount	address (in $v0)
exit	10		
print_char	11	$a0 = char	
read_char	12		char (in $v0)
open	13	$a0 = filename (string), $a1 = flags, $a2 = mode	file descriptor (in $v0)
read	14	$a0 = file descriptor, $a1 = buffer, $a2 = length	num chars read (in $v0)
write	15	$a0 = file descriptor, $a1 = buffer, $a2 = length	num chars written (in $v0)
close	16	$a0 = file descriptor	
exit2	17	$a0 = result	

A demo




```
#    text segment
     .text
     .globl main
main:                   # execution starts here
     la $a0,str         # put string address into a0
     li $v0,4           # system call to print a string
    syscall
     li $v0,10
    syscall             # system call to exit
#data segment
    .data

str:    .asciiz "hello Internet\n"
```

Update the demo by deleting the line ".globl main", rerun it on the Qtspim, what will happen?

Run the updated demo on the Mars, what will happen?

Practice & thinking

- 1. **Install QtSpim/Mars on your PC** and **refer to the 'help' page** to find:
  - Is the function of '**syscall**' in Qtspim the same with Mars?
  - What's the name and ID of the **registers** used while invoke the **"print integer" syscall**?
- 2. **Make an assembly file**, **load** and **run** it by QtSpim/Mars:
  - The assembly code should **get** your ID and name, and **print** them out
  - Is there any **object file** or **executable file** generated while doing the simulation?
  - **Where** is your ID and name **stored** while the assembly code get them? **register** or **memory**?
  - What's the **Machine code** of the MIPS instruction "li $v0,10"
- 3. Find an assembler for MIPS from the Internet, use it to assemble the code of question 2 to generate an executable file, Can the executable file run on your computer and explain the reason.