

ĐẠI HỌC BÁCH KHOA HÀ NỘI
TRƯỜNG CÔNG NGHỆ THÔNG TIN VÀ TRUYỀN THÔNG



BÁO CÁO

Bài tập thực hành tuần 2

Học phần: Thực hành kiến trúc máy tính

Giảng viên hướng dẫn: Lê Bá Vui

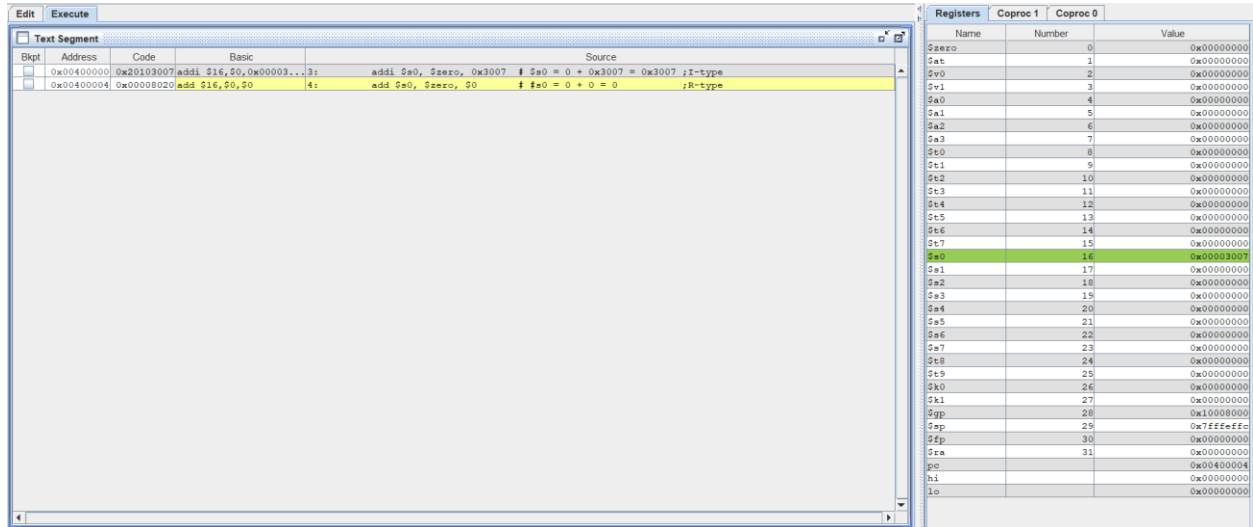
Sinh viên thực hiện: Phạm Huy Cảnh - 20194490

Mã lớp: 130938

Hà Nội, tháng 4 năm 2022

1. Assignment 1: Lệnh gán số 16-bit

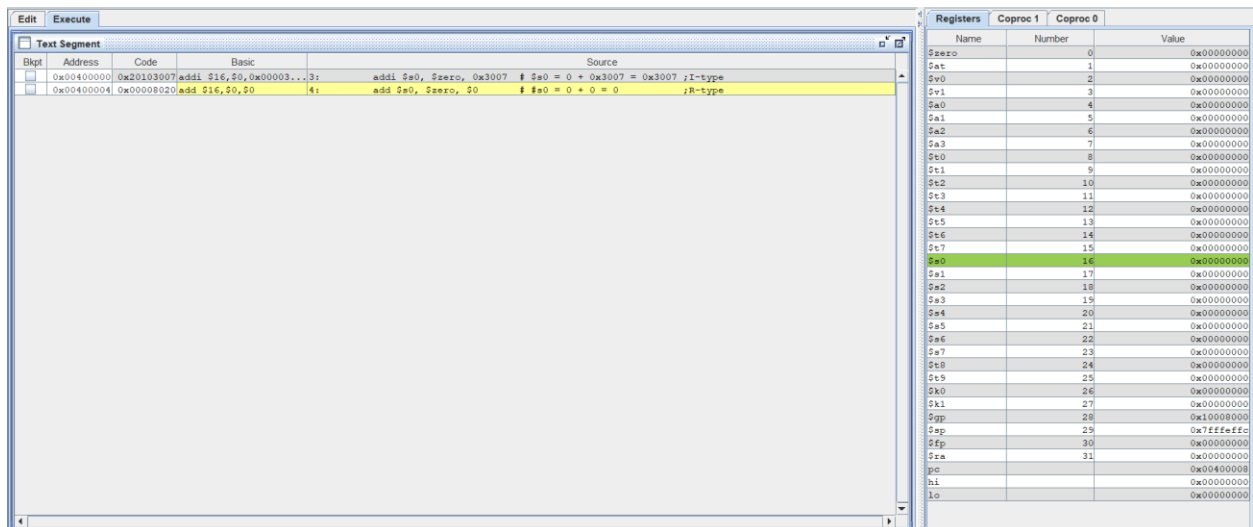
- Sau khi chạy dòng lệnh thứ nhất: `addi $s0, $zero, 0x3007`



Ta thấy:

- + Thanh ghi `$s0` thay đổi giá trị bằng `0x00003007` (`$zero` + `0x3007`)
 - + Thanh ghi `$pc` = `0x00400004` (Đúng bằng địa chỉ của câu lệnh thứ hai)
- => Thanh ghi `$pc` tự động tăng thêm 4 để chỉ đến địa chỉ của câu lệnh tiếp theo

- Sau khi chạy dòng lệnh thứ hai: `add $s0, $zero, $0`



Ta thấy:

+ Thanh ghi `$s0` thay đổi giá trị bằng `0x00000000` (`$zero` + `$0`)

+ Thanh ghi `$pc` = `0x00400008`, Thanh ghi `$pc` tiếp tục tăng thêm 4 để chỉ đến địa chỉ đến vùng nh tiếp theo

- *Khuôn dạng lệnh:*

+ Lệnh thứ nhất: `addi $16, $0, 0x00003007`

Mã lệnh = `0x20103007` = `0010 0000 0001 0000 0011 0000 0000 0111`

opcode	rs	rt	immediate
6 bits	5 bits	5 bits	16 bits
001000	00000	10000	00110000000000111
8	0	16	0x3007

=> Câu lệnh thứ nhất đã chuẩn so với khuôn dạng lệnh I

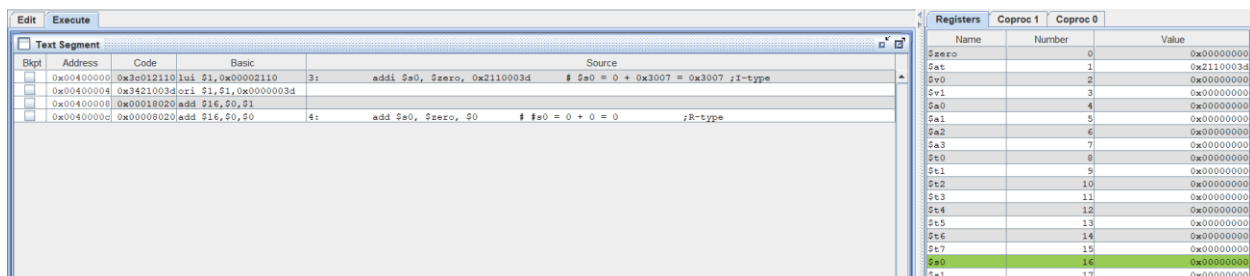
+ Lệnh thứ nhất: `add $16, $0, $0`

Mã lệnh = `0x00008020` = `0000 0000 0000 0000 1000 0000 0010 0000`

opcode	rs	rt	rd	shamt	funct
6 bits	5 bits	5 bits	5 bits	5 bits	6 bits
000000	00000	00000	10000	00000	100000
0	0	0	16	0	32

=> Câu lệnh thứ hai đã chuẩn so với khuôn dạng lệnh R

- *Sửa câu lệnh thành* `addi $s0, $zero, 0x2110003d`



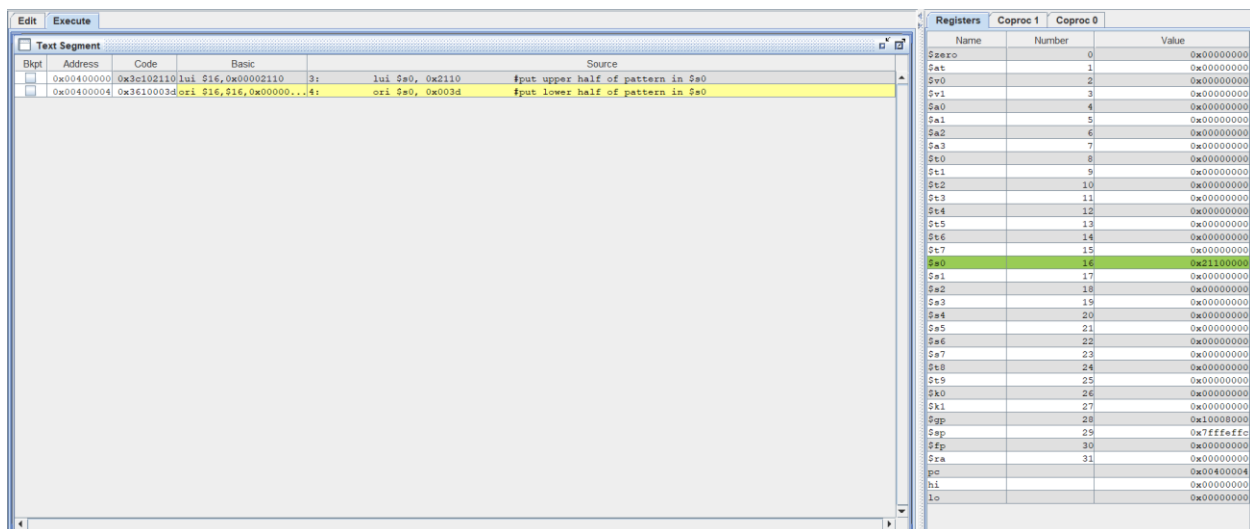
+ Hiện tượng xảy ra: Câu lệnh `addi $s0, $zero, 0x2110003d` được thực hiện bằng 3 câu lệnh:

```
lui $1, 0x00002110
ori $1, $1, 0x0000003d
add $16, $0, $1
```

+ Giải thích: Vì câu lệnh một câu lệnh có độ dài 32 bits, trong khi đó ở câu lệnh trên phần immediate lại chiếm hết 32 bits của câu lệnh, nên để tính toán được nó chia phần immediate thành 2 phần là: 16 bits cao và 16 bits thấp. Sau đó ghi từng phần vào một thanh ghi 32 bits (ở đây là thanh ghi `$1`). Lệnh `lui` sẽ ghi `2110(16)` vào 16 bits cao của thanh ghi `$1`, Lệnh `ori` sẽ ghi `003d(16)` vào 16 bits thấp của thanh ghi `$s1`. Khi này thanh ghi `$1` = `0x2110003d`, cuối cùng thực hiện lệnh `add` hai thanh ghi `$1` và `$0` kết quả được ghi vào thanh ghi `$16` (`$s0`)

2. Assignment 2: Lệnh gán số 32-bit

- Sau khi chạy dòng lệnh thứ nhất: `lui $s0, 0x2110`



Ta thấy:

+ Thanh ghi `$s0` thay đổi giá trị bằng `0x21100000` (Ghi giá trị `2110(16)` vào 2 bytes cao của thanh ghi `$s0`)

+ Thanh ghi `$pc` = `0x00400004` (Đúng bằng địa chỉ của câu lệnh thứ hai)

- Sau khi chạy dòng lệnh thứ hai: `ori $s0, 0x003d`

Text Segment					Registers		
Bkpt	Address	Code	Basic	Source	Name	Number	Value
	0x00400000	0x3c102110	lui \$16, 0x0002110	3: lui \$s0, 0x2110	\$zero	0	0x00000000
	0x00400004	0x3610003d	ori \$16, 0x0000...4:	ori \$s0, 0x003d	\$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	0x2110003d
					\$s1	17	0x00000000
					\$s2	18	0x00000000
					\$s3	19	0x00000000
					\$s4	20	0x00000000
					\$s5	21	0x00000000
					\$s6	22	0x00000000
					\$s7	23	0x00000000
					\$s8	24	0x00000000
					\$s9	25	0x00000000
					\$k0	26	0x00000000
					\$k1	27	0x00000000
					\$gp	28	0x10008000
					\$sp	29	0x7ffffeffc
					\$fp	30	0x00000000
					\$ra	31	0x00000000
					\$pc		0x00400008
					\$hi		0x00000000
					\$lo		0x00000000

Ta thấy:

+ Thanh ghi **\$s0** thay đổi giá trị bằng 0x2110003d (Ghi giá trị 003d₍₁₆₎ vào 2 bytes thấp của thanh ghi **\$s0**)

+ Thanh ghi **\$pc** = 0x00400008, Thanh ghi **\$pc** tiếp tục tăng thêm 4 để chỉ đến vùng nhớ tiếp theo

- Quan sát các byte trong vùng lệnh .text:

EditExecute

Text Segment

Bkpt

Address

Code

Basic

Source

0x00400000

0x3c102110

lui \$16, 0x00002110

3:

lui \$s0, 0x2110

\$put upper half of pa...

0x00400004

0x3610003d

ori \$16, 0x0000...4:

ori \$s0, 0x003d

\$put lower half of pa...

Data

Text

Data Segment

Address

Value (+0)

Value (+4)

Value (+8)

Value (+c)

Value (+10)

Value (+14)

Value (+18)

Value (+1c)

0x00400000

0x3c102110

0x3610003d

0x00000000

0x00000000

0x00000000

0x00000000

0x00000000

0x00000000

0x00400004

0x00000000

0x00000000

0x00000000

0x00000000

0x00000000

0x00000000

0x00000000

0x00000000

0x00400008

0x00000000

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0x0040000c

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0x00400014

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0x0040001c

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0x00400024

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0x00400028

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0x0040002c

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0x00400044

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0x0040004c

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0x00400150

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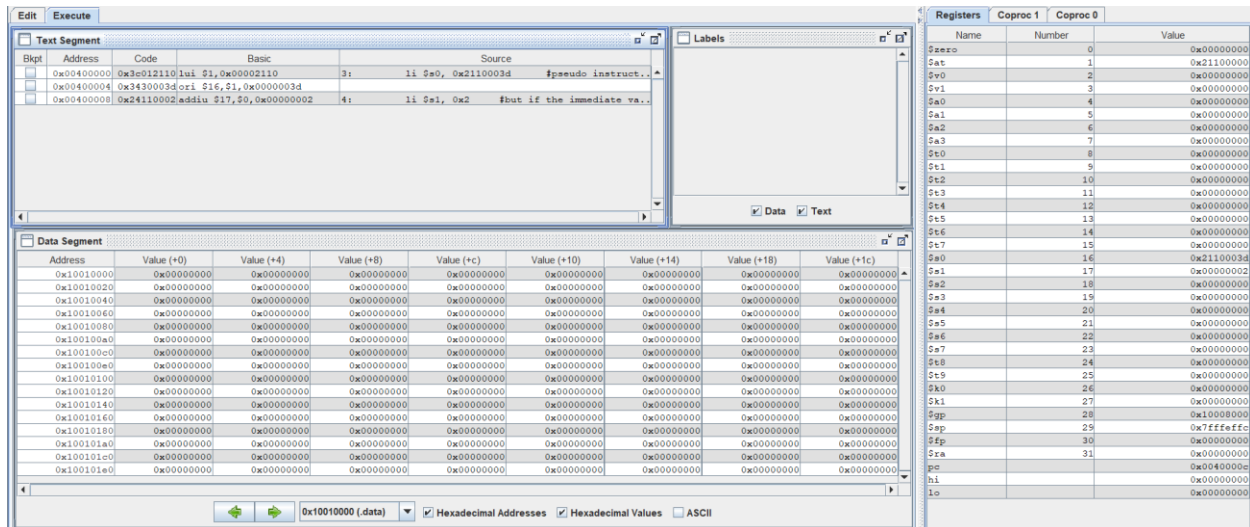
0x00000000

0x00400154

0x00000000

3. Assignment 3: Lệnh gán (giả lệnh)

Sau khi biến dịch:



- **Dòng lệnh thứ nhất:** `li $s0, 0x2110003d`

+ Câu lệnh này được thực hiện bởi hai câu lệnh:

`lui $1, 0x00002110`

`ori $16, $1, 0x0000003d`

+ Giải thích: Phần immediate đã vượt quá mức 16 bits nên phải tách thành hai câu lệnh như trên để ghi lần lượt 16 bits cao và 16 bits thấp vào thanh ghi `$s0`. Bằng cách đầu tiên sử dụng lệnh `lui $1, 0x00002110` để ghi `2110(16)` vào 16 bits cao của thanh ghi `$1`, khi đó thanh ghi `$1 = 0x21100000`; sau đó sử dụng lệnh `ori $16, $1, 0x0000003d` để OR thanh ghi `$16` với thanh ghi `$1`, khi đó thanh ghi `$16 = 0x2110003d`. Vậy kết quả ta gán được giá trị `0x2110003d` vào thanh ghi `$s0`

- **Dòng lệnh thứ hai:** `li $s1, 0x2`

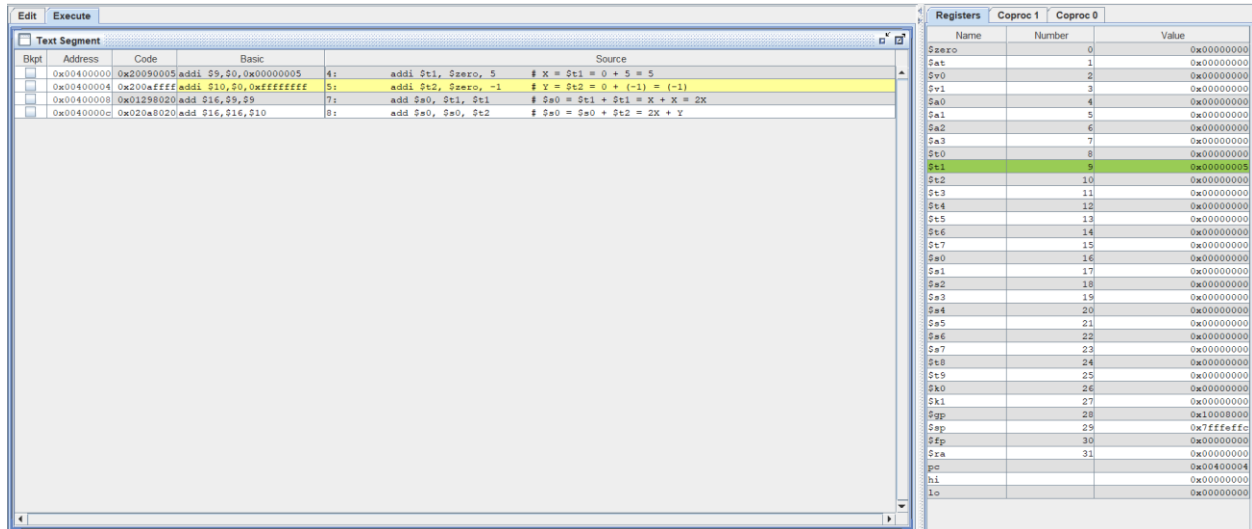
+ Câu lệnh này được thực hiện bởi một câu lệnh:

`addi $17, $0, 0x00000002`

+ Giải thích: Phần immediate nằm trong mức cho phép nên câu lệnh trên chỉ cần thực hiện bằng một câu lệnh `addi $17, $0, 0x00000002`, khi đó ta được kết quả thanh ghi `$s1` được gán bằng `0x2`

4. Assignment 4: Tính biểu thức $2x+y=?$

- Sau khi chạy dòng lệnh thứ nhất: `addi $t1, $zero, 5`

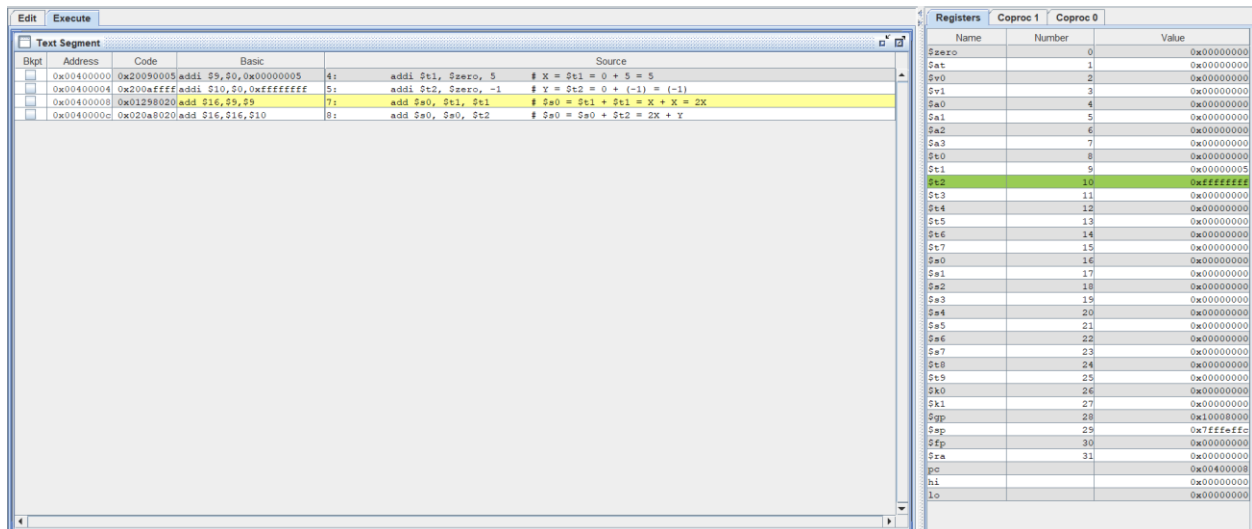


Blkpt	Address	Code	Basic	Source
	0x00400000	0x20090005	addi \$t1, \$zero, 5	4: addi \$t1, \$zero, 5 # X = \$t1 = 0 + 5 = 5
	0x00400004	0x200affff	addi \$t2, \$zero, -1	5: addi \$t2, \$zero, -1 # Y = \$t2 = 0 + (-1) = (-1)
	0x00400008	0x01298020	add \$s0, \$t1, \$t1	7: add \$s0, \$t1, \$t1 # \$s0 = \$t1 + \$t1 = X + X = 2X
	0x0040000c	0x020a8020	add \$s0, \$s0, \$t2	8: add \$s0, \$s0, \$t2 # \$s0 = \$s0 + \$t2 = 2X + Y

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	0x00000005
\$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	0x10000000
\$sp	29	0x7ffffc00
\$fp	30	0x00000000
\$ra	31	0x00000000
pc		0x00400004
hi		0x00000000
lo		0x00000000

Ta thấy: Thanh ghi `$t1` được gán giá trị bằng $0x00000005$ ($5_{(10)}$)

- Sau khi chạy dòng lệnh thứ hai: `addi $t2, $zero, -1`



Blkpt	Address	Code	Basic	Source
	0x00400000	0x20090005	addi \$t1, \$zero, 5	4: addi \$t1, \$zero, 5 # X = \$t1 = 0 + 5 = 5
	0x00400004	0x200affff	addi \$t2, \$zero, -1	5: addi \$t2, \$zero, -1 # Y = \$t2 = 0 + (-1) = (-1)
	0x00400008	0x01298020	add \$s0, \$t1, \$t1	7: add \$s0, \$t1, \$t1 # \$s0 = \$t1 + \$t1 = X + X = 2X
	0x0040000c	0x020a8020	add \$s0, \$s0, \$t2	8: add \$s0, \$s0, \$t2 # \$s0 = \$s0 + \$t2 = 2X + Y

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	0x00000005
\$t2	10	0xffffffff
\$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	0x10000000
\$sp	29	0x7ffffc00
\$fp	30	0x00000000
\$ra	31	0x00000000
pc		0x00400008
hi		0x00000000
lo		0x00000000

Ta thấy: Thanh ghi `$t2` được gán giá trị bằng $0xffffffff$ ($-1_{(10)}$)

- Sau khi chạy dòng lệnh thứ ba: `add $s0, $t1, $t1`

Text Segment	Address	Code	Basic	Source
<input type="checkbox"/>	0x00400000	0x20090005	addi \$9,\$0,0x00000005	4: addi \$t1, \$zero, 5 # X = \$t1 = 0 + 5 = 5
<input type="checkbox"/>	0x00400004	0x200affff	addi \$10,\$0,0xffffffff	5: addi \$t2, \$zero, -1 # Y = \$t2 = 0 + (-1) = (-1)
<input type="checkbox"/>	0x00400008	0x01298020	add \$16,\$9,\$9	7: add \$s0, \$t1, \$t1 # \$s0 = \$t1 + \$t1 = X + X = 2X
<input type="checkbox"/>	0x0040000c	0x020a8020	add \$16,\$16,\$10	8: add \$s0, \$s0, \$t2 # \$s0 = \$s0 + \$t2 = 2X + Y

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	0x00000005
\$t2	10	0xffffffff
\$t3	11	0x00000000
\$t4	12	0x00000000
\$t5	13	0x00000000
\$t6	14	0x00000000
\$t7	15	0x00000000
\$s0	16	0x0000000a
\$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	0x10000000
\$ap	29	0x7fffffc0
\$fp	30	0x00000000
\$ra	31	0x00000000
\$pc		0x0040000e
\$hi		0x00000000
\$lo		0x00000000

Ta thấy: Thanh ghi `$s0` có giá trị bằng `0x0000000a` ($10_{(10)}$)

- Sau khi chạy dòng lệnh thứ tư: `add $s0, $s0, $t2`

Text Segment	Address	Code	Basic	Source
<input type="checkbox"/>	0x00400000	0x20090005	addi \$9,\$0,0x00000005	4: addi \$t1, \$zero, 5 # X = \$t1 = 0 + 5 = 5
<input type="checkbox"/>	0x00400004	0x200affff	addi \$10,\$0,0xffffffff	5: addi \$t2, \$zero, -1 # Y = \$t2 = 0 + (-1) = (-1)
<input type="checkbox"/>	0x00400008	0x01298020	add \$16,\$9,\$9	7: add \$s0, \$t1, \$t1 # \$s0 = \$t1 + \$t1 = X + X = 2X
<input type="checkbox"/>	0x0040000c	0x020a8020	add \$16,\$16,\$10	8: add \$s0, \$s0, \$t2 # \$s0 = \$s0 + \$t2 = 2X + Y

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	0x00000005
\$t2	10	0xffffffff
\$t3	11	0x00000000
\$t4	12	0x00000000
\$t5	13	0x00000000
\$t6	14	0x00000000
\$t7	15	0x00000000
\$s0	16	0x00000009
\$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	0x10000000
\$ap	29	0x7fffffc0
\$fp	30	0x00000000
\$ra	31	0x00000000
\$pc		0x00400010
\$hi		0x00000000
\$lo		0x00000000

Ta thấy: Thanh ghi `$s0` có giá trị bằng `0x00000009` ($9_{(10)}$)

=> **Kết quả đúng**

- **Kiểm nghiệm khuôn dạng lệnh:**

+ Lệnh **addi**

Mã máy: $0 \times 20090005 = 0010\ 0000\ 0000\ 1001\ 0000\ 0000\ 0000\ 0101$

Hợp ngữ: **addi** \$9, \$0, 0×00000005

opcode	rs	rt	immediate
6 bits	5 bits	5 bits	16 bits
001000	00000	01001	00000000000000101
8	0	9	5

Mã máy: $0 \times 200affff = 0010\ 0000\ 0000\ 1010\ 1111\ 1111\ 1111\ 1111$

Hợp ngữ: **addi** \$10, \$0, $0 \times ffffffff$

opcode	rs	rt	immediate
6 bits	5 bits	5 bits	16 bits
001000	00000	01010	1111111111111111
8	0	10	-1

=> Cả hai câu lệnh **addi** đều đúng với khuôn dạng lệnh I

+ Lệnh **add**

Mã máy: $0 \times 01298020 = 0000\ 0001\ 0010\ 1001\ 1000\ 0000\ 0010\ 0000$

Hợp ngữ: **add** \$16, \$9, \$9

opcode	rs	rt	rd	shamt	funct
6 bits	5 bits	5 bits	5 bits	5 bits	6 bits
000000	01001	01001	10000	00000	100000
0	9	9	16	0	32

Mã máy: $0 \times 020a8020 = 0000\ 0010\ 0000\ 1010\ 1000\ 0000\ 0010\ 0000$

Hợp ngữ: **add** \$16, \$16, \$10

opcode	rs	rt	rd	shamt	funct
6 bits	5 bits	5 bits	5 bits	5 bits	6 bits
000000	10000	01010	10000	00000	100000
0	16	10	16	0	32

=> Cả hai câu lệnh `add` đều đúng với khuôn dạng lệnh R

5. Assignment 5: Phép nhân

- *Biên dịch và quan sát các lệnh mã máy trong cửa sổ Text Segment:*

Text Segment				
Bkpt	Address	Code	Basic	Source
<input type="checkbox"/>	0x00400000	0x20090004	addi \$s0,\$s0,0x00000004	4: addi \$t1, \$zero, 4 # X = \$t1 = 0 + 4 = 4
<input type="checkbox"/>	0x00400004	0x200a0005	addi \$t2,\$s0,0x00000005	5: addi \$t2, \$zero, 5 # X = \$t2 = 0 + 5 = 5
<input type="checkbox"/>	0x00400008	0x712a8002	mul \$s0,\$s0,\$t1	7: mul \$s0, \$t1, \$t2 # HI-LO = \$t1 * \$t2 = X * Y; \$s0 = LO
<input type="checkbox"/>	0x0040000c	0x20010003	addi \$t1,\$s0,0x00000003	8: mul \$s0, \$s0, 3 # \$s0 = \$s0 * 3 = 3 * X * Y
<input type="checkbox"/>	0x00400010	0x72018002	mul \$t6,\$t6,\$t1	
<input type="checkbox"/>	0x00400014	0x00008012	mflo \$t7	10: mflo \$s1

Nhận xét: Sự khác thường khi thực hiện hai câu lệnh `mul`

+ Khi thực hiện câu lệnh `mul $s0, $t1, $t2` thì máy thực hiện luôn việc nhân giữa hai thanh ghi `$t1` và `$t2`, kết quả được ghi vào thanh ghi `$s0`

+ Khi thực hiện câu lệnh `mul $s0, $s0, 3`. Vì không có thanh ghi nào lưu trữ riêng giá trị 3 nên để thực hiện được câu lệnh này thì được máy thực hiện bằng hai câu lệnh. Đầu tiên là câu lệnh `addi $t1, $s0, 0x00000003`, bước này là để gán giá trị 3 cho thanh ghi `$t1`. Sau đó thực hiện tiếp lệnh nhân `mul $t6, $t6, $t1`

- *Sau khi chạy dòng lệnh: `addi $t1, $zero, 4`*

Text Segment				
Bkpt	Address	Code	Basic	Source
<input type="checkbox"/>	0x00400000	0x20090004	addi \$s0,\$s0,0x00000004	4: addi \$t1, \$zero, 4 # X = \$t1 = 0 + 4 = 4
<input type="checkbox"/>	0x00400004	0x200a0005	addi \$t2,\$s0,0x00000005	5: addi \$t2, \$zero, 5 # X = \$t2 = 0 + 5 = 5
<input type="checkbox"/>	0x00400008	0x712a8002	mul \$s0,\$s0,\$t1	7: mul \$s0, \$t1, \$t2 # HI-LO = \$t1 * \$t2 = X * Y; \$s0 = LO
<input type="checkbox"/>	0x0040000c	0x20010003	addi \$t1,\$s0,0x00000003	8: mul \$s0, \$s0, 3 # \$s0 = \$s0 * 3 = 3 * X * Y
<input type="checkbox"/>	0x00400010	0x72018002	mul \$t6,\$t6,\$t1	
<input type="checkbox"/>	0x00400014	0x00008012	mflo \$t7	10: mflo \$s1

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	0x00000004
\$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
\$ap	29	0x7ffffefc
\$fp	30	0x00000000
\$ra	31	0x00000000
\$pc		0x00400004
hi		0x00000000
lo		0x00000000

Ta thấy: Thanh ghi $\$t1 = 0x00000004$ ($4_{(10)}$)

- Sau khi chạy dòng lệnh: `addi $t2, $zero, 5`

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Ta thấy: Thanh ghi $\$t2 = 0x00000005$ ($5_{(10)}$)

- Sau khi chạy dòng lệnh: `mul $s0, $t1, $t2`

EditExecute

Text Segment

Blkpt	Address	Code	Basic	Source
<input type="checkbox"/>	0x00400000	0x20090004	addi \$9,\$0,0x00000004	4: addi \$t1, \$zero, 4 # X = \$t1 = 0 + 4 = 4
<input type="checkbox"/>	0x00400004	0x200a0005	addi \$10,\$0,0x00000005	5: addi \$t2, \$zero, 5 # X = \$t2 = 0 + 5 = 5
<input type="checkbox"/>	0x00400008	0x712a8002	mul \$16,\$9,\$10	7: mul \$s0, \$t1, \$t2 # HI-LO = \$t1 * \$t2 = X * Y; \$s0 = LO
<input type="checkbox"/>	0x0040000c	0x20010003	addi \$1,\$0,0x00000003	8: mul \$s0, \$s0, 3 # \$s0 = \$s0 * 3 = 3 * X * Y
<input type="checkbox"/>	0x00400010	0x72018002	mul \$16,\$16,\$1	
<input type="checkbox"/>	0x00400014	0x00008812	mflo \$17	10: mflo \$a1

RegistersCoproc 1Coproc 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	0x00000004
\$t2	10	0x00000005
\$t3	11	0x00000000
\$t4	12	0x00000000
\$t5	13	0x00000000
\$t6	14	0x00000000
\$t7	15	0x00000000
\$s0	16	0x00000014
\$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
\$d0	26	0x00000000
\$t11	27	0x00000000
\$gp	28	0x10008000
\$sp	29	0x7fffffc0
\$fp	30	0x00000000
\$ra	31	0x00000000
\$pc		0x0040000c
\$hi		0x00000000
\$lo		0x00000014

Ta thấy: + Thanh ghi $\$s0 = 0x00000014$ ($20_{(10)}$)

+ Thanh ghi $lo = 0x00000014$ ($20_{(10)}$)

- Sau khi chạy dòng lệnh: `mul $s0, $s0, 3`

Edit Execute					Registers		
Text Segment					Name	Coproc 1	Coproc 0
Bkpt	Address	Code	Basic	Source	Number		Value
	0x00400000	0x20090004	addi \$s, \$s, 0x00000004	4: addi \$t1, \$zero, 4 # X = \$t1 = 0 + 4 = 4	0		0x00000000
	0x00400004	0x200a0005	addi \$t0, \$s, 0x00000005	5: addi \$t2, \$zero, 5 # X = \$t2 = 0 + 5 = 5	1		0x00000003
	0x00400008	0x712a8002	mul \$s0, \$s, \$s	7: mul \$s0, \$t1, \$t2 # HI-LO = \$t1 * \$t2 = X * Y; \$s0 = LO	2		0x00000000
	0x0040000c	0x20010003	addi \$t, \$s, 0x00000003	8: mul \$s0, \$s0, 3 # \$s0 = \$s0 * 3 = 3 * X * Y	3		0x00000000
	0x00400010	0x72018002	mul \$s1, \$s, \$s		4		0x00000000
	0x00400014	0x00008012	mflo \$s1	10: mflo \$s1	5		0x00000000
					6		0x00000000
					7		0x00000000
					8		0x00000000
					9		0x00000004
					10		0x00000005
					11		0x00000000
					12		0x00000000
					13		0x00000000
					14		0x00000000
					15		0x00000000
					16		0x0000003c
					17		0x00000000
					18		0x00000000
					19		0x00000000
					20		0x00000000
					21		0x00000000
					22		0x00000000
					23		0x00000000
					24		0x00000000
					25		0x00000000
					26		0x00000000
					27		0x00000000
					28		0x10008000
					29		0x7fffffc0
					30		0x00000000
					31		0x00000000
							0x00400014
							0x00000000
							0x0000003c

Ta thấy: + Đầu tiên thanh ghi `$1` được gán bằng `0x00000003` ($3_{(10)}$)

+ Sau lệnh nhân ta có `$s0` = `0x0000003c` ($60_{(10)}$) và

`lo` = `0x0000003c` ($60_{(10)}$)

- Sau khi chạy dòng lệnh: `mflo $s1`

Edit Execute					Registers		
Text Segment					Name	Coproc 1	Coproc 0
Bkpt	Address	Code	Basic	Source	Number		Value
	0x00400000	0x20090004	addi \$s, \$s, 0x00000004	4: addi \$t1, \$zero, 4 # X = \$t1 = 0 + 4 = 4	0		0x00000000
	0x00400004	0x200a0005	addi \$t0, \$s, 0x00000005	5: addi \$t2, \$zero, 5 # X = \$t2 = 0 + 5 = 5	1		0x00000003
	0x00400008	0x712a8002	mul \$s0, \$s, \$s	7: mul \$s0, \$t1, \$t2 # HI-LO = \$t1 * \$t2 = X * Y; \$s0 = LO	2		0x00000000
	0x0040000c	0x20010003	addi \$t, \$s, 0x00000003	8: mul \$s0, \$s0, 3 # \$s0 = \$s0 * 3 = 3 * X * Y	3		0x00000000
	0x00400010	0x72018002	mul \$s1, \$s, \$s		4		0x00000000
	0x00400014	0x00008012	mflo \$s1	10: mflo \$s1	5		0x00000000
					6		0x00000000
					7		0x00000000
					8		0x00000000
					9		0x00000004
					10		0x00000005
					11		0x00000000
					12		0x00000000
					13		0x00000000
					14		0x00000000
					15		0x00000000
					16		0x0000003c
					17		0x0000003c
					18		0x00000000
					19		0x00000000
					20		0x00000000
					21		0x00000000
					22		0x00000000
					23		0x00000000
					24		0x00000000
					25		0x00000000
					26		0x00000000
					27		0x00000000
					28		0x10008000
					29		0x7fffffc0
					30		0x00000000
					31		0x00000000
							0x00400018
							0x00000000
							0x0000003c

Ta thấy: Giá trị của thanh ghi `lo` được ghi vào trong thanh ghi

`$s1` = `0x0000003c` ($60_{(10)}$)

=> **Kết quả đúng**

6. Assignment 6: Tạo biến và truy cập biến

- *Biên dịch và quan sát các lệnh mã máy trong cửa sổ Text Segment:*

Text Segment					
Bkpt	Address	Code	Basic	Source	
	0x00400000	0x3c011001	lui \$1,0x00001001	8: la \$t8, X	# Get the address of X in Data Segment
	0x00400004	0x34380000	ori \$24,\$1,0x00000000		
	0x00400008	0x3c011001	lui \$1,0x00001001	9: la \$t9, Y	# Get the address of Y in Data Segment
	0x0040000c	0x34390004	ori \$25,\$1,0x00000004		
	0x00400010	0x8f090000	lw \$9,0x00000000(\$24)	10: lw \$t1, 0(\$t8)	# \$t1 = X
	0x00400014	0x8f2a0000	lw \$10,0x00000000(\$25)	11: lw \$t2, 0(\$t9)	# \$t2 = Y
	0x00400018	0x01298020	add \$16,\$9,\$9	14: add \$s0, \$t1, \$t1	# \$s0 = \$t1 + \$t1 = X + X = 2X
	0x0040001c	0x020a8020	add \$16,\$16,\$10	15: add \$s0, \$s0, \$t2	# \$s0 = \$s0 + \$t2 = 2X + Y
	0x00400020	0x3c011001	lui \$1,0x00001001	18: la \$t7, Z	# Get the address of Z in Data Segment
	0x00400024	0x342f0008	ori \$15,\$1,0x00000008		
	0x00400028	0xadf00000	sw \$16,0x00000000(\$15)	19: sw \$s0, 0(\$t7)	# Z = \$s0 = 2X + Y

Ta thấy: Lệnh `la` được biên dịch bằng hai lệnh `lui` và `ori`. Vì địa chỉ của X, Y, Z được khai báo với chỉ thị là `.word` nên địa chỉ của X, Y, Z là số 32 bits nên cần thực hiện bằng việc thực hiện hai câu lệnh `lui` và `ori`

- *Ở cửa sổ Label và quan sát địa chỉ của X, Y, Z:*

Text Segment					
Bkpt	Address	Code	Basic	Source	
	0x00400000	0x3c011001	lui \$1,0x00001001	8: la \$t8, X	# Get the add..
	0x00400004	0x34380000	ori \$24,\$1,0x00000000		
	0x00400008	0x3c011001	lui \$1,0x00001001	9: la \$t9, Y	# Get the add..
	0x0040000c	0x34390004	ori \$25,\$1,0x00000004		
	0x00400010	0x8f090000	lw \$9,0x00000000(\$24)	10: lw \$t1, 0(\$t8)	# \$t1 = X
	0x00400014	0x8f2a0000	lw \$10,0x00000000(\$25)	11: lw \$t2, 0(\$t9)	# \$t2 = Y
	0x00400018	0x01298020	add \$16,\$9,\$9	14: add \$s0, \$t1, \$t1	# \$s0 = \$t1 + ..
	0x0040001c	0x020a8020	add \$16,\$16,\$10	15: add \$s0, \$s0, \$t2	# \$s0 = \$s0 + ..
	0x00400020	0x3c011001	lui \$1,0x00001001	18: la \$t7, Z	# Get the add..
	0x00400024	0x342f0008	ori \$15,\$1,0x00000008		
	0x00400028	0xae300000	sw \$16,0x00000000(\$17)	19: sw \$s0, 0(\$s1)	# Z = \$s0 = 2..

Labels	
Label	Address ▲
Assignment6.asm	
X	0x10010000
Y	0x10010004
Z	0x10010008

Ta thấy: Địa chỉ của X, Y, Z được chia làm hai phần: 2 bytes cao và 2 bytes thấp. Tương ứng với mỗi lệnh `la` thì lệnh `lui` sẽ ghi 2 bytes cao của địa chỉ vào thanh ghi `$1` và lệnh `ori` sẽ OR thanh ghi `$1` với 2 bytes thấp của địa chỉ.

Edit Execute

Text Segment

Bkpt	Address	Code	Basic	Source
	0x00400000	0x3e011001	lui \$1,0x00001001	8: la \$t8, X # Get the add..
	0x00400004	0x34380000	ori \$24,\$1,0x00000000	
	0x00400008	0x3e011001	lui \$1,0x00001001	9: la \$t9, Y # Get the add..
	0x0040000c	0x34390004	ori \$25,\$1,0x00000004	
	0x00400010	0x8f090000	lw \$9,0x00000000(\$24)	10: lw \$t1, 0(\$t8) # \$t1 = X
	0x00400014	0x8f2a0000	lw \$10,0x00000000(\$25)	11: lw \$t2, 0(\$t9) # \$t2 = Y
	0x00400018	0x01298020	add \$16,\$9,\$9	14: add \$s0, \$t1, \$t1 # \$s0 = \$t1 +..
	0x0040001c	0x020a8020	add \$16,\$16,\$10	15: add \$s0, \$s0, \$t2 # \$s0 = \$s0 +..
	0x00400020	0x3e011001	lui \$1,0x00001001	18: la \$t7, Z # Get the add..
	0x00400024	0x342f0008	ori \$15,\$1,0x00000008	
	0x00400028	0xadf00000	sw \$16,0x00000000(\$15)	19: sw \$s0, 0(\$t7) # Z = \$s0 = 2..

Labels

Label	Address
Assignment6.asm	
X	0x10010000
Y	0x10010004
Z	0x10010008

☒ Data ☒ Text

Data Segment

Address	Value (+0)	Value (+4)	Value (+8)	Value (+c)	Value (+10)	Value (+14)	Value (+18)	Value (+1c)
0x10010000	0x00000005	0xffffffff	0x00000009	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000
0x10010020	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000
0x10010040	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000
0x10010060	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000
0x10010080	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000
0x100100a0	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000
0x100100c0	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000
0x100100e0	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000
0x10010100	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000
0x10010120	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000
0x10010140	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000
0x10010160	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000
0x10010180	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000
0x100101a0	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000
0x100101c0	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000
0x100101e0	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000

0x10010000 (.data) ☒ Hexadecimal Addresses ☒ Hexadecimal Values ☐ ASCII

Edit Execute

Text Segment

Bkpt	Address	Code	Basic	Source
	0x00400000	0x3e011001	lui \$1,0x00001001	8: la \$t8, X # Get the add..
	0x00400004	0x34380000	ori \$24,\$1,0x00000000	
	0x00400008	0x3e011001	lui \$1,0x00001001	9: la \$t9, Y # Get the add..
	0x0040000c	0x34390004	ori \$25,\$1,0x00000004	
	0x00400010	0x8f090000	lw \$9,0x00000000(\$24)	10: lw \$t1, 0(\$t8) # \$t1 = X
	0x00400014	0x8f2a0000	lw \$10,0x00000000(\$25)	11: lw \$t2, 0(\$t9) # \$t2 = Y
	0x00400018	0x01298020	add \$16,\$9,\$9	14: add \$s0, \$t1, \$t1 # \$s0 = \$t1 +..
	0x0040001c	0x020a8020	add \$16,\$16,\$10	15: add \$s0, \$s0, \$t2 # \$s0 = \$s0 +..
	0x00400020	0x3e011001	lui \$1,0x00001001	18: la \$t7, Z # Get the add..
	0x00400024	0x342f0008	ori \$15,\$1,0x00000008	
	0x00400028	0xadf00000	sw \$16,0x00000000(\$15)	19: sw \$s0, 0(\$t7) # Z = \$s0 = 2..

Labels

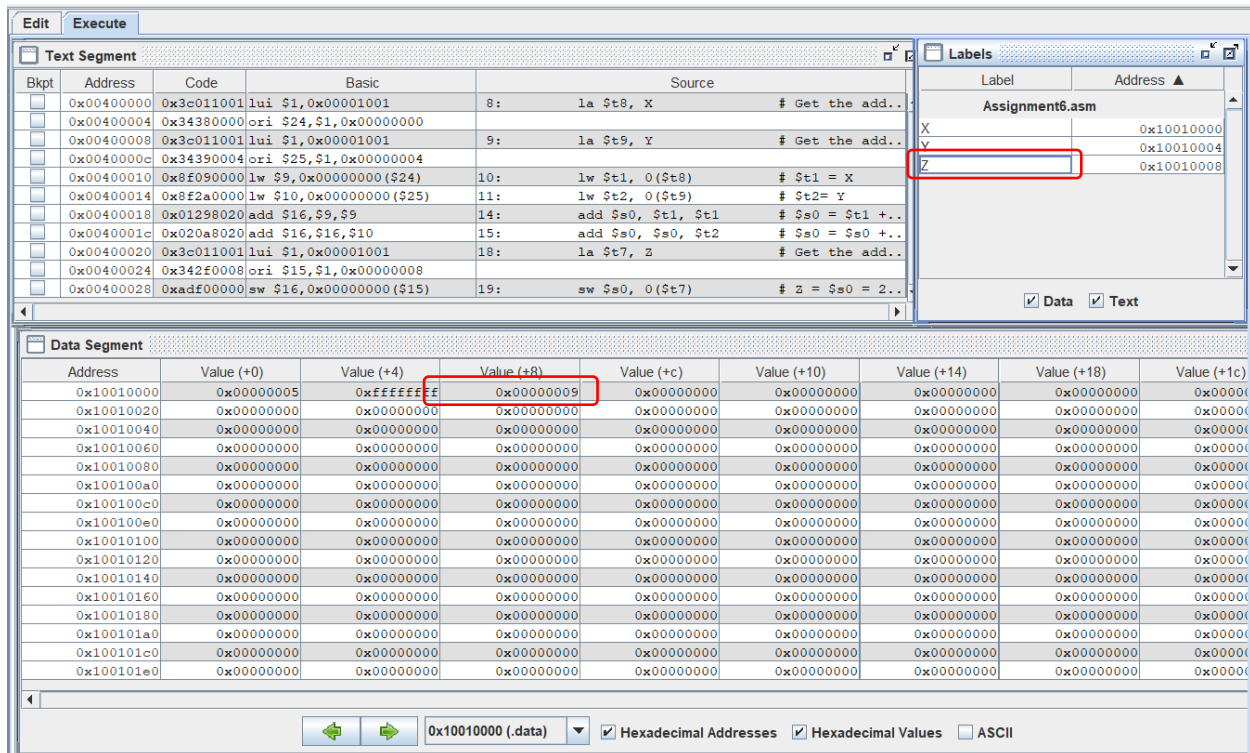
Label	Address
Assignment6.asm	
X	0x10010000
Y	0x10010004
Z	0x10010008

☒ Data ☒ Text

Data Segment

Address	Value (+0)	Value (+4)	Value (+8)	Value (+c)	Value (+10)	Value (+14)	Value (+18)	Value (+1c)
0x10010000	0x00000005	0xffffffff	0x00000009	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000
0x10010020	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000
0x10010040	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000
0x10010060	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000
0x10010080	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000
0x100100a0	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000
0x100100c0	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000
0x100100e0	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000
0x10010100	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000
0x10010120	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000
0x10010140	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000
0x10010160	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000
0x10010180	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000
0x100101a0	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000
0x100101c0	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000
0x100101e0	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000

0x10010000 (.data) ☒ Hexadecimal Addresses ☒ Hexadecimal Values ☐ ASCII



- Sau khi chạy lần lượt các dòng lệnh:

Ta thấy: + Sau khi lấy địa chỉ của các biến X, Y, Z và ghi địa chỉ đó vào các thanh ghi `$t8`, `$t9`, `$t7` bằng lệnh `la`

`la $t8, X`

`la $t9, Y`

+ Tiếp tục lấy ra giá trị 32 bit (word) nằm trong các ô nhớ có địa chỉ vừa ghi được vào thanh ghi `$t8`, `$t9` bằng lệnh `lw` vào các thanh ghi `$t1`, `$t2`

`lw $t1, 0($t8)`

`lw $t2, 0($t9)`

+ Sau khi thực hiện các câu lệnh `add`, kết quả đang được ghi trong thanh ghi `$s0`. Để ghi giá trị 32 bit (word) trong thanh ghi `$s0` vào ô nhớ có địa chỉ được ghi trong thanh ghi `$t7` thì ta sử dụng lệnh `sw`

`sw $s0, 0($t7)`

- Lệnh `lb`, `sb`

+ `lb` - Để lấy ra dữ liệu kiểu byte (8 bit) tại ô nhớ thông qua địa chỉ trỏ đến ô nhớ đó ra thanh ghi

+ `sb` - Để ghi dữ liệu kiểu byte (8 bit, 8 bit này được lưu vào 8 bit thấp của ô nhớ) vào ô nhớ thông qua địa chỉ trỏ đến ô nhớ đó