CENG3420

Lab 1-1: MIPS assembly language programing

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Overview

SPIM

Assembly programing

System service in SPIM

Lab assignment

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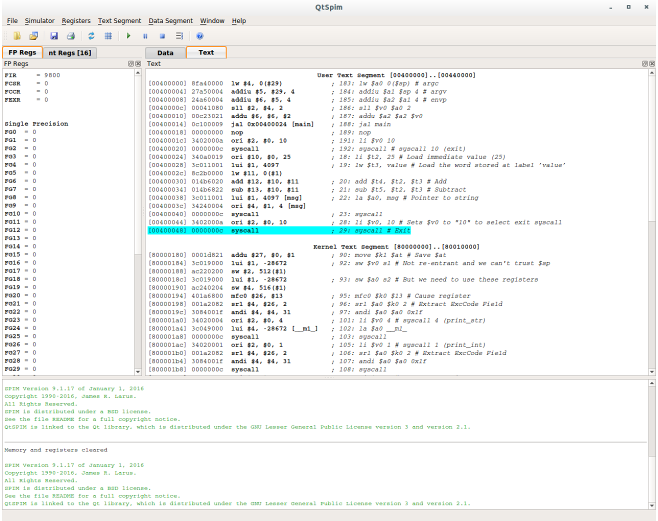
What is SPIM

- **SPIM is a MIPS32 simulator.**
- *Spim* is a self-contained simulator that runs MIPS32 programs.
- It reads and executes assembly language programs written for this processor.
- *Spim* also provides a simple debugger and minimal set of operating system services.
- *Spim* does not execute binary (compiled) programs.

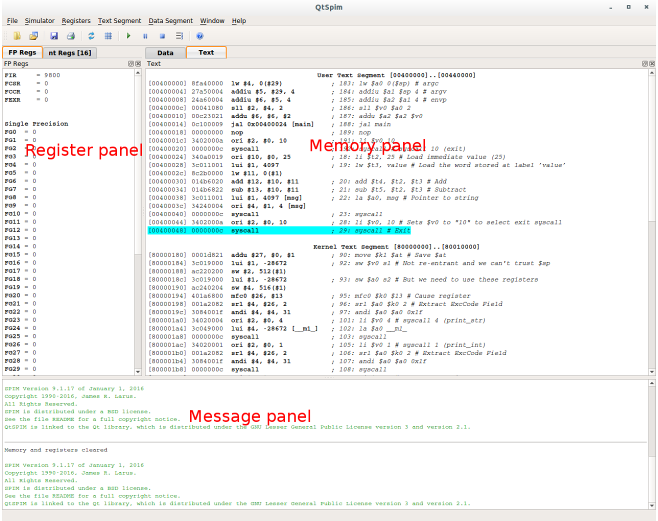
Dowload it here: `http://sourceforge.net/projects/spimsimulator/files/`

SPIM Overview



What SPIM looks like.

Register Panel and Memory Panel



There's also a console window.

Operations

- Load a source file: File $\rightarrow$ Reinitialize and Load File
- Run the code: F5 or Press the green triangle button
- Single stepping: F10
- Breakpoint: in Text panel, right click on an address to set a breakpoint there.

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Registers

- 32 general-purpose registers
- register preceded by $ in assembly language instruction
- two formats for addressing:
  - using register number e.g. `$0` through `$31`
  - using equivalent names e.g. `$t1`, `$sp`
- special registers Lo and Hi used to store result of multiplication and division
  - not directly addressable; contents accessed with special instruction `mfhi` ("move from Hi") and `mflo` ("move from Lo")

Register Names and Descriptions

Name	Register Number	Usage	Preserve on call?
$zero	0	constant 0 (hardware)	n.a.
$at	1	reserved for assembler	n.a.
$v0 - $v1	2-3	returned values	no
$a0 - $a3	4-7	arguments	yes
$t0 - $t7	8-15	temporaries	no
$s0 - $s7	16-23	saved values	yes
$t8 - $t9	24-25	temporaries	no
$gp	28	global pointer	yes
$sp	29	stack pointer	yes
$fp	30	frame pointer	yes
$ra	31	return addr (hardware)	yes

Data Types and Literals

Data types:

- Instructions are all 32 bits
- byte(8 bits), halfword (2 bytes), word (4 bytes)
- a character requires 1 byte of storage
- an integer requires 1 word (4 bytes) of storage
- Data types: `.asciiz` for string, `.word` for int, ...

Literals:

- numbers entered as is. e.g. 4
- characters enclosed in single quotes. e.g. ‘b’
- strings enclosed in double quotes. e.g. “A string”

Program Structure I

- Just plain text file with data declarations, program code (name of file should end in suffix .s to be used with SPIM simulator)
- Data declaration section followed by program code section

Data Declarations

- Identified with assembler directive **.data**.
- Declares variable names used in program
- Storage allocated in main memory (RAM)
- `<name>:   .<datatype> <value>`

Program Structure II

Code

- placed in section of text identified with assembler directive **.text**
- contains program code (instructions)
- starting point for code e.g. execution given label **main:**
- ending point of main code should use exit system call

Comments

anything following # on a line

Program Structure III

The structure of an assembly program looks like this:

Program outline

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

    .globl main

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

main:        # indicates start of code
             # ...

# End of program, leave a blank line afterwards
```

An Example Program

```
      .globl main
      .data
msg:  .asciiz "Welcome to CENG3420.\n"
      .text
main:
      li $v0,4
      la $a0,msg
      syscall
      li $v0,10
      syscall
```

- `li`: load immediate
- `la`: load address

More Information

For more information about MIPS instructions and assembly programing you can refer to:

1. Lecture slides and textbook.
2. http://www.mrc.uidaho.edu/mrc/people/jff/digital/MIPSir.html

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System calls in SPIM I

SPIM provides a small set of operating system-like services through the system call (`syscall`) instruction.

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 $a0)
read	14	$a0 = file descriptor, $a1 = buffer, $a2 = length	num chars read (in $a0)
write	15	$a0 = file descriptor, $a1 = buffer, $a2 = length	num chars written (in $a0)
close	16	$a0 = file descriptor	
exit2	17	$a0 = result	

System calls in SPIM II

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). Like this example:

Using system call

```
      .data
str: .asciiz "the␣answer␣=␣" #labels always followed by colon
      .text

       li     $v0, 4     # system call code for print_str
       la     $a0, str   # address of string to print
       syscall           # print the string
       li     $v0, 1     # system call code for print_int
       li     $a0, 5     # integer to print
       syscall           # print it
```

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Lab Assignment

Write an assembly program with the following requirements:

1. Define two variables `var1` and `var2` which have initial value 15 and 19, respectively.
2. Print `var1` and `var2`.
3. Print RAM addresses of `var1` and `var2` using syscall.
4. Swap `var1` and `var2` and print them.

Lab report should include (1) source code, (2) console output.

Some Tips

1. Variables should be declared following the `.data` identifier.
2. `<name>:   .<datatype> <value>`
3. Use `la` instruction to access the RAM address of declared data.
4. Use system call to print integers.
5. Do not forget exit system call.