Computer Architecture

SPIM Simulator

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LIST

- SPIM Definition
- Multiple versions
- Memory Layout
- PCSPIM
- Example
- Homework

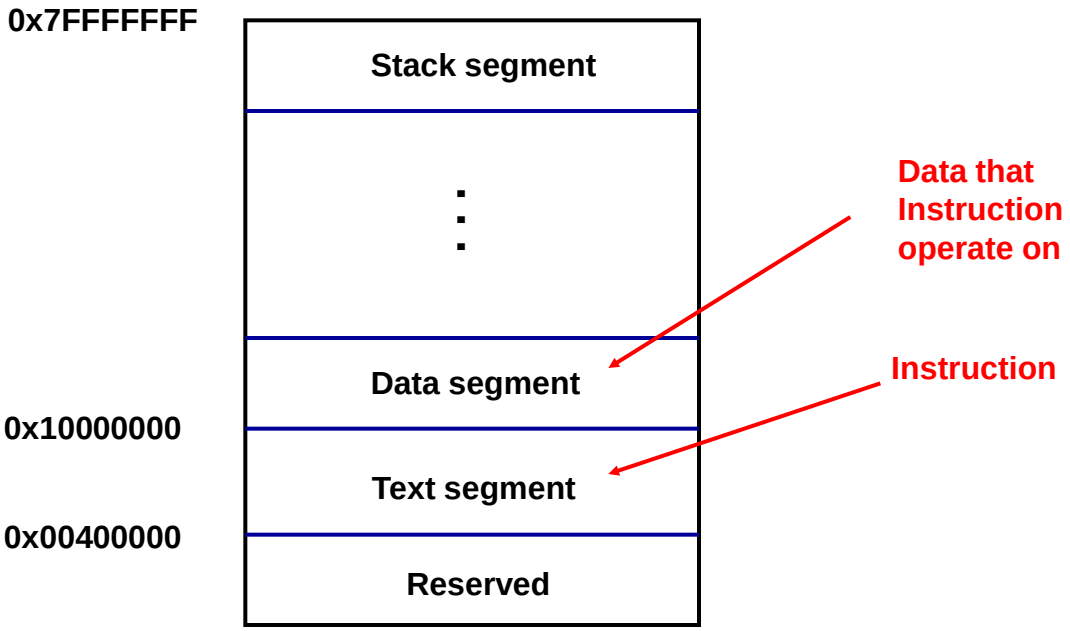
SPIM

- Definition
  - SPIM is a software simulator that runs programs written for MIPS R2000/R3000 processors
  - SPIM can read and immediately execute assembly language files or MIPS executable files
  - SPIM is a self-contained system
    - Debugger
    - A few operating system-like services

SPIM of Multiple versions

- SPIM
  - Command-line-driven program
  - Requires only an alphanumeric terminal to display
- XSPIM
  - X-windows environment
  - Much easier program to learn
- PCSPIM
  - Windows version of SPIM

Memory Layout



PCSPIM

- Download and Install
- Windows
  - Register display
  - Text segments
  - Data and stack segments
  - SPIM messages
- Function
  - Load
  - Go
  - Single step
  - Multiple steps
  - Breakpoint

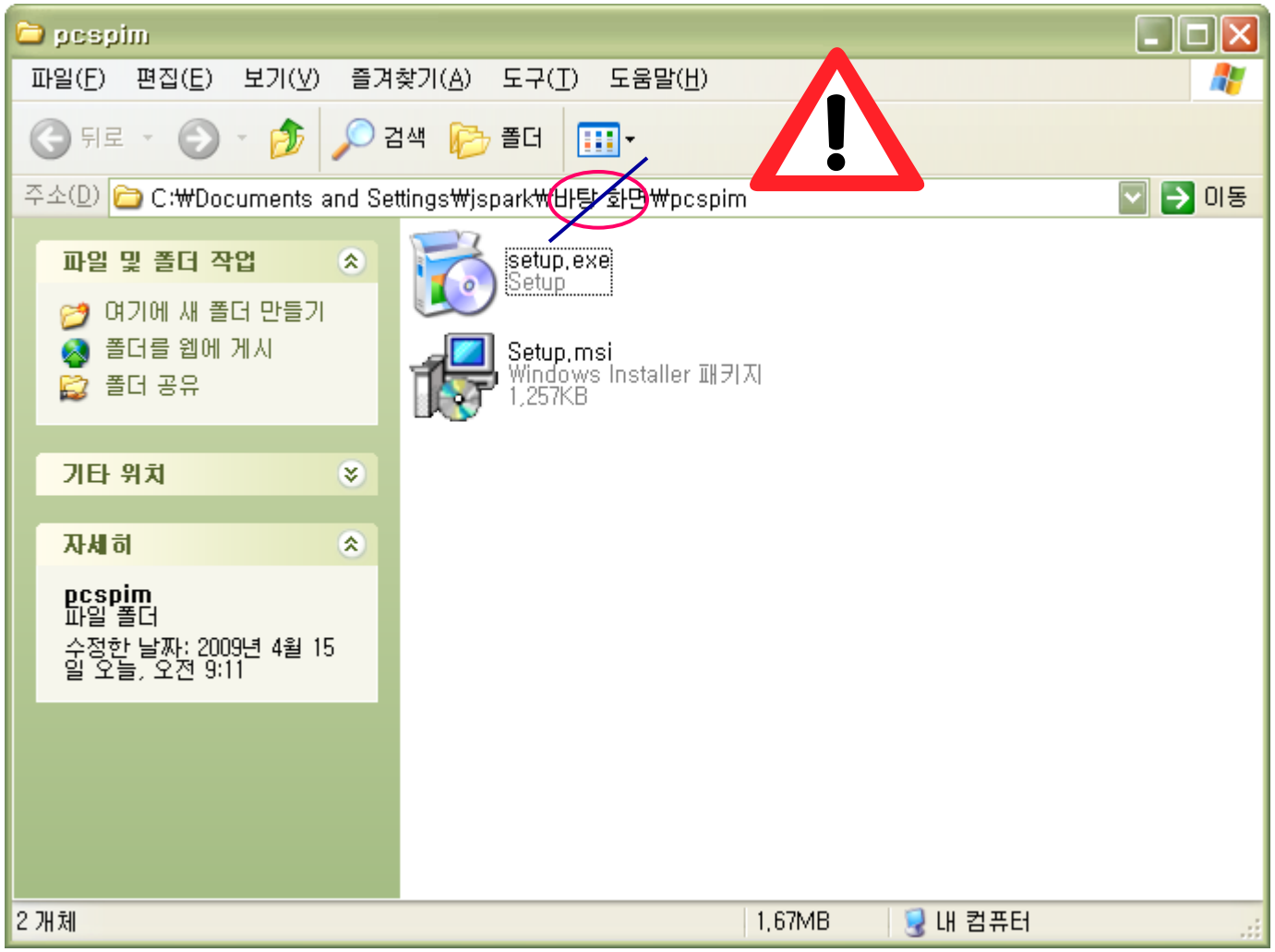
PCSPIM Download

- Downloading PCSPIM
  - http://www.cs.wisc.edu/~larus/spim.html

Downloading SPIM

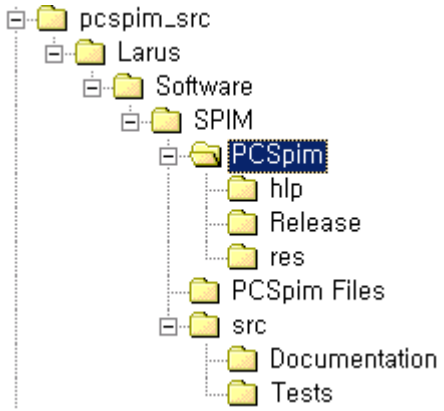
Platform	Program	Form	File
Unix or Linux system Mac OS X	*spim* *xspim*	Source code	http://www.cs.wisc.edu/~larus/SPIM/spim.tar.Z or http://www.cs.wisc.edu/~larus/SPIM/spim.tar.gz
Linux	*spim* *xspim*	Binary RPM for Fedora	http://www.cs.wisc.edu/cbi/downloads/
Microsoft Windows (Windows NT, 2000, XP) (spim 7.0 and later versions no longer run on Windows 95/98. Use version 6.5 or earlier.)	*spim* *PCSpim*	Executable	http://www.cs.wisc.edu/~larus/SPIM/pcspim.zip
		Source code	http://www.cs.wisc.edu/~larus/SPIM/pcspim_src.zip

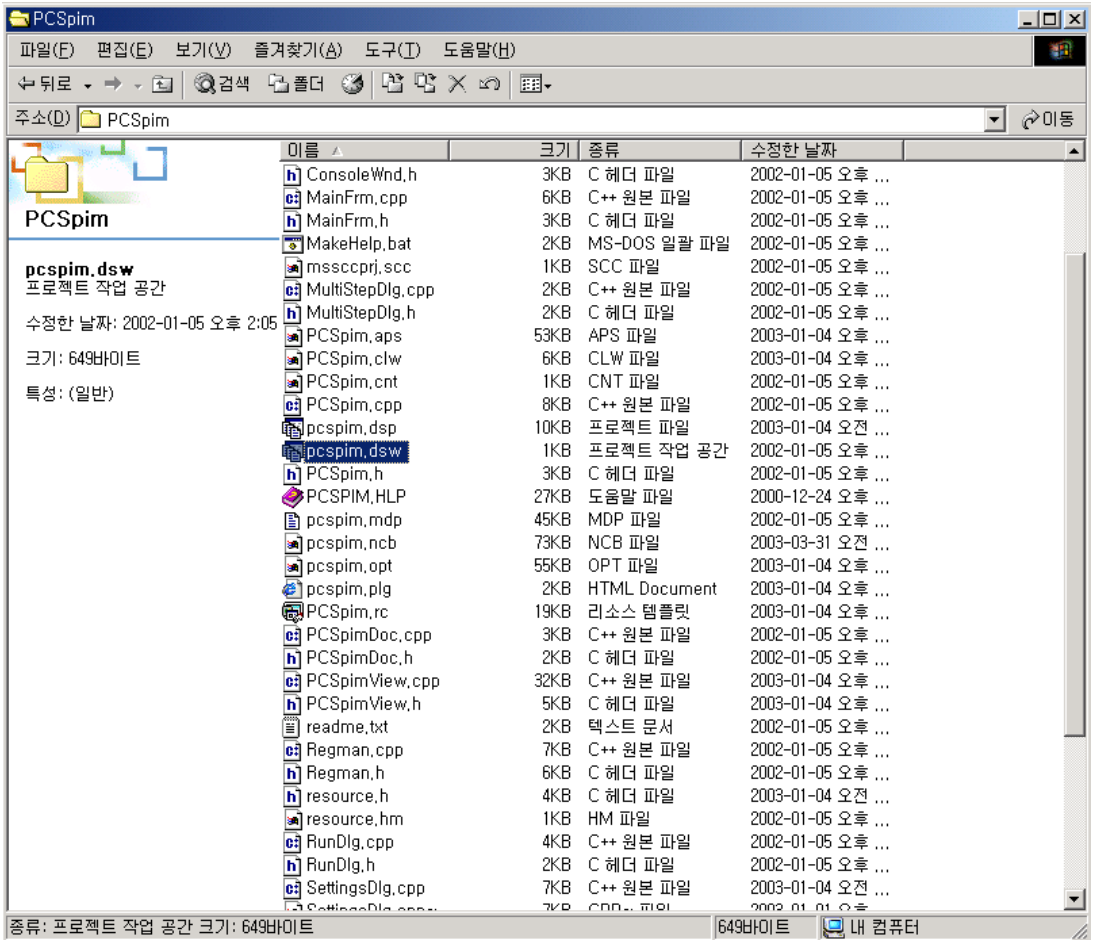
Executable File Install



Source Code Install

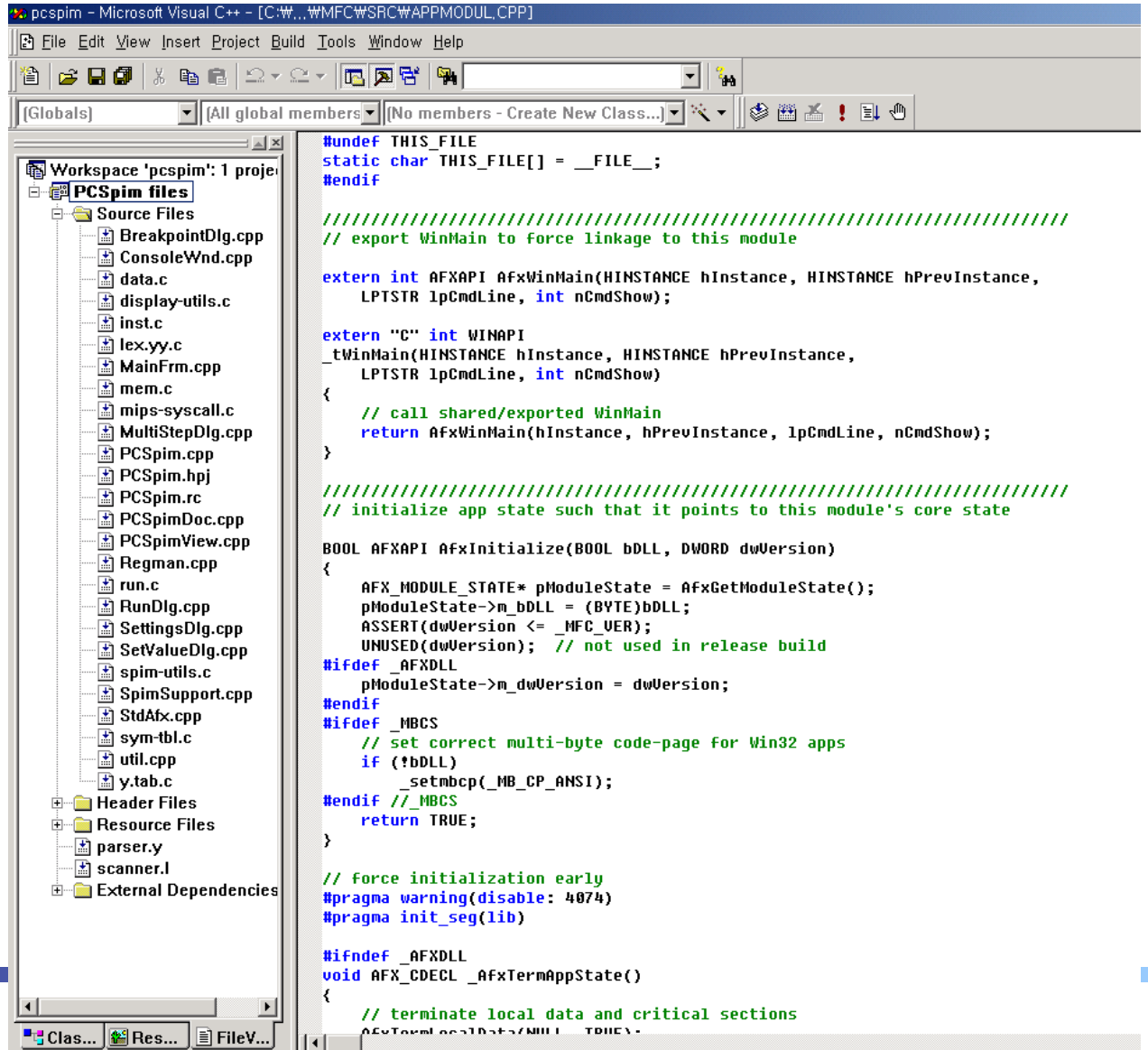
- **Step 1**





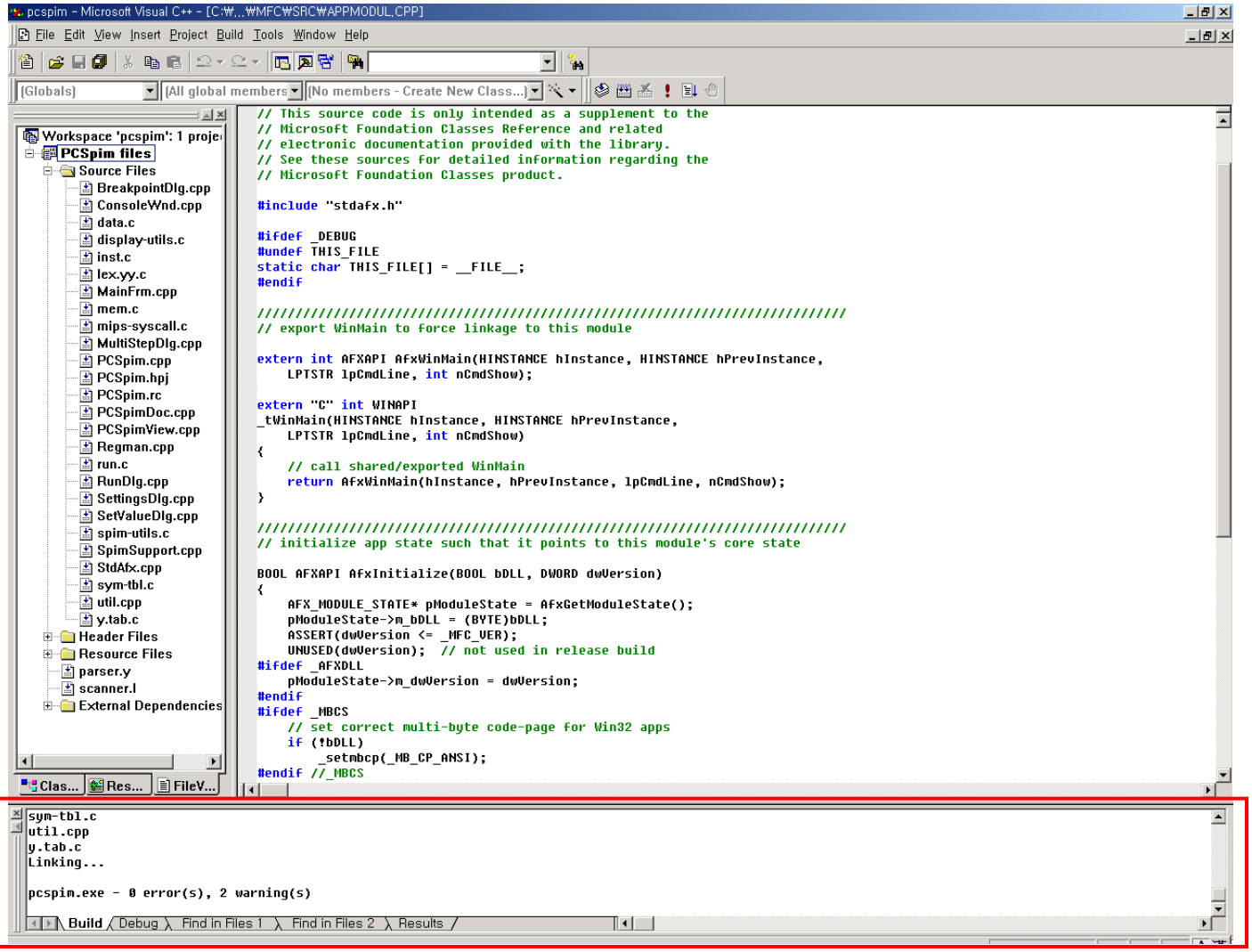
Source Code Install

- Step 2



Source Code Install

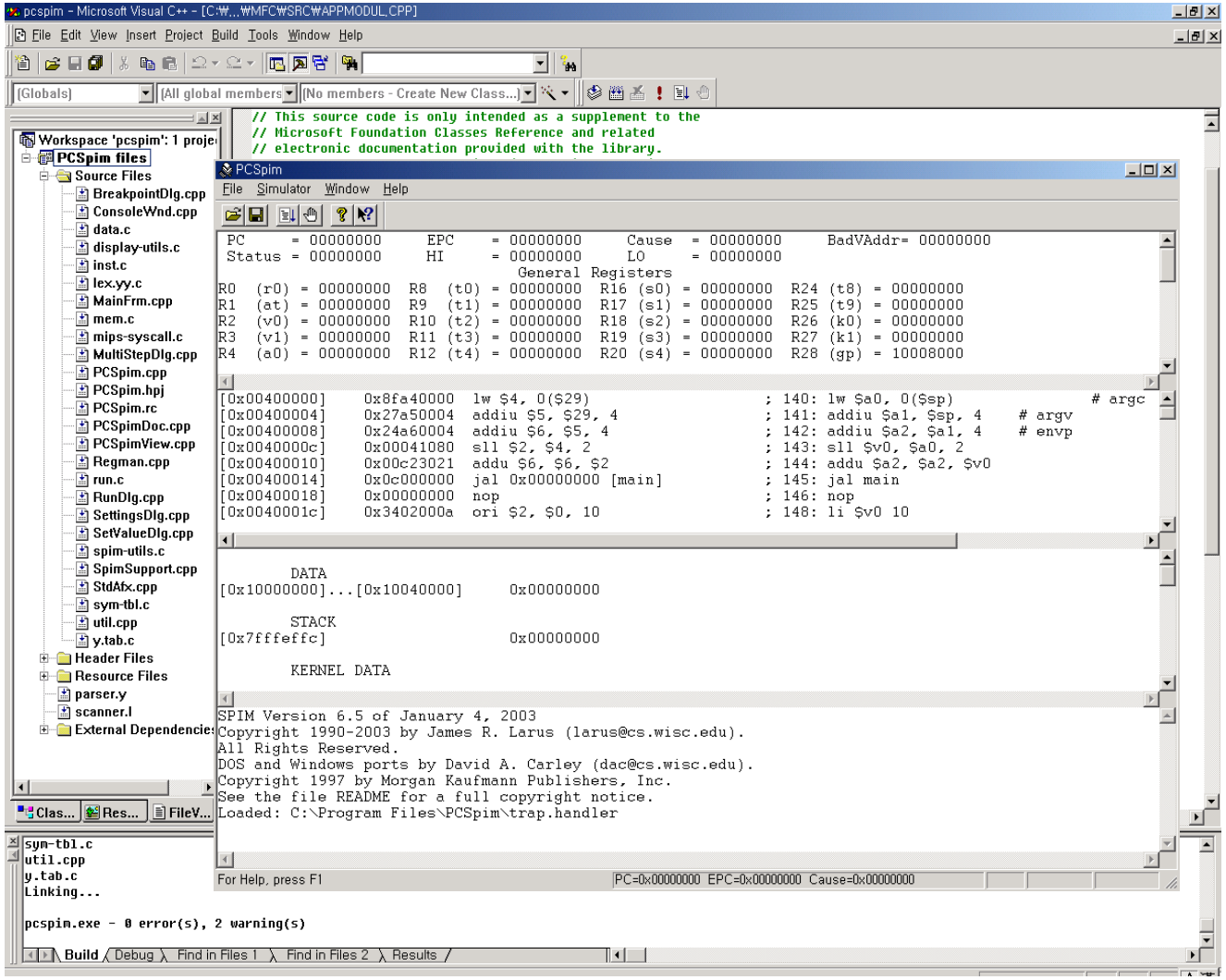
- **Step 3**



F7 - Compile

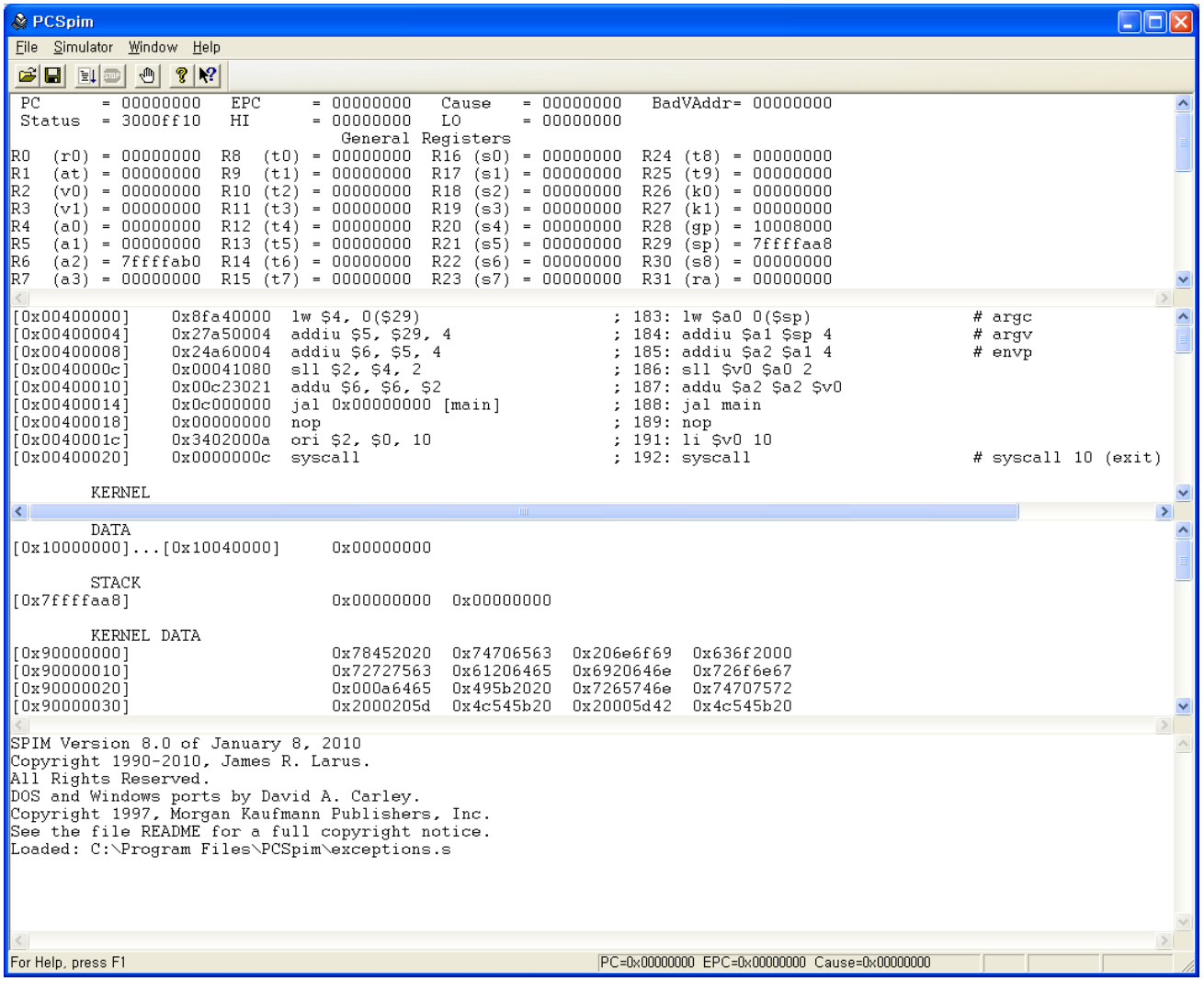
Source Code Install

- **Step 4**



Ctrl + F5
Program Run

Windows



Register display

Text segments

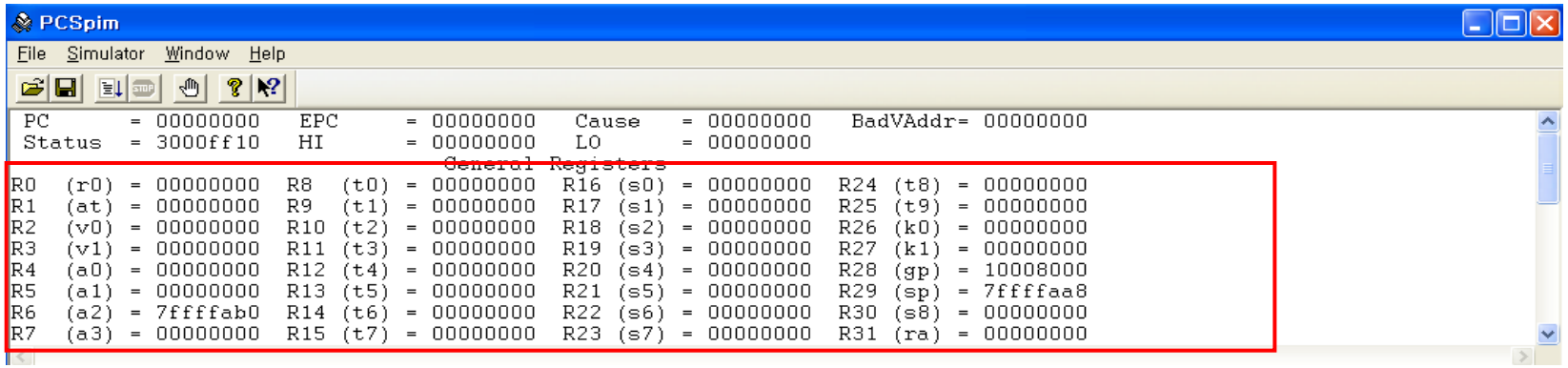
Data segments

SPIM messages

Windows

- **Register display**

  It shows the values of all registers in the MIPS CPU and FPU.



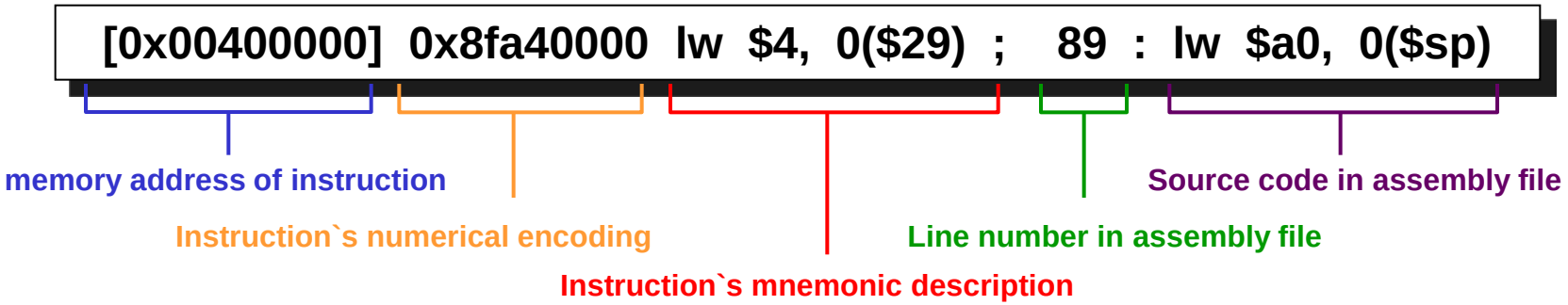
General-purpose registers

Windows

- **Text segments**

  Displays instructions both from your program and the system code that is loaded automatically when PCSPIM starts running

```
[0x00400000]    0x8fa40000  lw $4, 0($29)              ; 183: lw $a0 0($sp)            # argc
[0x00400004]    0x27a50004  addiu $5, $29, 4          ; 184: addiu $a1 $sp 4          # argv
[0x00400008]    0x24a60004  addiu $6, $5, 4           ; 185: addiu $a2 $a1 4          # envp
[0x0040000c]    0x00041080  sll $2, $4, 2             ; 186: sll $v0 $a0 2
[0x00400010]    0x00c23021  addu $6, $6, $2           ; 187: addu $a2 $a2 $v0
[0x00400014]    0x0c000000  jal 0x00000000 [main]     ; 188: jal main
[0x00400018]    0x00000000  nop                       ; 189: nop
[0x0040001c]    0x3402000a  ori $2, $0, 10            ; 191: li $v0 10
[0x00400020]    0x0000000c  syscall                   ; 192: syscall                  # syscall 10 (exit)
```



Windows

- **Data segments (Data and stack segments)**

  Displays the data loaded into your program`s memory and the data on the program`s stack

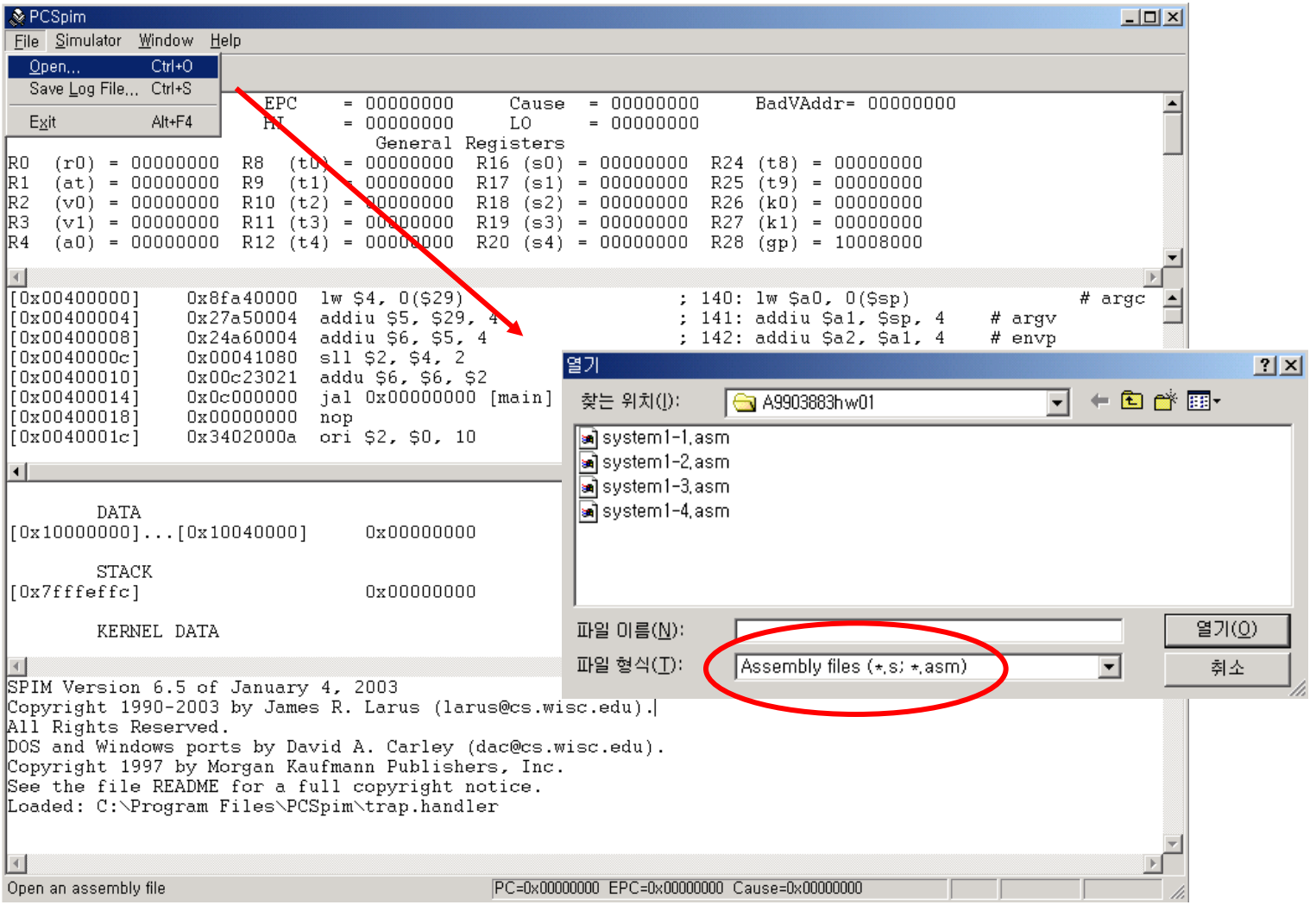
- **SPIM messages**

  This is where error messages appear

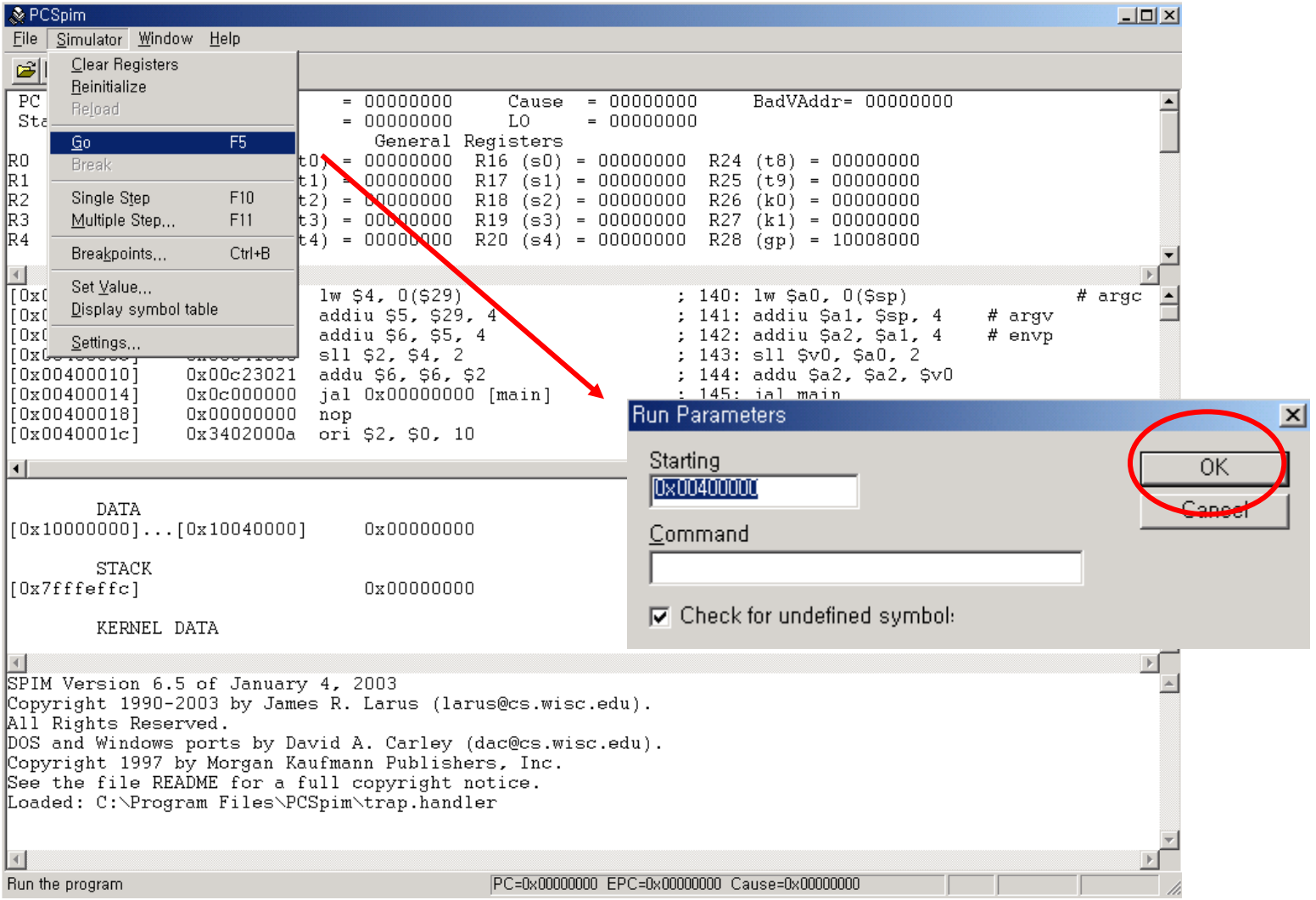
Simulator Function

- **Load**
  - File → Open
  - Select assembly file
- **Reload**
  - File → Reload
  - Reload source file after change it with editor program
- **Go**
  - Simulator → Go
  - Results are displayed in console
- **Single step**
  - Simulator → Single Step
  - Run an instruction at a time
- **Multiple step**
  - Simulator → Multiple Step
  - Run given number of instruction at a time
- **Breakpoint**
  - Simulator → Breakpoint
  - Stop program immediately before it executes a particular instruction

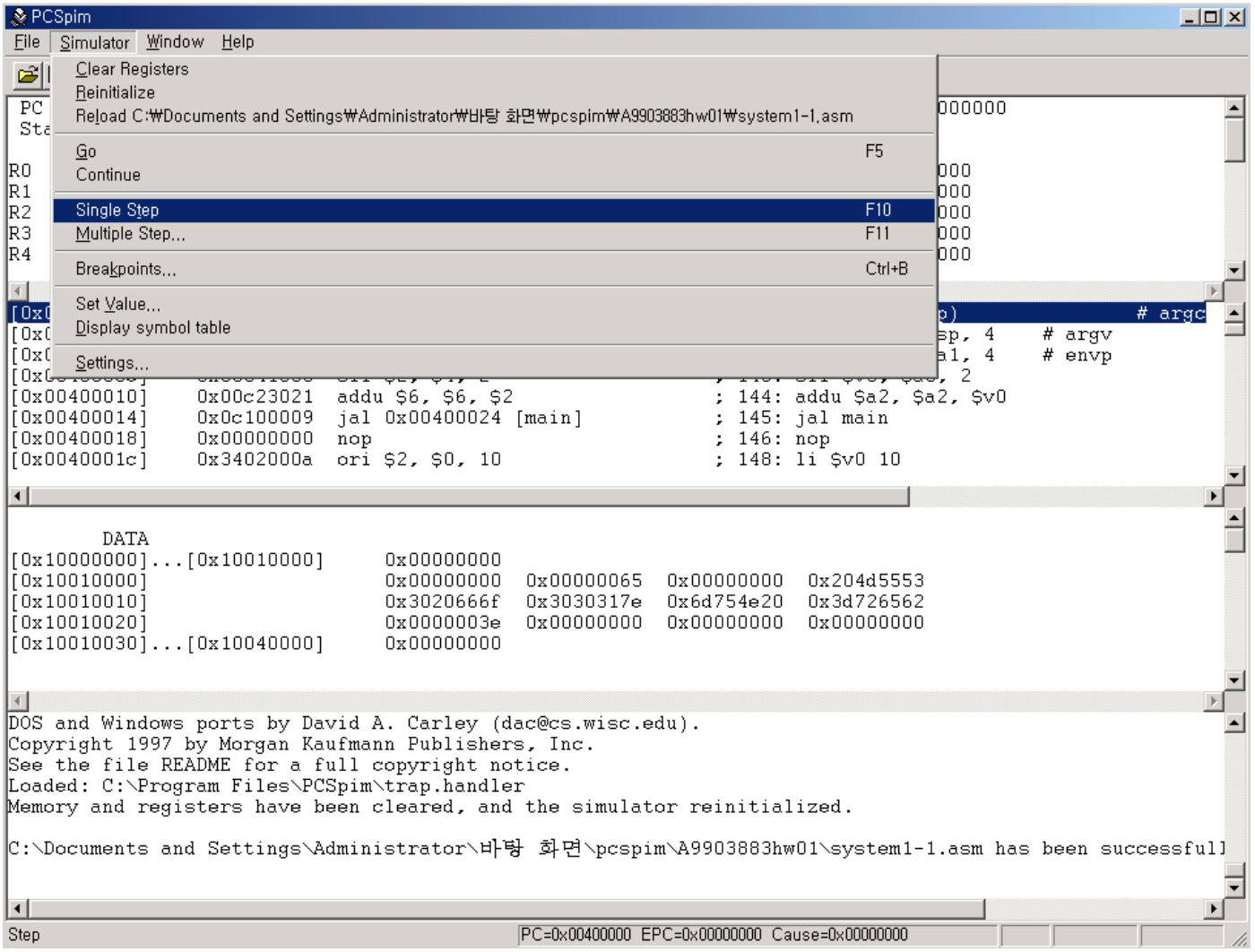
Function - Load



Function - Go

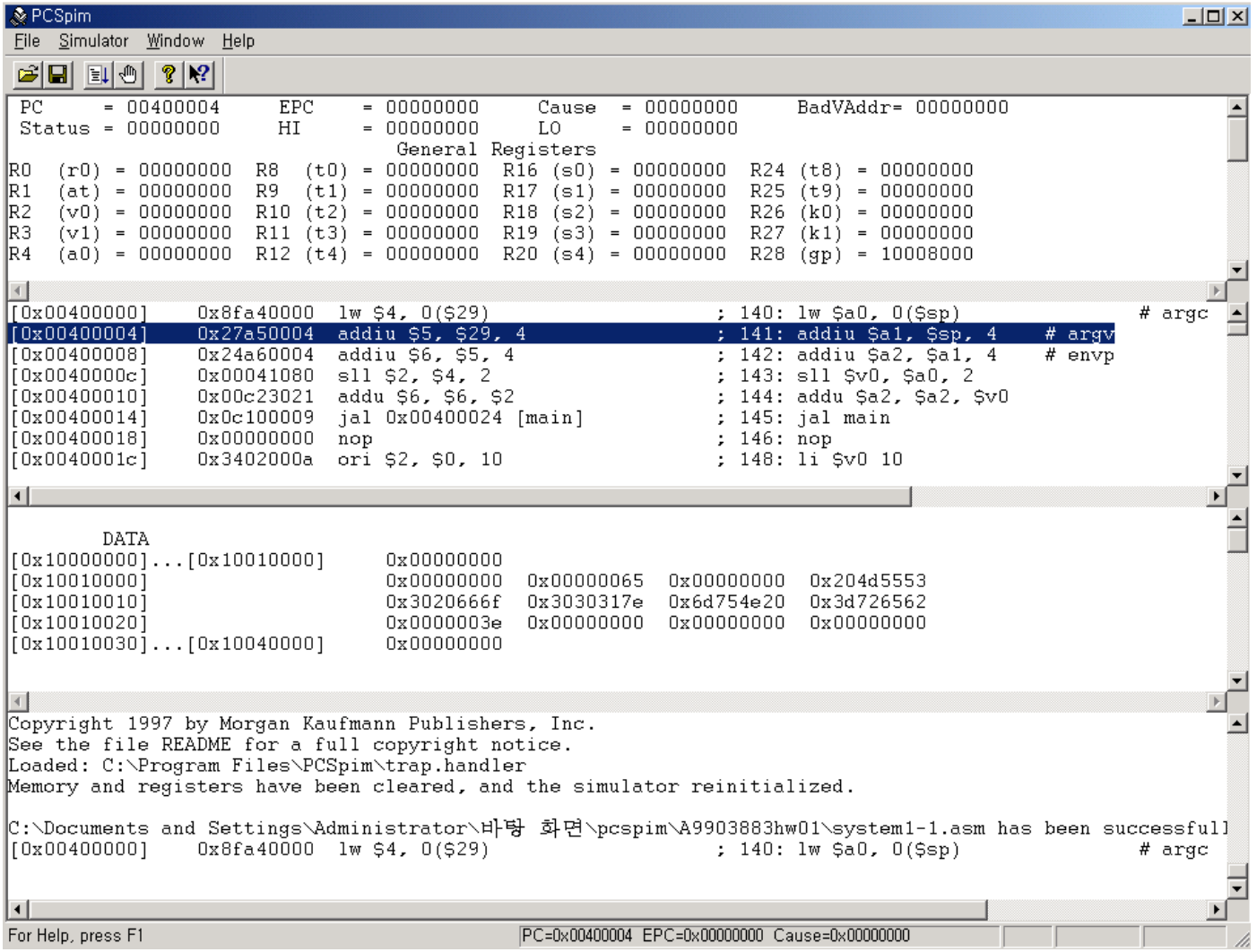

PCSpim
File
Simulator
Window
Help
Clear Registers
Reinitialize
Reload
Go F5
Break
Single Step F10
Multiple Step... F11
Breakpoints... Ctrl+B
Set Value...
Display symbol table
Settings...
PC = 00000000 Cause = 00000000 BadVAddr= 00000000
Sta = 00000000 LO = 00000000
General Registers
R0 (t0) = 00000000 R16 (s0) = 00000000 R24 (t8) = 00000000
R1 (t1) = 00000000 R17 (s1) = 00000000 R25 (t9) = 00000000
R2 (t2) = 00000000 R18 (s2) = 00000000 R26 (k0) = 00000000
R3 (t3) = 00000000 R19 (s3) = 00000000 R27 (k1) = 00000000
R4 (t4) = 00000000 R20 (s4) = 00000000 R28 (gp) = 10008000
[0x00400010] 0x00c23021 addu $6, $6, $2 ; 144: addu $a2, $a2, $v0
[0x00400014] 0x0c000000 jal 0x00000000 [main] ; 145: jal main
[0x00400018] 0x00000000 nop
[0x0040001c] 0x3402000a ori $2, $0, 10
DATA
[0x10000000]...[0x10040000] 0x00000000
STACK
[0x7fffeffc] 0x00000000
KERNEL DATA
Run Parameters
Starting
0x00400000
Command
Check for undefined symbol:
OK
Cancel
SPIM Version 6.5 of January 4, 2003
Copyright 1990-2003 by James R. Larus (larus@cs.wisc.edu).
All Rights Reserved.
DOS and Windows ports by David A. Carley (dac@cs.wisc.edu).
Copyright 1997 by Morgan Kaufmann Publishers, Inc.
See the file README for a full copyright notice.
Loaded: C:\Program Files\PCSpim\trap.handler
Run the program
PC=0x00000000 EPC=0x00000000 Cause=0x00000000

Function – Single step

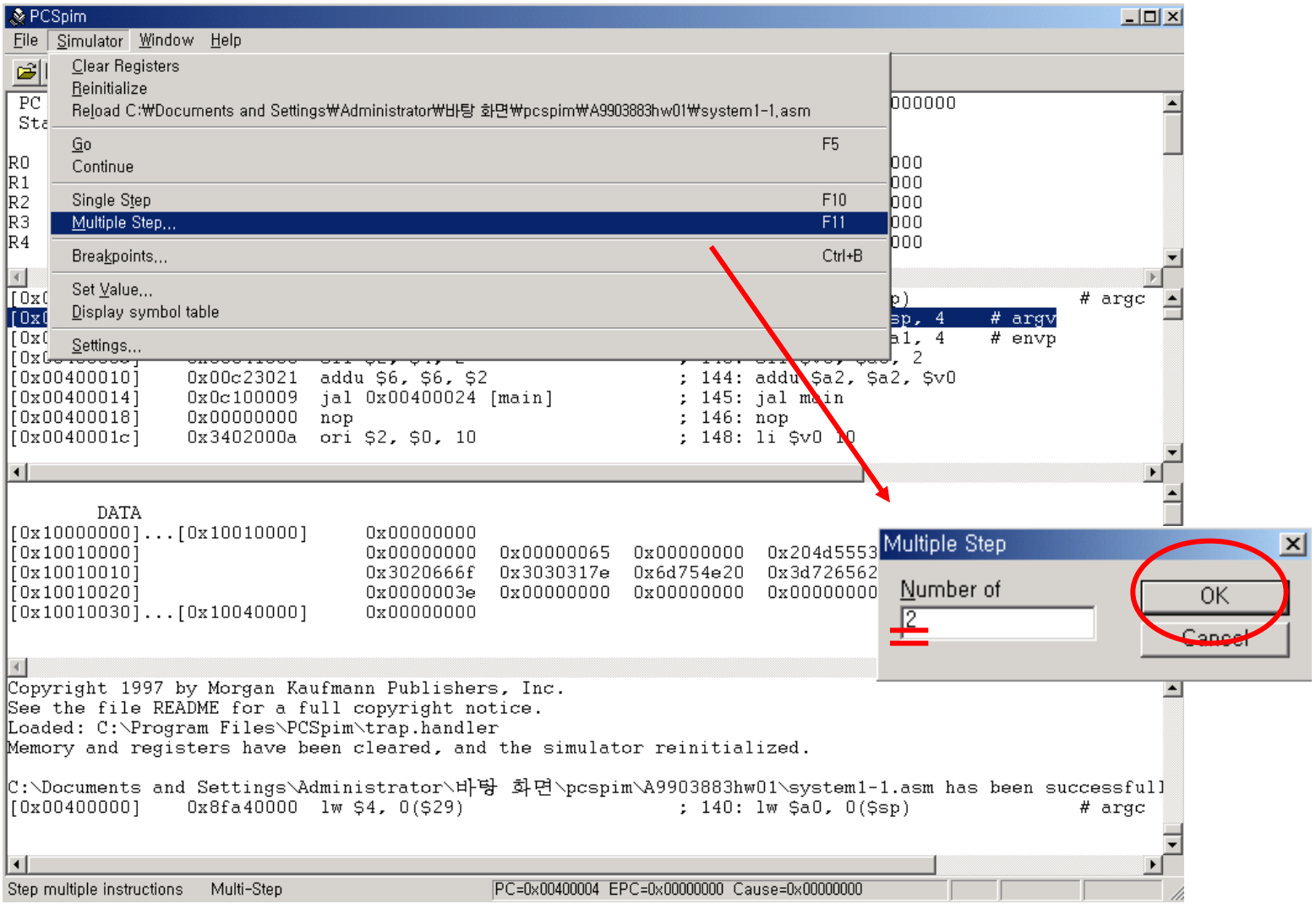


Function – Single step

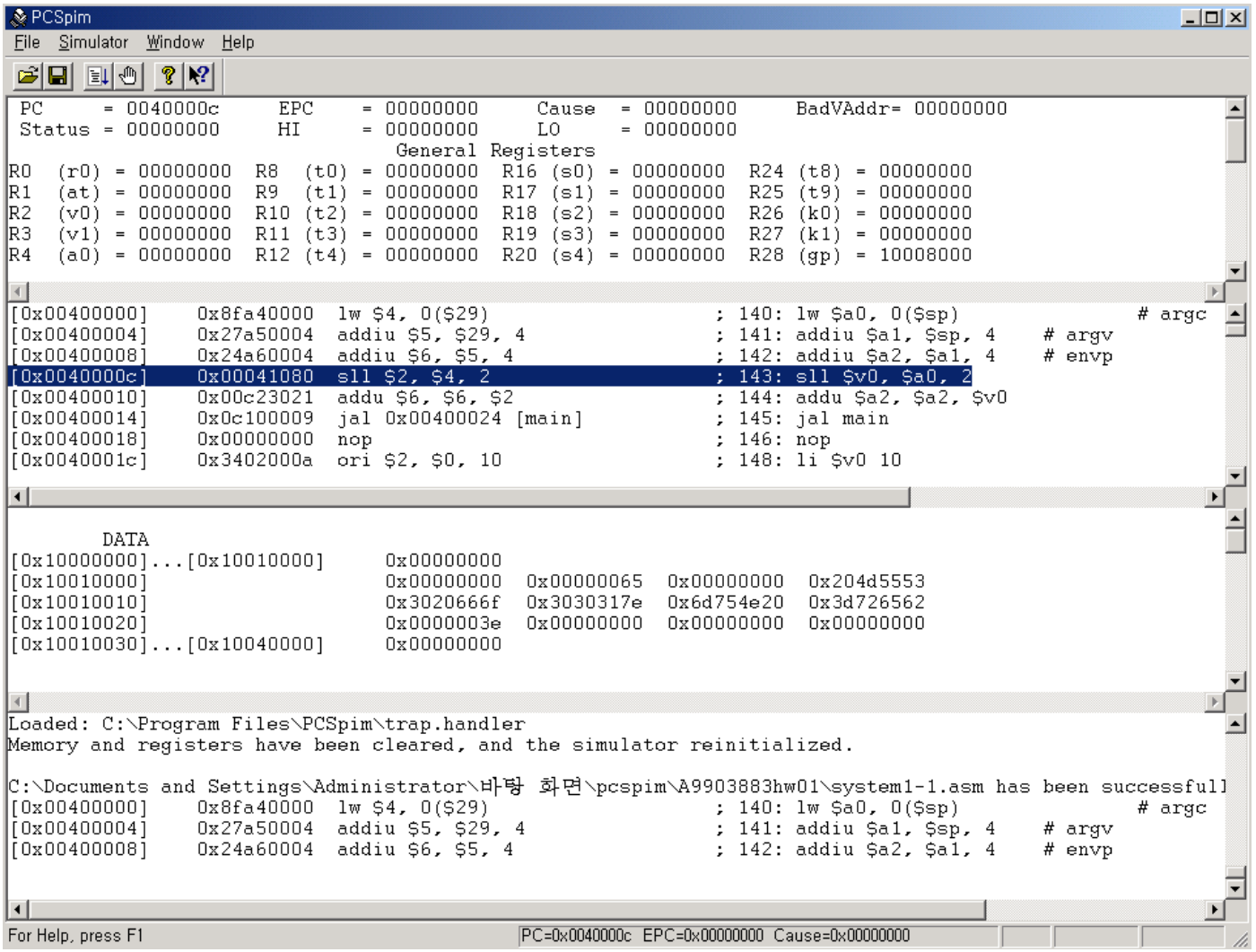
One step



Function – Multiple step

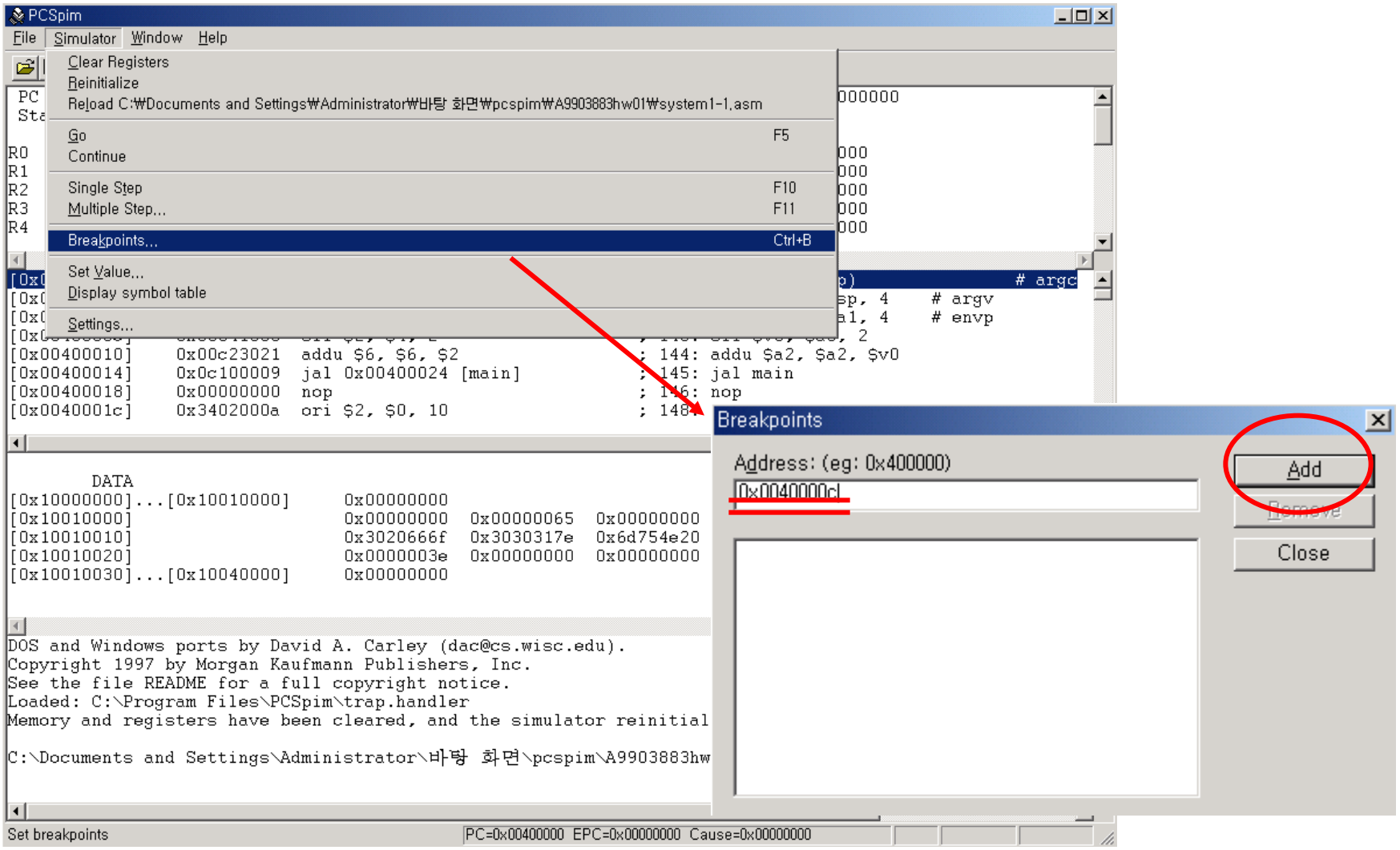


Function – Multiple step

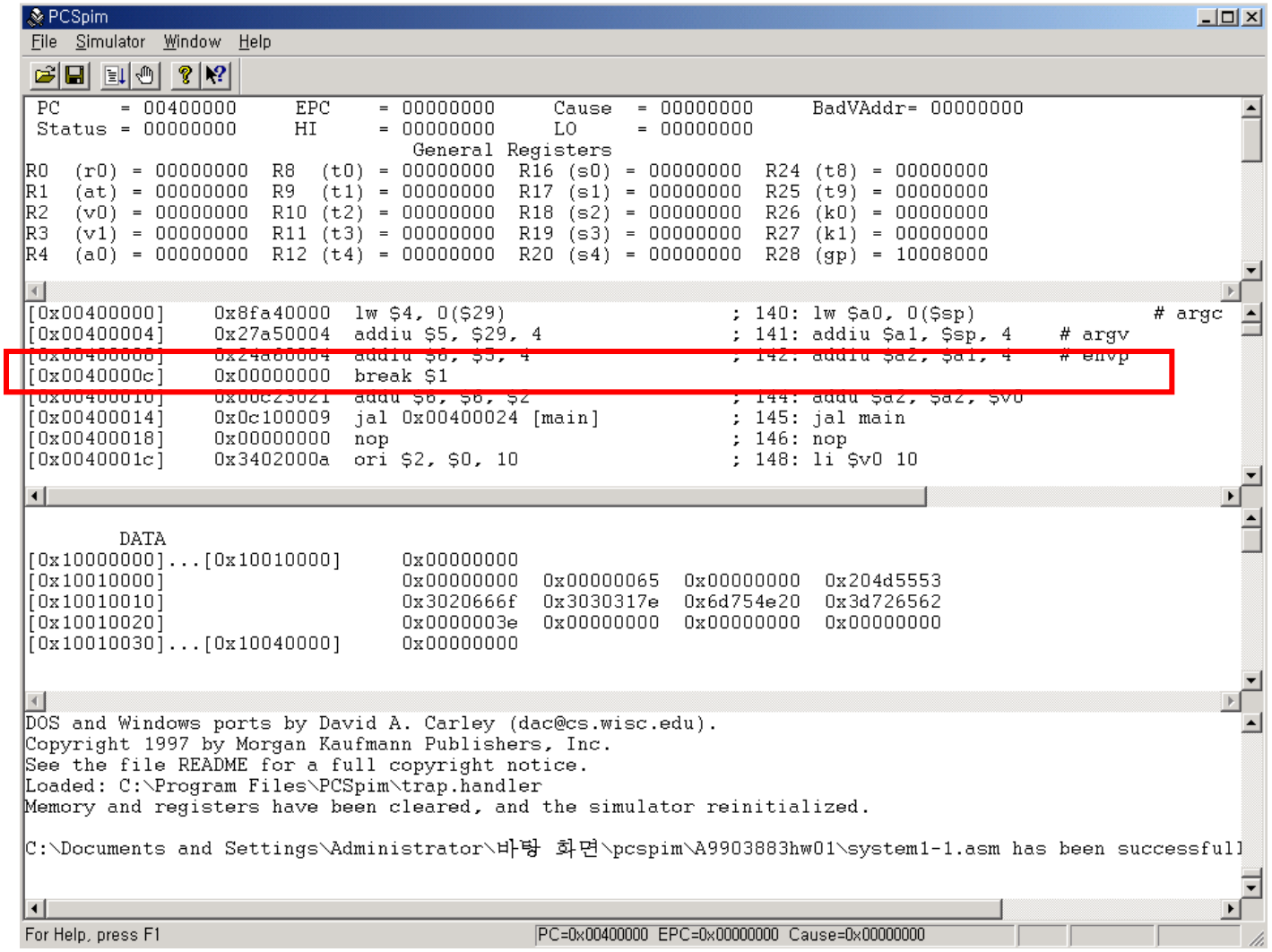


Two step

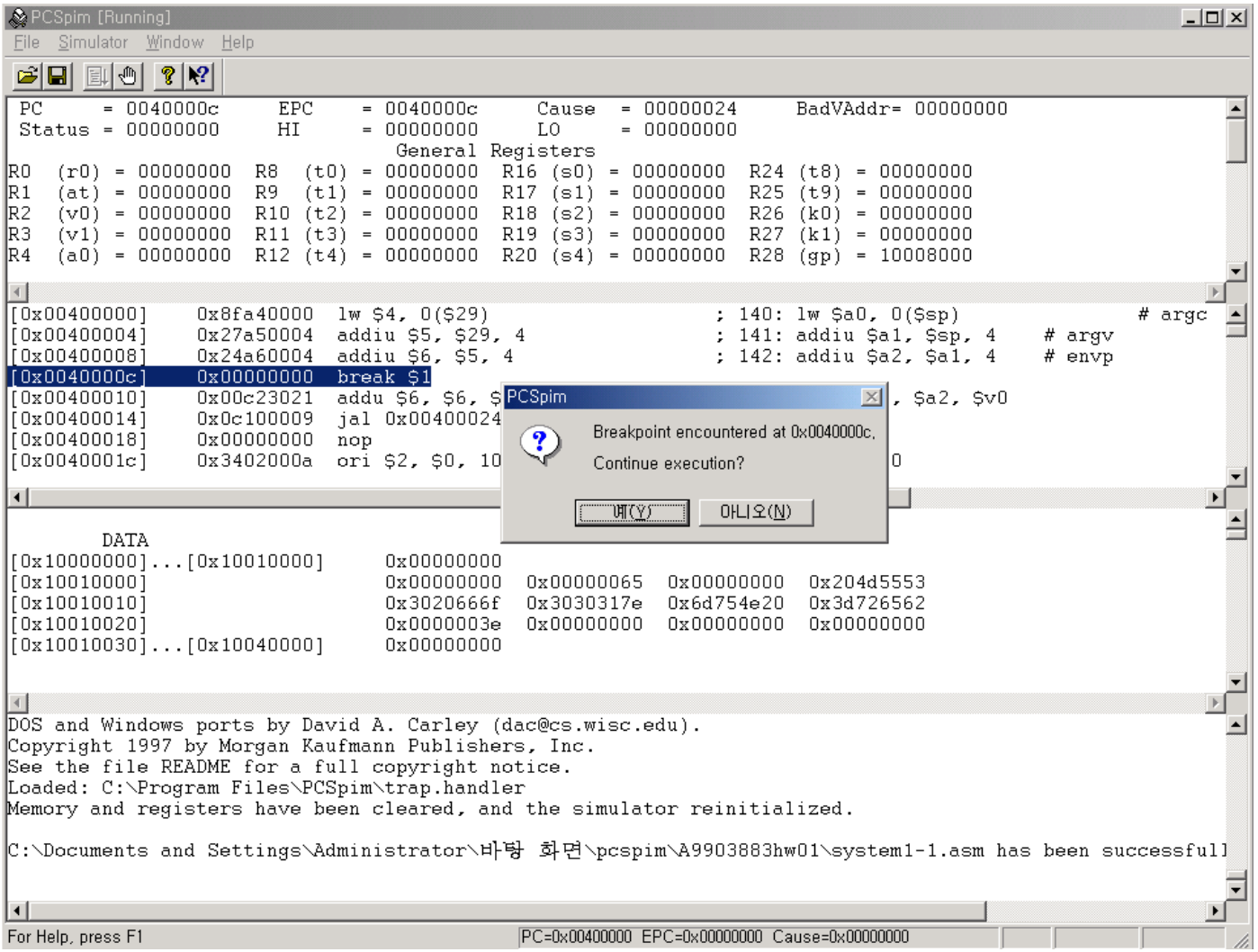
Function - breakpoint



Function - breakpoint



Function - breakpoint

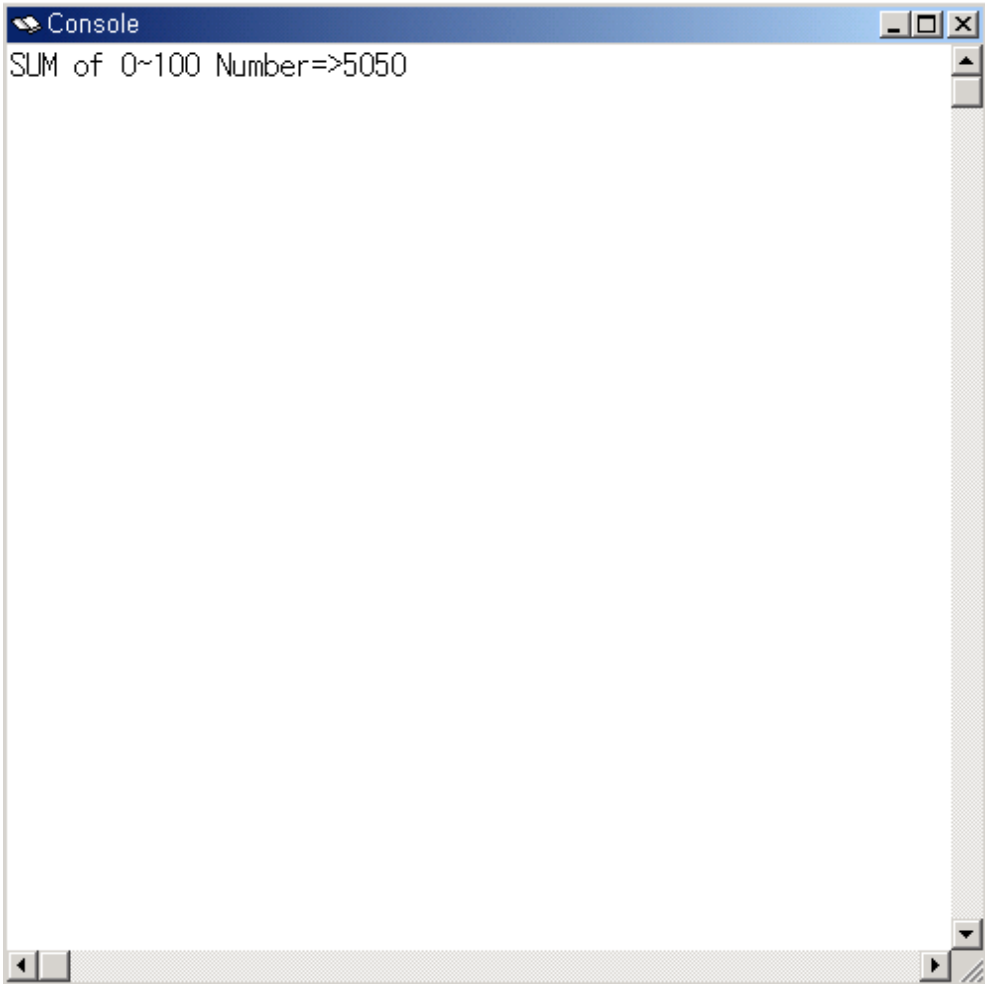


Example

- **Sum**

```
.text                          # text section
.globl main                    # call main by SPIM

main:  la    $t0, value        # load address 'value' into $t0
       lw    $t1, 0($t0)       # load word 0(value) into $t1
       lw    $t2, 4($t0)       # load word 4(value) into $t2
       lw    $t3, 8($t0)       # load word 8(value) into $t3

Loop:  beqz  $t2, End          # t2가 0이면 End로 가고 아니면 다음으로 내려간다
       addi  $t1, $t1, 1       # t1의 값을 하나씩 증가시킨다
       add   $t3, $t3, $t1     # t3에 t1을 더해 t3에 넣으며 같은 누적한다
       addi  $t2, $t2, -1      # t2의 값을 하나씩 감소시킨다
       j Loop                  # Loop로 이동시켜 루프를 돌린다

End:   sw    $t3, 8($t0)       # store word $t3 into 8($t0)

       li    $v0, 4
       la    $a0, msg1
       syscall

       li    $v0, 1
       move  $a0, $t3
       syscall

.data                          # data section
value: .word 0, 100, 0         # data for addition
msg1:  .asciiz "SUM of 0~100 Number=>"
```

Function - Go

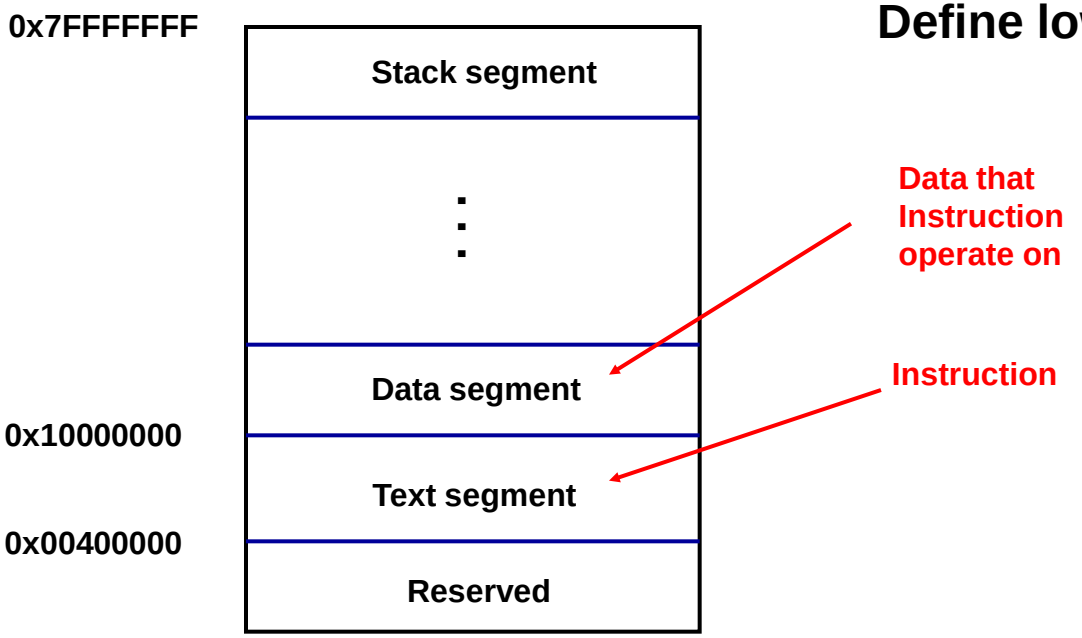


Function - Go

```
[0x00400050]    0x34020004  ori $2, $0, 4                    ; 17: li    $v0, 4
[0x00400054]    0x3c011001  lui $1, 4097 [msg1]              ; 18: la    $a0, msg1
[0x00400058]    0x3424000c  ori $4, $1, 12 [msg1]
[0x0040005c]    0x0000000c  syscall                          ; 19: syscall
[0x00400060]    0x34020001  ori $2, $0, 1                    ; 21: li    $v0, 1
[0x00400064]    0x000b2021  addu $4, $0, $11                 ; 22: move  $a0, $t3
[0x00400068]    0x0000000c  syscall                          ; 23: syscall
[0x0040006c]    0x03e00008  jr $31                           ; 25: jr    $ra
```

Define upper 2 bytes

Define lower 2 bytes



Directives

- .text – Indicates that following items are stored in the user text segment
- .globl *sym* – Declare that symbol *sym* is global and can be referenced from other files
- .data – Indicates that following data items are stored in the data segment

Data Types

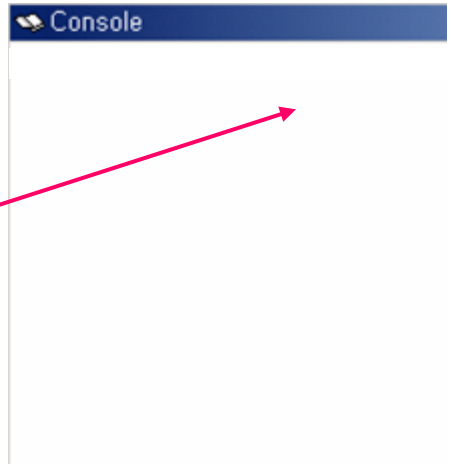
- .word, .half - 32/16 bit integer
- .byte - 8 bit integer (similar to 'char' type in C)
- .ascii, .asciiz - string (asciiz is null terminated)
  - Strings are enclosed in double-quotas(")
  - Special characters in strings follow the C convention
    - newline(\n), tab(\t), quote(\")
- .double, .float - floating point

System calls

- System Calls (syscall)
  - OS-like services
- Method
  - Load system call code into register $v0
  - Load arguments into registers $a0...$a3
  - After call, return value is in register $v0

Example)

```
li      $v0, 4     # print string
la      $a0, msg1
syscall

li      $v0, 1   # print integer
move  $a0, $t3
syscall
```



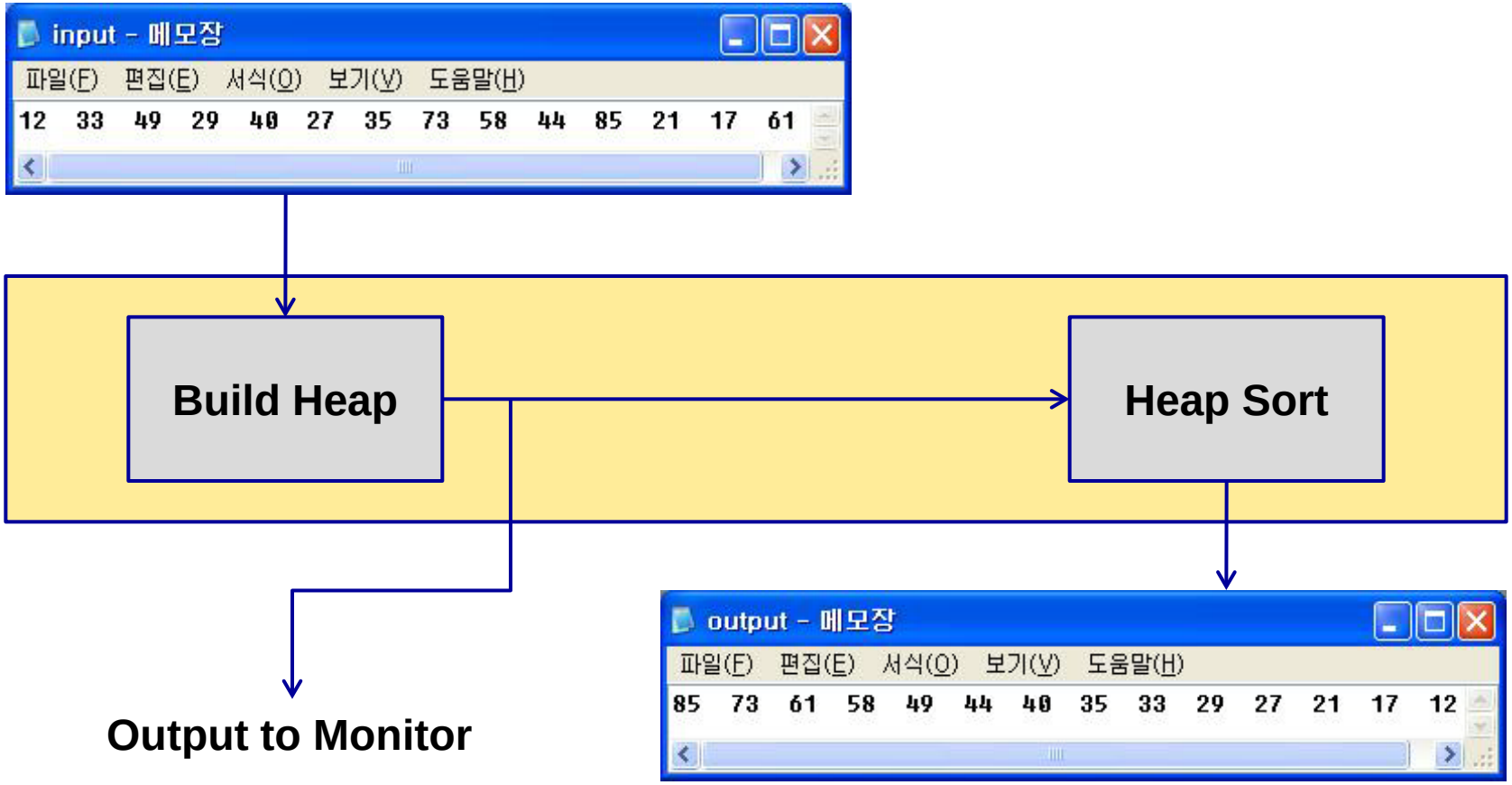
◆ **msg1 =** "SUM of 0~100 Number=>“ , **$t3** = 5050

System calls

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 $a0)
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	

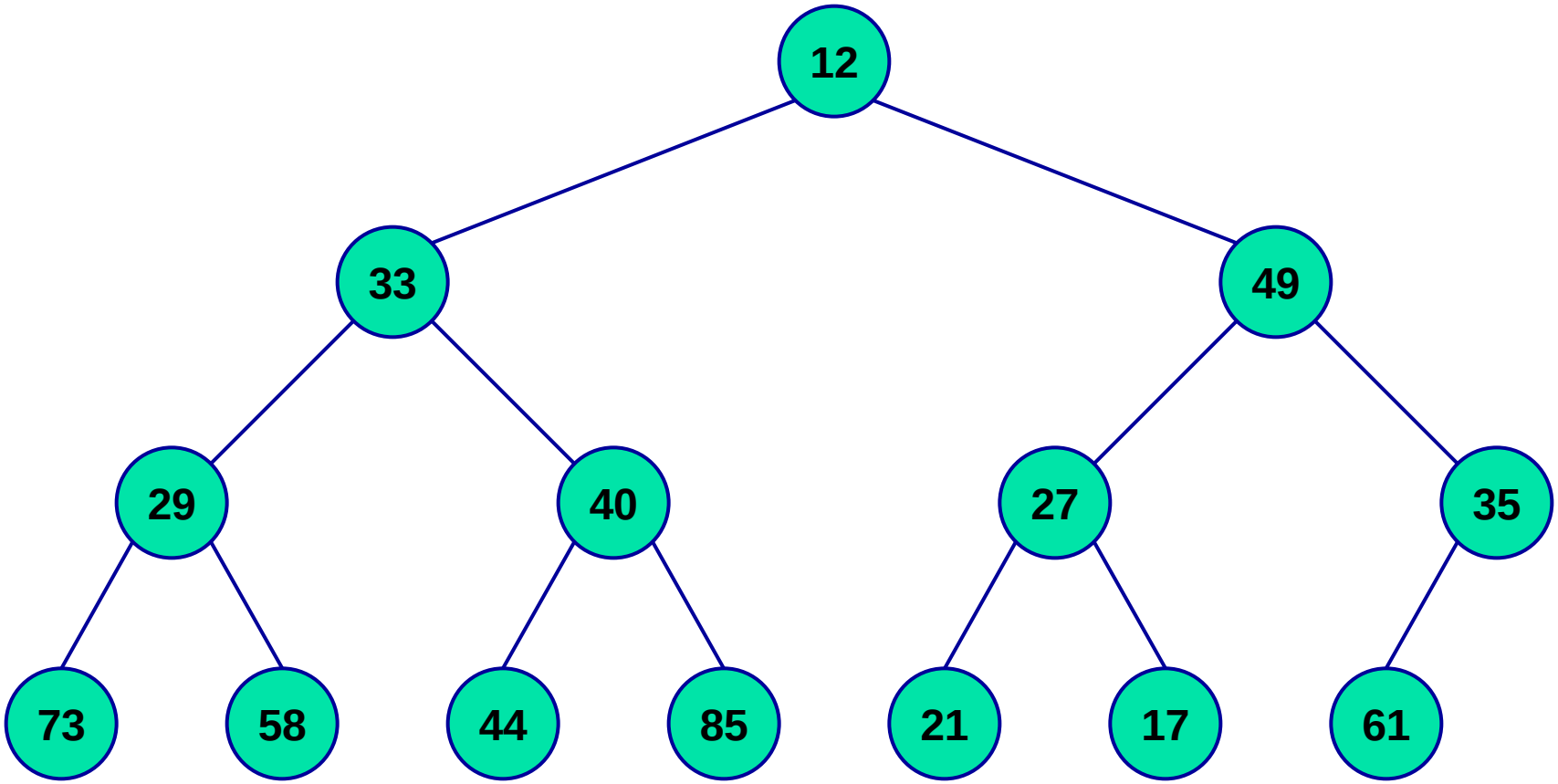
MIPS Program Assignment

- Heap sort



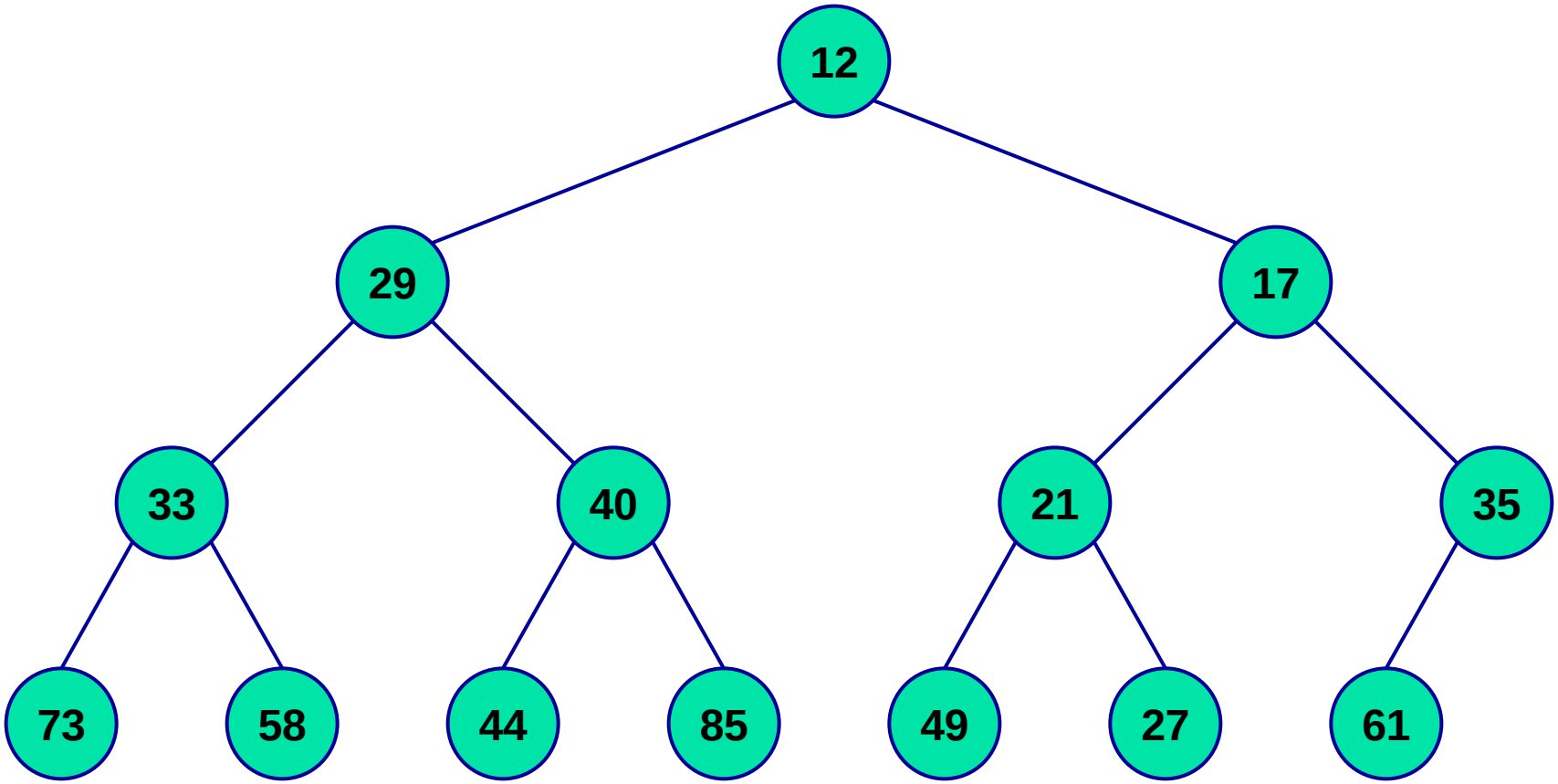
Sequence

Sequence: {12, 33, 49, 29, 40, 27, 35, 73, 58, 44, 85, 21, 17, 61}



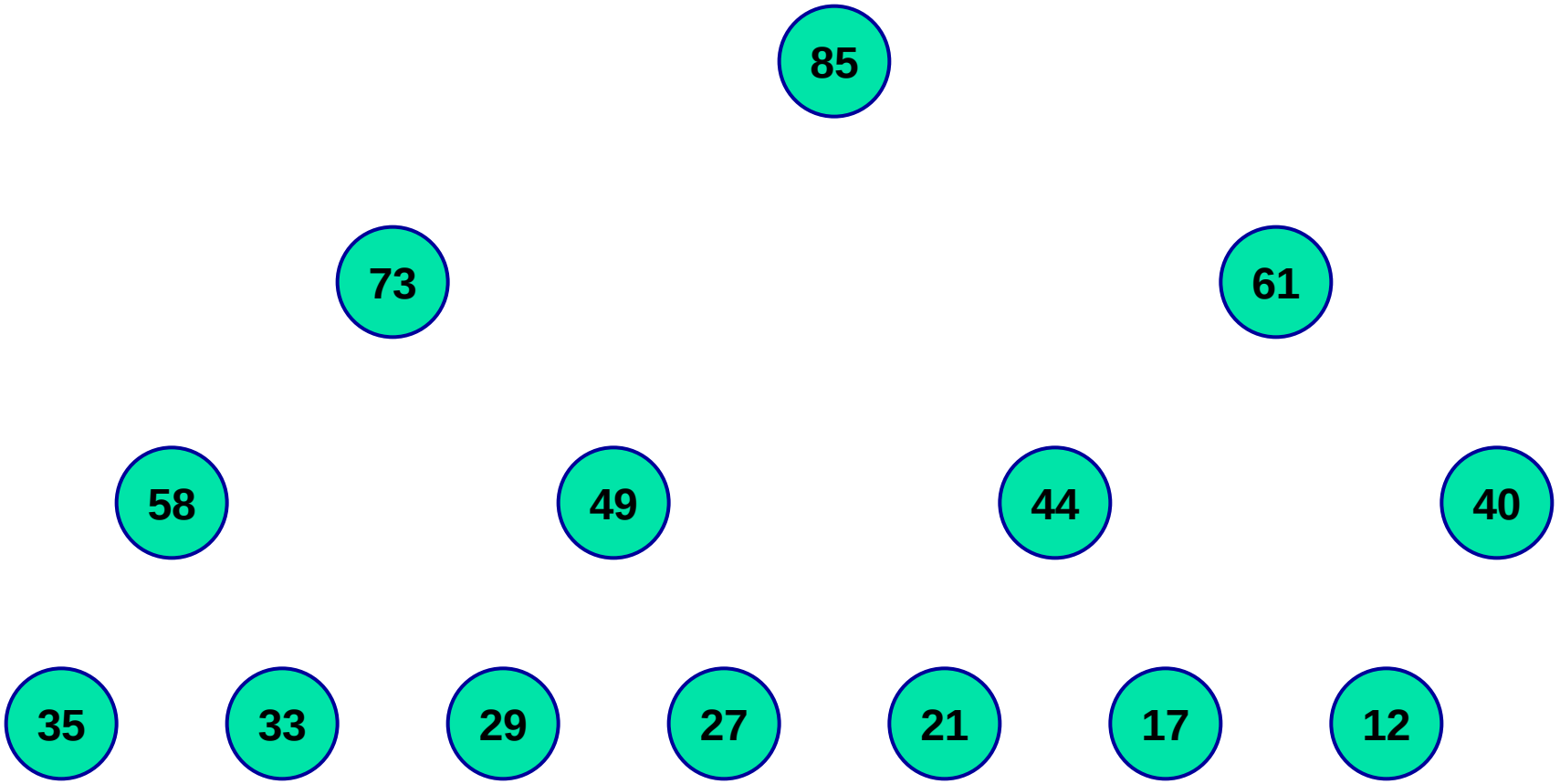
Build Heap

After Build: {12, 29, 17, 33, 40, 21, 35, 73, 58, 44, 85, 49, 27, 61}l



Heap Sort

After Sort: {85, 73, 61, 58, 49, 44, 40, 35, 33, 29, 27, 21, 17, 12}



MIPS Program Assignment

- 제출기한 : **2010.11.22**(월) **11:59 PM**
- 제출항목 : **source code,** 보고서
- 제출방식 : 지정된 **FTP** 에 **upload** (추후공지)
- 평가: **total 100**점, **-5%/(1-day delay)**
  - **Build heap: 40**점
  - **Heap sort: 20**점
  - **File I/O: 20**점
  - **Report: 20**점

Reference

- 문병로, “쉽게 배우는 알고리즘, 관계 중심의 사고법”, 한빛 미디어, **pp.93-99**
- **C source code on course homepage**