Lab 6

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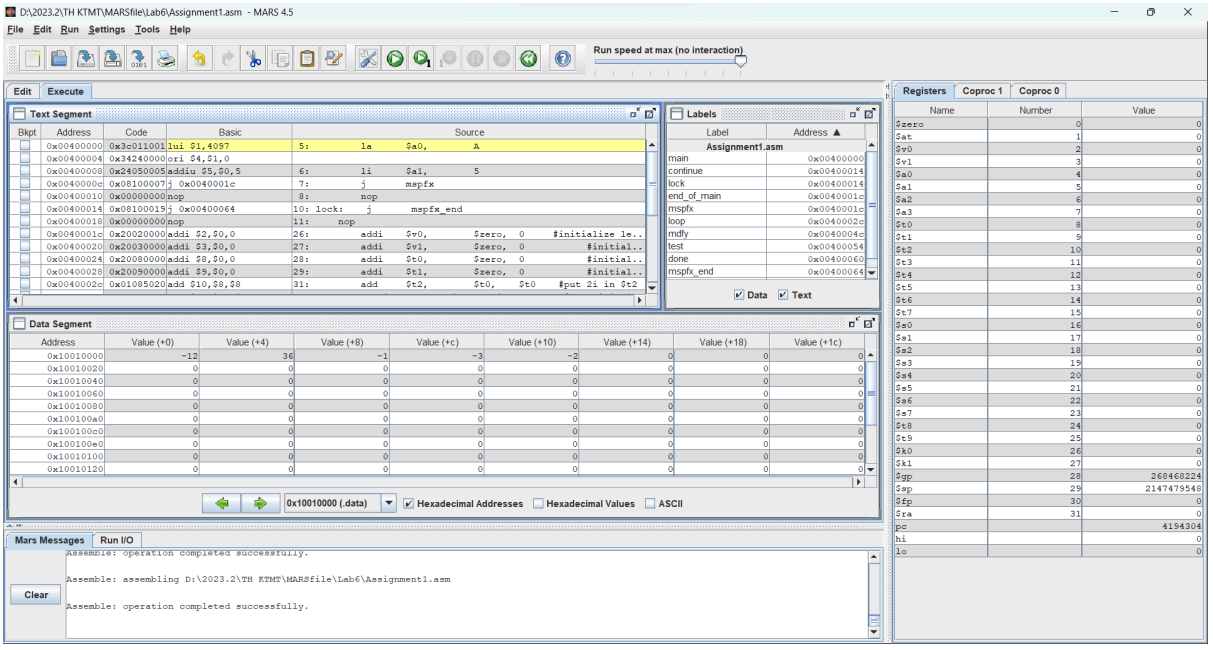
Assignment 1

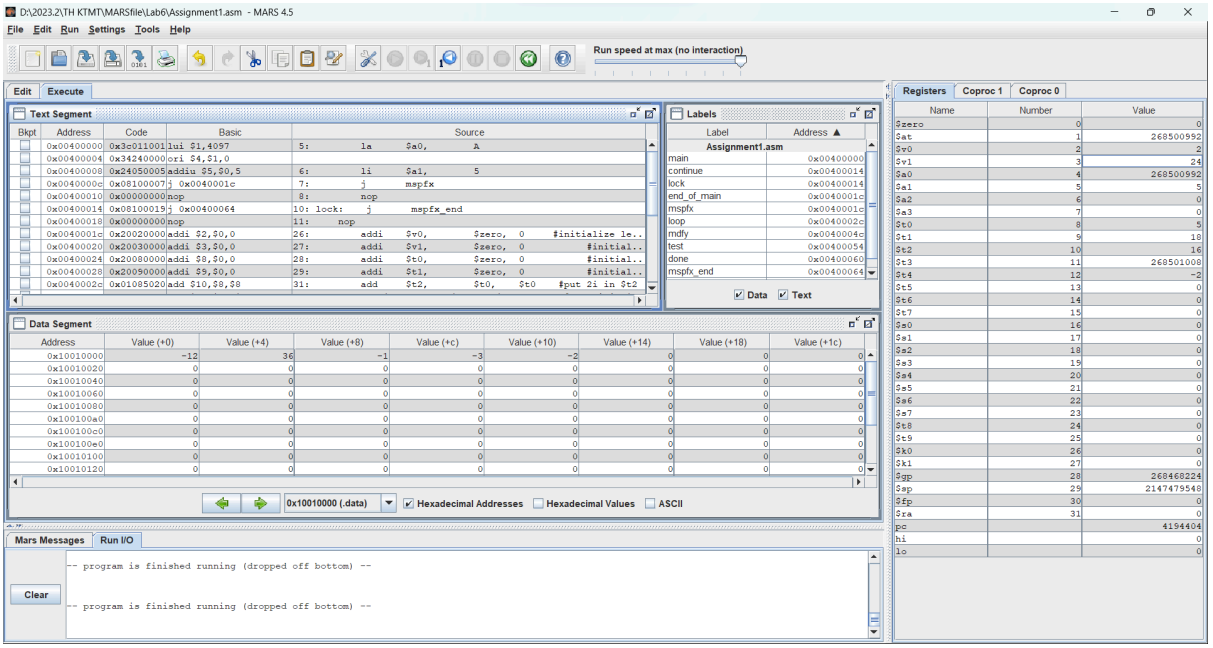
Code:

```
.data
A:  .word   -12, 36, -1, 20, -2
.text
main:
        la      $a0,        A
        li      $a1,        5
        j       mspfx
        nop
continue:
lock:   j       mspfx_end
   nop
end_of_main:
   #---------------------------------------------------------------
   #Procedure mspfx
   # @brief find the maximum-sum prefix in a list of integers
   # @param[in] a0 the base address of this list(A) need to be processed
   # @param[in] a1 the number of elements in list(A)
   # @param[out] v0 the length of sub-array of A in which max sum reachs.
   # @param[out] v1 the max sum of a certain sub-array
   #---------------------------------------------------------------
   #Procedure mspfx
   #function: find the maximum-sum prefix in a list of integers
   #the base address of this list(A) in $a0 and the number of
   #elements is stored in a1
mspfx:
        addi    $v0,        $zero,  0    #initialize length in $v0 to 0
        addi    $v1,        $zero,  0         #initialize max sum in $v1to 0
        addi    $t0,        $zero,  0         #initialize index i in $t0 to 0
        addi    $t1,        $zero,  0         #initialize running sum in $t1 to 0
```

```
loop:
        sll $t2, $t2, 2       #put 4i in $t2
   add    $t3,       $t2,    $a0        #put 4i+A (address of A[i]) in $t3
   lw     $t4,       0($t3)             #load A[i] from mem(t3) into $t4
   add    $t1,       $t1,    $t4        #add A[i] to running sum in $t1
   slt    $t5,       $v1,    $t1        #set $t5 to 1 if max sum < new sum
   bne    $t5,       $zero,  mdfy       #if max sum is less, modify results
   j      test                          #done?
mdfy:   addi   $v0,       $t0,    1     #new max-sum prefix has length i+1
   addi   $v1,       $t1,    0          #new max sum is the running sum
test:   addi   $t0,       $t0,    1     #advance the index i
   slt    $t5,       $t0,    $a1        #set $t5 to 1 if i<n
   bne    $t5,       $zero,  loop       #repeat if i<n
done:   j      continue
mspfx_end:
```

Result:





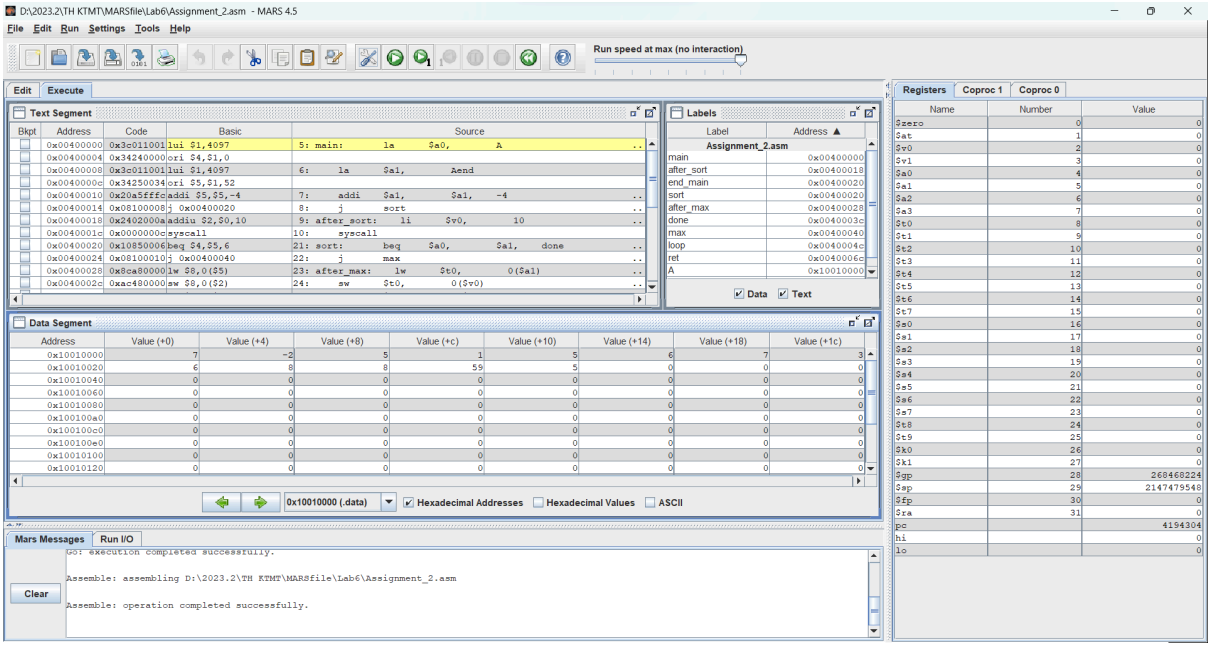
Assignment 2

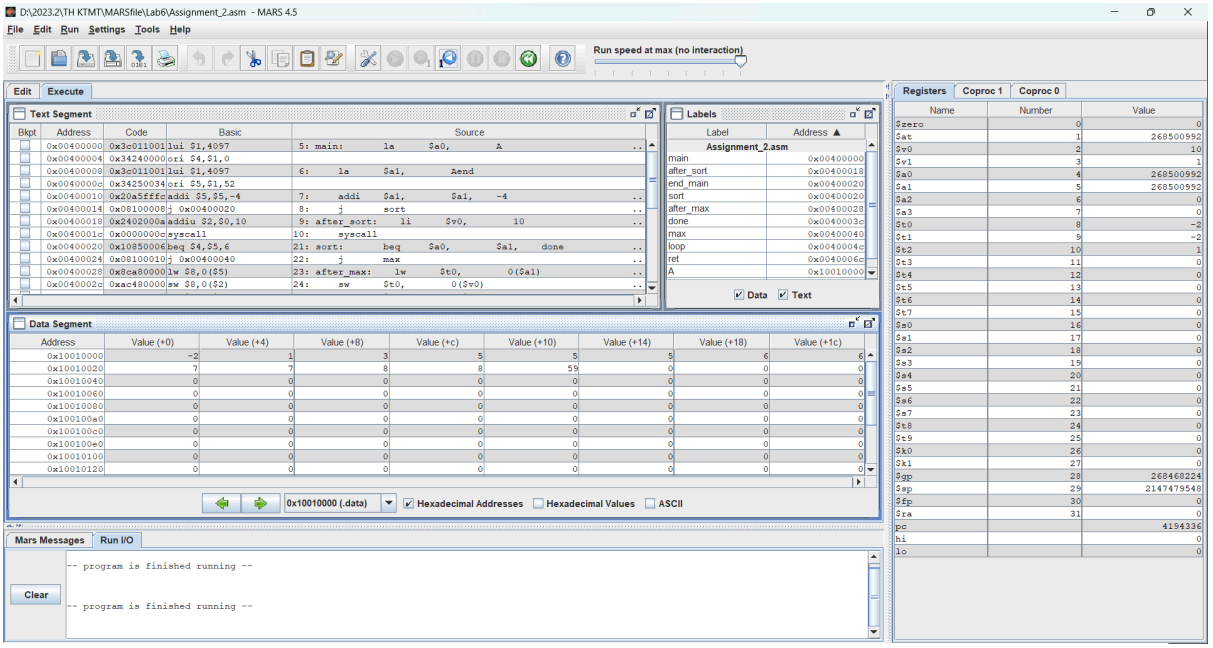
Code:

```
.data
A:      .word   7, -2, 5, 1, 5, 6, 7, 3, 6, 8, 8, 59, 5
Aend:   .word
.text
main:       la      $a0,        A                   #$a0 = Address(A[0])
    la      $a1,        Aend
    addi    $a1,        $a1,    -4                  #$a1 = Address(A[n-1])
    j       sort                                    #sort
after_sort:     li      $v0,        10              #exit
    syscall
end_main:
    #-----------------------------------------------------------
    #procedure sort (ascending selection sort using pointer)
    #register usage in sort program
    #$a0 pointer to the first element in unsorted part
    #$a1 pointer to the last element in unsorted part
    #$t0 temporary place for value of last element
    #$v0 pointer to max element in unsorted part
    #$v1 value of max element in unsorted part
    #-----------------------------------------------------------
sort:       beq     $a0,        $a1,    done        #single element list is sorted
    j       max                                     #call the max procedure
after_max:      lw      $t0,        0($a1)          #load last element into $t0
    sw      $t0,        0($v0)                      #copy last element to max location
    sw      $v1,        0($a1)                      #copy max value to last element
    addi    $a1,        $a1,    -4                  #decrement pointer to last element
    j       sort                                    #repeat sort for smaller list
done:       j       after_sort
```

```
   #---------------------------------------------------------------
   #Procedure max
   #function: fax the value and address of max element in the list
   #$a0 pointer to first element
   #$a1 pointer to last element
   #---------------------------------------------------------------
max:
   addi   $v0,      $a0,    0              #init max pointer to first element
   lw     $v1,      0($v0)                 #init max value to first value
   addi   $t0,      $a0,    0              #init next pointer to first
loop:
   beq    $t0,      $a1,    ret            #if next=last, return
   addi   $t0,      $t0,    4              #advance to next element
   lw     $t1,      0($t0)                 #load next element into $t1
   slt    $t2,      $t1,    $v1            #(next)<(max) ?
   bne    $t2,      $zero,  loop           #if (next)<(max), repeat
   addi   $v0,      $t0,    0              #next element is new max element
   addi   $v1,      $t1,    0              #next value is new max value
   j      loop                           #change completed; now repeat
ret:
   j      after_max
```

Result:





Assignment 4

Code:

```
void insertionSort(int arr[], int n)
{
    int i, key, j;
    for (i = 1; i < n; i++) {
        key = arr[i];
        j = i - 1;

        /* Move elements of arr[0..i-1], that are
          greater than key, to one position ahead
          of their current position */
        while (j >= 0 && arr[j] > key) {
            arr[j + 1] = arr[j];
            j = j - 1;
        }
        arr[j + 1] = key;
    }
}
```

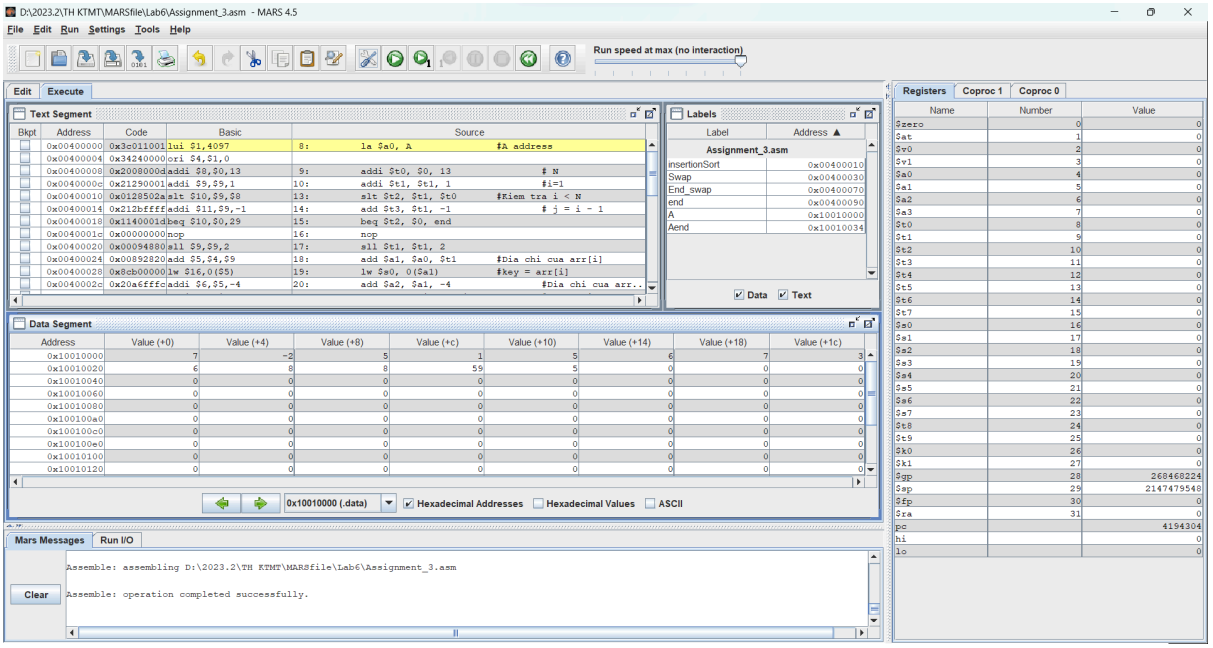
#Lab 6, Assignment 3

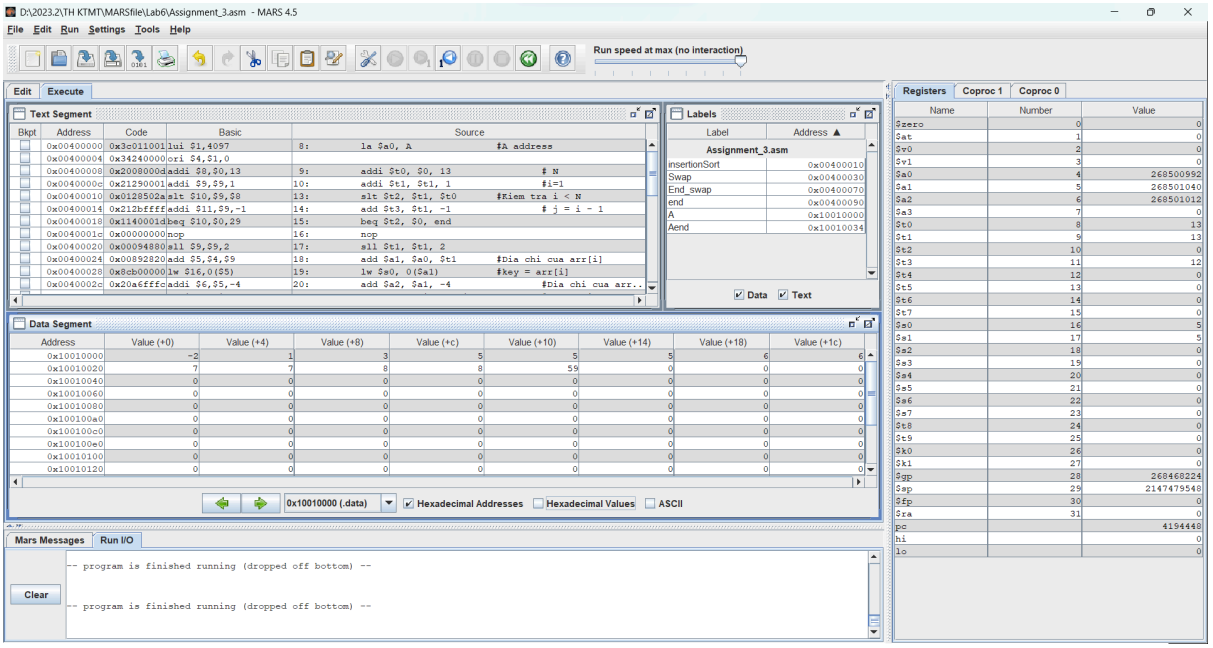
.data

A: .word 7, -2, 5, 1, 5, 6, 7, 3, 6, 8, 8, 59, 5

Aend: .word

```
.text

        la $a0, A               #A address
        addi $t0, $0, 13                # N
        addi $t1, $t1, 1                #i=1

insertionSort:
        slt $t2, $t1, $t0       #Kiem tra i < N
        add $t3, $t1, -1                # j = i - 1
        beq $t2, $0, end
        nop
        sll $t1, $t1, 2
        add $a1, $a0, $t1       #Dia chi cua arr[i]
        lw $s0, 0($a1)          #key = arr[i]
        add $a2, $a1, -4                #Dia chi cua arr[j] voi j = i - 1


        Swap:
                lw $s1, 0($a2)          # = arr[j]
                slt $t4, $t3, $0        #check j>=0
                beq $t4, 1, End_swap
                slt $t5, $s0, $s1       #check arr[j] > key
                beq $t5, 0, End_swap
                nop
                sw $s1, 4($a2)                  #Dia chi cua arr[j+1] va arr[j+1] = arr[j]
                add $t3, $t3, -1                # j = j - 1
                beq $t3, -1, End_swap           #Check j<0 thi nhay ra khoi swap
                nop
                add $a2, $a2, -4                #Thay doi dia chi thanh arr[j = j - 1]
                j Swap
                nop
        End_swap:
                add $t3, $t3, 1
                sll $t3, $t3, 2         #Cap nhat lai j + 1
                add $a2, $a0, $t3       #Dia chi cua arr[j+1]
                sw $s0, 0($a2)                  #arr[j+1] = key
                srl $t1, $t1, 2
                add $t1, $t1, 1
                j insertionSort
                nop
end:

Result:
```


D:\2023.2\TH KTMT\MARSfile\Lab6\Assignment_3.asm - MARS 4.5
File Edit Run Settings Tools Help
Run speed at max (no interaction)
Edit Execute
Text Segment
Bkpt Address Code Basic Source
0x00400000 0x3c011001 lui $1,4097 8: la $a0, A #A address
0x00400004 0x34240000 ori $4,$1,0
0x00400008 0x2008000d addi $8,$0,13 9: addi $t0, $0, 13 # N
0x0040000c 0x21290001 addi $9,$9,1 10: addi $t1, $t1, 1 #i=1
0x00400010 0x0128502a slt $10,$9,$8 13: slt $t2, $t1, $t0 #Kiem tra i < N
0x00400014 0x212bffff addi $11,$9,-1 14: add $t3, $t1, -1 # j = i - 1
0x00400018 0x1140001d beq $10,$0,29 15: beq $t2, $0, end
0x0040001c 0x00000000 nop 16: nop
0x00400020 0x00094880 sll $9,$9,2 17: sll $t1, $t1, 2
0x00400024 0x00892820 add $5,$4,$9 18: add $a1, $a0, $t1 #Dia chi cua arr[i]
0x00400028 0x8cb00000 lw $16,0($5) 19: lw $s0, 0($a1) #key = arr[i]
0x0040002c 0x20a6fffc addi $6,$5,-4 20: add $a2, $a1, -4 #Dia chi cua arr..
Labels
Label Address
Assignment_3.asm
insertionSort 0x00400010
Swap 0x00400030
End_swap 0x00400070
end 0x00400090
A 0x10010000
Aend 0x10010034
Data Text
Registers Coproc 1 Coproc 0
Name Number Value
$zero 0 0
$at 1 0
$v0 2 0
$v1 3 0
$a0 4 0
$a1 5 0
$a2 6 0
$a3 7 0
$t0 8 0
$t1 9 0
$t2 10 0
$t3 11 0
$t4 12 0
$t5 13 0
$t6 14 0
$t7 15 0
$s0 16 0
$s1 17 0
$s2 18 0
$s3 19 0
$s4 20 0
$s5 21 0
$s6 22 0
$s7 23 0
$t8 24 0
$t9 25 0
$k0 26 0
$k1 27 0
$gp 28 268468224
$sp 29 2147479548
$fp 30 0
$ra 31 0
pc 4194304
hi 0
lo 0
Data Segment
Address Value (+0) Value (+4) Value (+8) Value (+c) Value (+10) Value (+14) Value (+18) Value (+1c)
0x10010000 7 -2 5 1 5 6 7 3
0x10010020 6 8 8 59 5 0 0 0
0x10010040 0 0 0 0 0 0 0 0
0x10010060 0 0 0 0 0 0 0 0
0x10010080 0 0 0 0 0 0 0 0
0x100100a0 0 0 0 0 0 0 0 0
0x100100c0 0 0 0 0 0 0 0 0
0x100100e0 0 0 0 0 0 0 0 0
0x10010100 0 0 0 0 0 0 0 0
0x10010120 0 0 0 0 0 0 0 0
0x10010000 (.data) Hexadecimal Addresses Hexadecimal Values ASCII
Mars Messages Run I/O
Assemble: assembling D:\2023.2\TH KTMT\MARSfile\Lab6\Assignment_3.asm
Assemble: operation completed successfully.
Clear


D:\2023.2\TH KTMT\MARSfile\Lab6\Assignment_3.asm - MARS 4.5
File Edit Run Settings Tools Help
Run speed at max (no interaction)
Edit Execute
Text Segment
Bkpt Address Code Basic Source
0x00400000 0x3c011001 lui $1,4097 8: la $a0, A #A address
0x00400004 0x34240000 ori $4,$1,0
0x00400008 0x2008000d addi $8,$0,13 9: addi $t0, $0, 13 # N
0x0040000c 0x21290001 addi $9,$9,1 10: addi $t1, $t1, 1 #i=1
0x00400010 0x0128502a slt $10,$9,$8 13: slt $t2, $t1, $t0 #Kiem tra i < N
0x00400014 0x212bffff addi $11,$9,-1 14: add $t3, $t1, -1 # j = i - 1
0x00400018 0x1140001d beq $10,$0,29 15: beq $t2, $0, end
0x0040001c 0x00000000 nop 16: nop
0x00400020 0x00094880 sll $9,$9,2 17: sll $t1, $t1, 2
0x00400024 0x00892820 add $5,$4,$9 18: add $a1, $a0, $t1 #Dia chi cua arr[i]
0x00400028 0x8cb00000 lw $16,0($5) 19: lw $s0, 0($a1) #key = arr[i]
0x0040002c 0x20a6fffc addi $6,$5,-4 20: add $a2, $a1, -4 #Dia chi cua arr..
Labels
Label Address
Assignment_3.asm
insertionSort 0x00400010
Swap 0x00400030
End_swap 0x00400070
end 0x00400090
A 0x10010000
Aend 0x10010034
Data Text
Registers Coproc 1 Coproc 0
Name Number Value
$zero 0 0
$at 1 0
$v0 2 0
$v1 3 0
$a0 4 268500992
$a1 5 268501040
$a2 6 268501012
$a3 7 0
$t0 8 13
$t1 9 13
$t2 10 0
$t3 11 12
$t4 12 0
$t5 13 0
$t6 14 0
$t7 15 0
$s0 16 5
$s1 17 5
$s2 18 0
$s3 19 0
$s4 20 0
$s5 21 0
$s6 22 0
$s7 23 0
$t8 24 0
$t9 25 0
$k0 26 0
$k1 27 0
$gp 28 268468224
$sp 29 2147479548
$fp 30 0
$ra 31 0
pc 4194448
hi 0
lo 0
Data Segment
Address Value (+0) Value (+4) Value (+8) Value (+c) Value (+10) Value (+14) Value (+18) Value (+1c)
0x10010000 -2 1 3 5 5 5 6 6
0x10010020 7 7 8 8 59 0 0 0
0x10010040 0 0 0 0 0 0 0 0
0x10010060 0 0 0 0 0 0 0 0
0x10010080 0 0 0 0 0 0 0 0
0x100100a0 0 0 0 0 0 0 0 0
0x100100c0 0 0 0 0 0 0 0 0
0x100100e0 0 0 0 0 0 0 0 0
0x10010100 0 0 0 0 0 0 0 0
0x10010120 0 0 0 0 0 0 0 0
0x10010000 (.data) Hexadecimal Addresses Hexadecimal Values ASCII
Mars Messages Run I/O
-- program is finished running (dropped off bottom) --
-- program is finished running (dropped off bottom) --
Clear

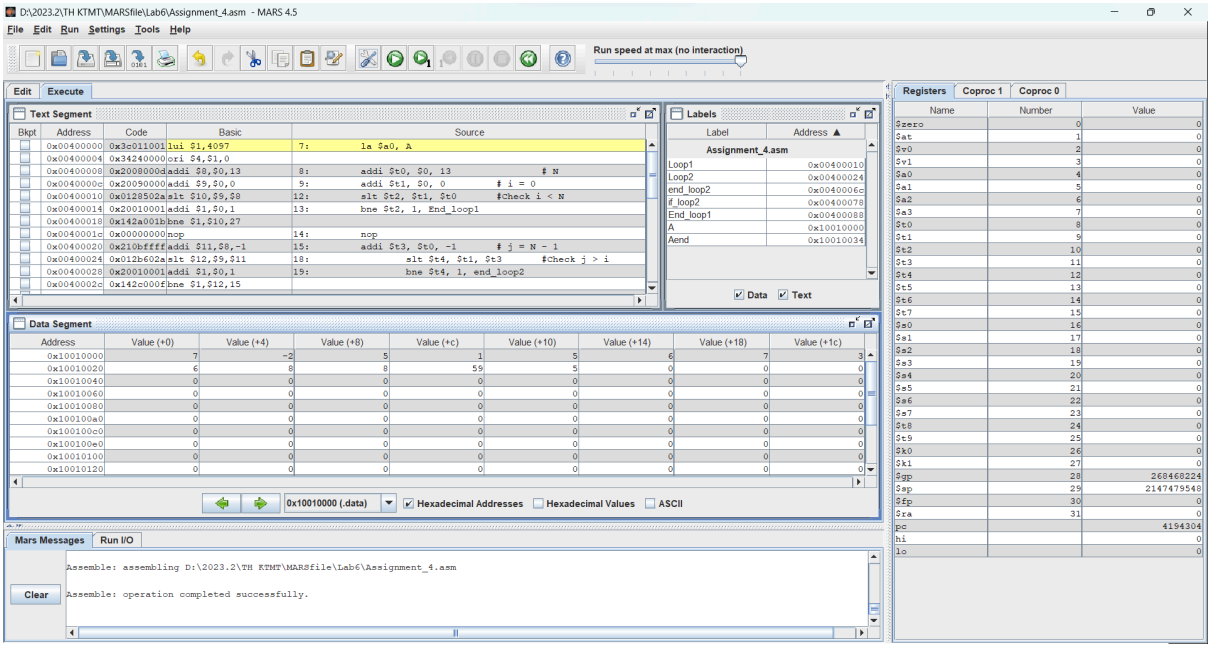
Assignment 3

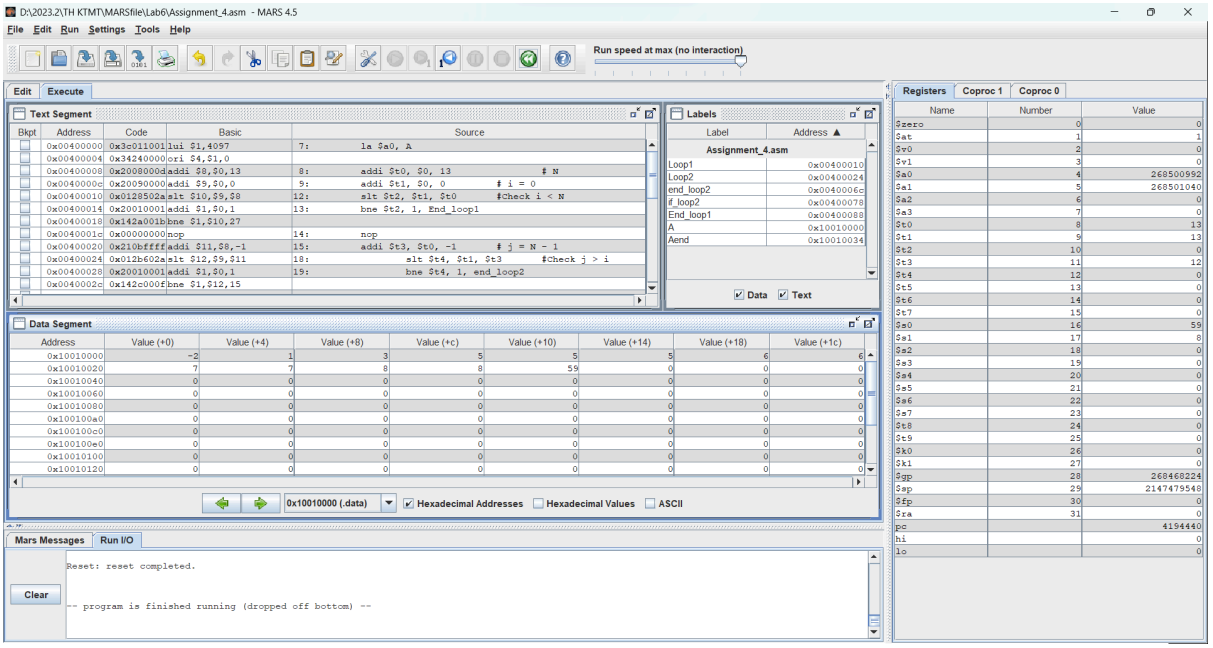
Code:

```
// Bubble sort
void BubbleSort(int arr[], int N)
{
    int i, j;
    for (i = 0; i < N; i++)
    {
        for (j = N-1; j > i; j--)
        {
            if(arr[j] < arr[j-1])
                swap(&arr[j], &arr[j-1]);
        }
    }
}
```

```
#Lab 6, Assignment 4
.data
        A: .word  7, -2, 5, 1, 5, 6, 7, 3, 6, 8, 8, 59, 5
        Aend: .word

.text
        la $a0, A
        addi $t0, $0, 13                # N
        addi $t1, $0, 0         # i = 0

Loop1:
        slt $t2, $t1, $t0       #Check i < N
        bne $t2, 1, End_loop1
        nop
        addi $t3, $t0, -1       # j = N - 1

        Loop2:
                slt $t4, $t1, $t3       #Check j > i
                bne $t4, 1, end_loop2
```

```
                nop
                sll $t3, $t3, 2
                add $a1, $a0, $t3       #Dia chi cua arr[j]
                lw $s0, 0($a1)          # = arr[j]
                lw $s1, -4($a1)                 # = arr[j-1]

                slt $t5, $s0, $s1       #Check arr[j] < arr[j-1]
                bne $t5, 1, if_loop2
                nop
                #SWAP
                sw $s0, -4($a1)
                sw $s1, 0($a1)
                srl $t3, $t3, 2
                addi $t3, $t3, -1       # j--
                j Loop2
                nop

        end_loop2:

                addi $t1, $t1, 1                # i++
                j Loop1
                nop


        if_loop2:
                srl $t3, $t3, 2
                addi $t3, $t3, -1       # j--
                j Loop2
                nop

End_loop1:

Result:
```


D:\2023.2\TH KTMT\MARSfile\Lab6\Assignment_4.asm - MARS 4.5
File Edit Run Settings Tools Help
Run speed at max (no interaction)
Edit Execute
Text Segment
Bkpt Address Code Basic Source
0x00400000 0x3c011001 lui $1,4097 7: la $a0, A
0x00400004 0x34240000 ori $4,$1,0
0x00400008 0x2008000d addi $8,$0,13 8: addi $t0, $0, 13 # N
0x0040000c 0x20090000 addi $9,$0,0 9: addi $t1, $0, 0 # i = 0
0x00400010 0x0128502a slt $10,$9,$8 12: slt $t2, $t1, $t0 #Check i < N
0x00400014 0x20010001 addi $1,$0,1 13: bne $t2, 1, End_loop1
0x00400018 0x142a001b bne $1,$10,27
0x0040001c 0x00000000 nop 14: nop
0x00400020 0x210bffff addi $11,$8,-1 15: addi $t3, $t0, -1 # j = N - 1
0x00400024 0x012b602a slt $12,$9,$11 18: slt $t4, $t1, $t3 #Check j > i
0x00400028 0x20010001 addi $1,$0,1 19: bne $t4, 1, end_loop2
0x0040002c 0x142c000f bne $1,$12,15
Labels
Label Address
Assignment_4.asm
Loop1 0x00400010
Loop2 0x00400024
end_loop2 0x0040006c
if_loop2 0x00400078
End_loop1 0x00400088
A 0x10010000
Aend 0x10010034
Data Text
Data Segment
Address Value (+0) Value (+4) Value (+8) Value (+c) Value (+10) Value (+14) Value (+18) Value (+1c)
0x10010000 7 -2 5 1 5 6 7 3
0x10010020 6 8 8 59 5 0 0 0
0x10010040 0 0 0 0 0 0 0 0
0x10010060 0 0 0 0 0 0 0 0
0x10010080 0 0 0 0 0 0 0 0
0x100100a0 0 0 0 0 0 0 0 0
0x100100c0 0 0 0 0 0 0 0 0
0x100100e0 0 0 0 0 0 0 0 0
0x10010100 0 0 0 0 0 0 0 0
0x10010120 0 0 0 0 0 0 0 0
0x10010000 (.data) Hexadecimal Addresses Hexadecimal Values ASCII
Mars Messages Run I/O
Assemble: assembling D:\2023.2\TH KTMT\MARSfile\Lab6\Assignment_4.asm
Assemble: operation completed successfully.
Clear
Registers Coproc 1 Coproc 0
Name Number Value
$zero 0 0
$at 1 0
$v0 2 0
$v1 3 0
$a0 4 0
$a1 5 0
$a2 6 0
$a3 7 0
$t0 8 0
$t1 9 0
$t2 10 0
$t3 11 0
$t4 12 0
$t5 13 0
$t6 14 0
$t7 15 0
$s0 16 0
$s1 17 0
$s2 18 0
$s3 19 0
$s4 20 0
$s5 21 0
$s6 22 0
$s7 23 0
$t8 24 0
$t9 25 0
$k0 26 0
$k1 27 0
$gp 28 268468224
$sp 29 2147479548
$fp 30 0
$ra 31 0
pc 4194304
hi 0
lo 0


D:\2023.2\TH KTMT\MARSfile\Lab6\Assignment_4.asm - MARS 4.5
File Edit Run Settings Tools Help
Run speed at max (no interaction)
Edit Execute
Text Segment
Bkpt Address Code Basic Source
0x00400000 0x3c011001 lui $1,4097 7: la $a0, A
0x00400004 0x34240000 ori $4,$1,0
0x00400008 0x2008000d addi $8,$0,13 8: addi $t0, $0, 13 # N
0x0040000c 0x20090000 addi $9,$0,0 9: addi $t1, $0, 0 # i = 0
0x00400010 0x0128502a slt $10,$9,$8 12: slt $t2, $t1, $t0 #Check i < N
0x00400014 0x20010001 addi $1,$0,1 13: bne $t2, 1, End_loop1
0x00400018 0x142a001b bne $1,$10,27
0x0040001c 0x00000000 nop 14: nop
0x00400020 0x210bffff addi $11,$8,-1 15: addi $t3, $t0, -1 # j = N - 1
0x00400024 0x012b602a slt $12,$9,$11 18: slt $t4, $t1, $t3 #Check j > i
0x00400028 0x20010001 addi $1,$0,1 19: bne $t4, 1, end_loop2
0x0040002c 0x142c000f bne $1,$12,15
Labels
Label Address
Assignment_4.asm
Loop1 0x00400010
Loop2 0x00400024
end_loop2 0x0040006c
if_loop2 0x00400078
End_loop1 0x00400088
A 0x10010000
Aend 0x10010034
Data Text
Data Segment
Address Value (+0) Value (+4) Value (+8) Value (+c) Value (+10) Value (+14) Value (+18) Value (+1c)
0x10010000 -2 1 3 5 5 5 6 6
0x10010020 7 7 8 8 59 0 0 0
0x10010040 0 0 0 0 0 0 0 0
0x10010060 0 0 0 0 0 0 0 0
0x10010080 0 0 0 0 0 0 0 0
0x100100a0 0 0 0 0 0 0 0 0
0x100100c0 0 0 0 0 0 0 0 0
0x100100e0 0 0 0 0 0 0 0 0
0x10010100 0 0 0 0 0 0 0 0
0x10010120 0 0 0 0 0 0 0 0
0x10010000 (.data) Hexadecimal Addresses Hexadecimal Values ASCII
Mars Messages Run I/O
Reset: reset completed.
-- program is finished running (dropped off bottom) --
Clear
Registers Coproc 1 Coproc 0
Name Number Value
$zero 0 0
$at 1 1
$v0 2 0
$v1 3 0
$a0 4 268500992
$a1 5 268501040
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pc 4194440
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