Introduction to MIPS programs

COMP2611:
Computer Organization

Overview

- You will learn the following in this tutorial:
  - MIPS data types and some pseudoinstructions.
  - the translation of program codes between MIPS and C++.

MIPS

MIPS data types

- the definition of MIPS data types

Program codes

- text segment
- pseudoinstructions
- exercises

Exercises

Sample MIPS program

```
# We need to declare "variables" & "Arrays" used in the program in a data segment.
# - The compiler recognizes .data as the beginning of data segment
.data
h: .word 1 2 3 4          # h is an array of size 4, each element is a word (32 bit)
s: .word 5
# The 3 lines below let the system know the program begins here
.text
.globl __start
__start:
# Write your program code here
la $s0, h             # Obtain starting address of array h, s0 = x (a constant)
lw $s1,8($s0)         # $s1 = content in memory address x + 8 = 3 = h[2]
la $s2, s
lw $s3, -12($s2)
sub $s3, $s3, $s1
sw $s3, 0($s0)
```

MIPS data types

- .ascii
  - String (without null terminator)
- .asciiz
  - String (with null terminator)
  - "z" refers to zero (ASCII code for the null character)
- .byte
  - Byte
  - values can be written in either base 10 or in hex

MIPS data types

- .half
  - 2 bytes
  - values can be written in either base 10 or in hex
  - Half word aligned in memory
  - i.e. initial byte stored at addresses divisible by 2
- .word
  - 4 bytes
  - values can be written in either base 10 or in hex
  - word-aligned in memory
  - i.e. initial byte stored at addresses divisible by 4
- .space num
  - Reserves num bytes of space in memory.

Examples

Variable name	Data type	Initialized value	Remarks
var1:	.half	14	# A half-word storing the integer 14
array1:	.word	5 6 7 8	# same as int array1[4] = {5,6,7,8} in C++
array2:	.word	3:5	# the part before ":" in the initialized value is # the initial value of each element in the # array, and the part after ":" is the array size. # same as int array2[5] = {3,3,3,3,3} in C++
string1:	.byte	0x32 # '2' in ASCII code 0x4a # 'J' in ASCII code 0 # '\0' in ASCII code	# string type is actually an array of char (a byte) # same as char string1[3] = {'2','J','\0'} in C++
string2:	.asciiz	"2J"	# equivalent to string1
array3:	.space	10	An array of 10 bytes is allocated for array3 in memory.

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MIPS text segment

- Under the .text segment of a MIPS program, we usually define the label __start or main for the first instruction of the program code in execution, like:

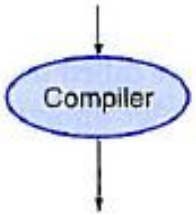
```
.text
.globl __start
__start:
```

- This label is often defined as a global label using .globl. A global label is a label that can be accessed across all the code files in a multiple-file assembly program. But you don't need to know this kind of program since we will not teach it.
- Defining this label or any others (using .globl or not) for the first instruction is optional.

Program compilation to instructions

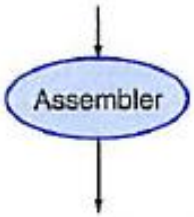
High-level language program (in C)

```
swap(int v[], int k)
{int temp;
   temp = v[k];
   v[k] = v[k+1];
   v[k+1] = temp;
}
```



Assembly language program (for MIPS)

```
swap:
        muli $2, $5,4
        add  $2, $4,$2
        lw   $15, 0($2)
        lw   $16, 4($2)
        sw   $16, 0($2)
        sw   $15, 4($2)
        jr   $31
```



Binary machine language program (for MIPS)

```
00000000101000010000000000011000
00000000000011000000110000100001
10001100011000100000000000000000
10001100111100100000000000000100
10101100111100100000000000000000
10101100011000100000000000000100
00000011111000000000000000001000
```

MIPS pseudoinstructions

- They are MIPS assembly instructions that do not have the corresponding machine instructions. Some examples are:

Instructions	Explanation	Example	C++ Equivalent
(Load Immediate) **li Rdest, Imm**	Move the immediate *Imm* (constant) into register *Rdest*.	li $v0, 5	v0 = 5;
(move) **move Rdest, Rsrc1**	Copy the value of *Rsrc1* into register *Rdest*.	move $a0, $t0	a0 = t0;

Pseudoinstructions	Translation	Example
(Load Immediate) **li Rdest, small (16-bits)**	addi Rdest, Rdest, small	addi $t0, $t0, 0x0123
(Load Immediate) **li Rdest, big** (32-bits) e.g. 0x0123abcd	lui Rdest, upper(big) ori Rdest, Rdest, lower(big)	lui $r1, 0x0123 ori $r1, $r1, 0xabcd
(move) **move Rdest, Rsrc1**	addi Rdest, Rsrc1, 0	addi $t0, $s0, 0

Exercises

Question 1: Write down the shortest sequence (any one) of MIPS instructions for the following C++ code, assuming each variable is stored in a different register (you name it):

```
a = a - 1;
```

Exercises

Question 2: Write down the shortest sequence (any one) of MIPS instructions for the following C++ code, assuming each variable is stored in a different register (you name it):

```
b = a * 5;
```

Question 3: Write down the shortest sequence (any one) of MIPS instructions for the following C++ code, assuming the base address of the int array A is stored in the register s0. You can use some registers for storing temporary values.

A[2] = A[7] + 11;

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Question 1: Write down the shortest sequence (any one) of MIPS instructions for the following C++ code, assuming the base address of the array A of int elements is stored in the register s0 and each variable is stored in a different register (you name it). You can use some registers for storing temporary values.

```
A[c++] = A[b] + 17;
```

Conclusion

- You have learnt:
  - MIPS data types and some pseudoinstructions.
  - the translation of program codes between MIPS and C++.