Homework 2

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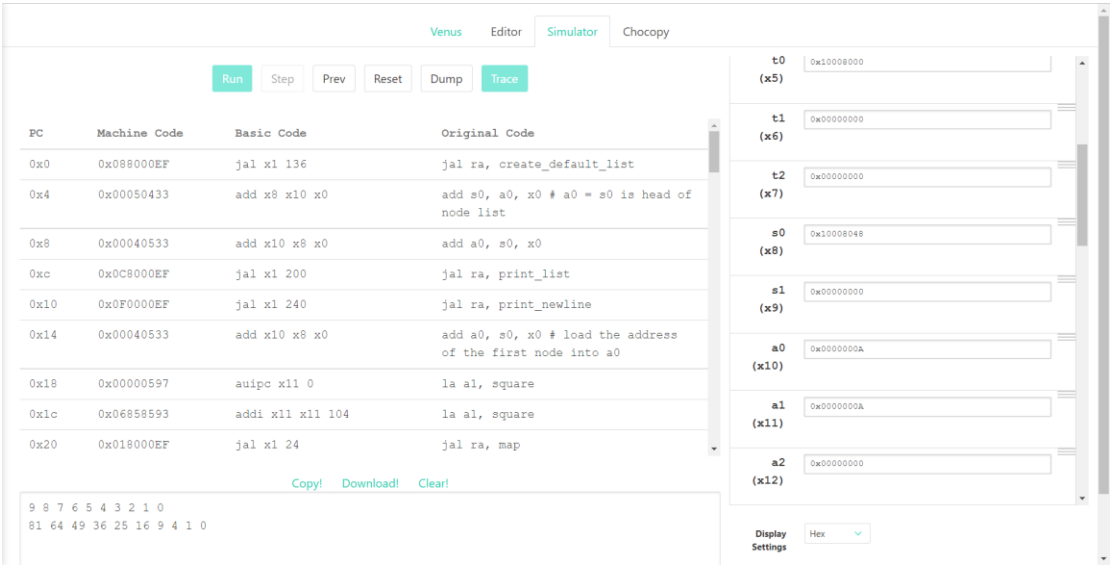
练习 3

结果截图:



代码:

```
.globl map

.text
main:
    jal ra, create_default_list
    add s0, a0, x0    # a0 = s0 is head of node list

    #print the list
    add a0, s0, x0
    jal ra, print_list

    # print a newline
    jal ra, print_newline

    # load your args
    add a0, s0, x0    # load the address of the first node into a0

    # load the address of the function in question into a1 (check out la on the green sheet)
    ### YOUR CODE HERE ###
    la a1, square
```

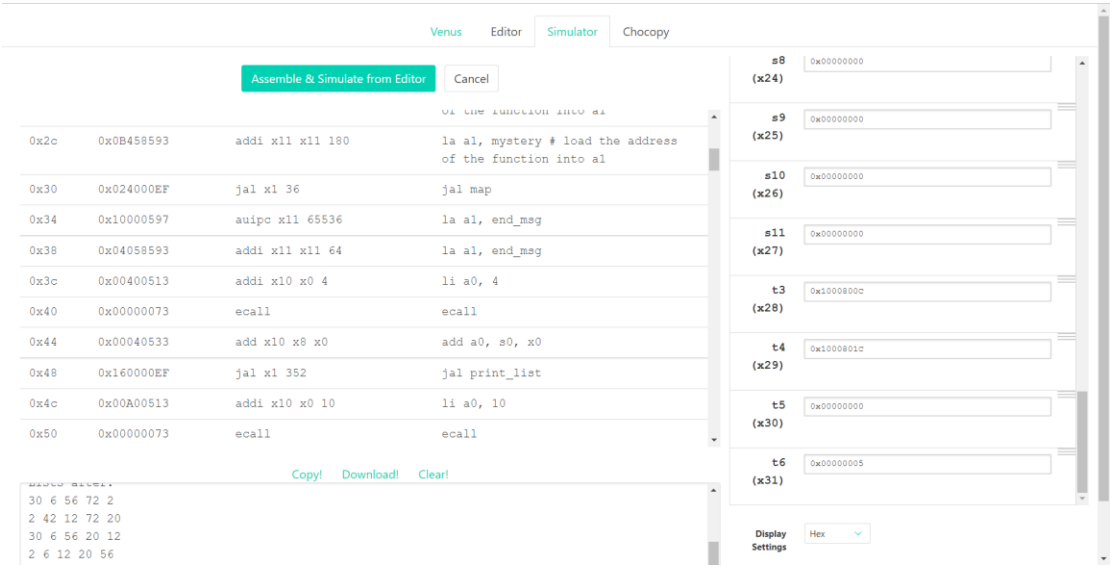
```
    # issue the call to map
    jal ra, map

    # print the list
    add a0, s0, x0
    jal ra, print_list

    # print another newline
    jal ra, print_newline

    addi a0, x0, 10
    ecall #Terminate the program

map:
    # Prologue: Make space on the stack and back-up registers
    ### YOUR CODE HERE ###
    addi sp sp -12
    sw s0 0(sp)
    sw s1 4(sp)
    sw ra 8(sp)

    beq a0, x0, done       # If we were given a null pointer (address 0), we're done.

    add s0, a0, x0    # Save address of this node in s0
    add s1, a1, x0    # Save address of function in s1

    # Remember that each node is 8 bytes long: 4 for the value followed by 4 for the pointer to next.
    # What does this tell you about how you access the value and how you access the pointer to next?

    # load the value of the current node into a0
    # THINK: why a0?
    ### YOUR CODE HERE ###
    lw a0 0(s0)

    # Call the function in question on that value. DO NOT use a label (be prepared to answer why).
    # What function? Recall the parameters of "map"
    ### YOUR CODE HERE ###
    jalr ra a1 0

    # store the returned value back into the node
    # Where can you assume the returned value is?
```

```
    ### YOUR CODE HERE ###
    sw a0 0(s0)

    # Load the address of the next node into a0
    # The Address of the next node is an attribute of the current node.
    # Think about how structs are organized in memory.
    ### YOUR CODE HERE ###
    lw a0 4(s0)

    # Put the address of the function back into a1 to prepare for the recursion
    # THINK: why a1? What about a0?
    ### YOUR CODE HERE ###
    add a1 s1 x0

    # recurse
    ### YOUR CODE HERE ###
    jal ra, map

done:
    # Epilogue: Restore register values and free space from the stack
    ### YOUR CODE HERE ###
    lw s0 0(sp)
    lw s1 4(sp)
    lw ra 8(sp)
    addi sp sp 12

    jr ra # Return to caller

square:
    mul a0 ,a0, a0
    jr ra

create_default_list:
    addi sp, sp, -12
    sw   ra, 0(sp)
    sw   s0, 4(sp)
    sw   s1, 8(sp)
    li   s0, 0          # pointer to the last node we handled
    li   s1, 0          # number of nodes handled
loop:    #do...
    li   a0, 8
    jal ra, malloc          # get memory for the next node
    sw   s1, 0(a0)    # node->value = i
    sw   s0, 4(a0)    # node->next = last
```

```
        add s0, a0, x0    # last = node
        addi        s1, s1, 1      # i++
        addi t0, x0, 10
        bne s1, t0, loop        # ... while i!= 10
        lw    ra, 0(sp)
        lw    s0, 4(sp)
        lw    s1, 8(sp)
        addi sp, sp, 12
        jr ra

print_list:
        bne a0, x0, printMeAndRecurse
        jr ra             # nothing to print
printMeAndRecurse:
        add t0, a0, x0    # t0 gets current node address
        lw    a1, 0(t0)      # a1 gets value in current node
        addi a0, x0, 1            # prepare for print integer ecall
        ecall
        addi        a1, x0, ' '         # a0 gets address of string containing space
        addi        a0, x0, 11            # prepare for print string syscall
        ecall
        lw    a0, 4(t0)      # a0 gets address of next node
        jal x0, print_list    # recurse. We don't have to use jal because we already have where
we want to return to in ra

print_newline:
        addi        a1, x0, '\n' # Load in ascii code for newline
        addi        a0, x0, 11
        ecall
        jr    ra

malloc:
        addi        a1, a0, 0
        addi        a0, x0 9
        ecall
        jr    ra
```

练习 4

结果截图:



代码:

```
.globl map

.data
arrays: .word 5, 6, 7, 8, 9
            .word 1, 2, 3, 4, 7
            .word 5, 2, 7, 4, 3
            .word 1, 6, 3, 8, 4
            .word 5, 2, 7, 8, 1

start_msg:    .asciiz "Lists before: \n"
end_msg:       .asciiz "Lists after: \n"

.text
main:
      jal create_default_list
      mv s0, a0      # v0 = s0 is head of node list

      #print "lists before: "
      la a1, start_msg
      li a0, 4
      ecall

      #print the list
      add a0, s0, x0
      jal print_list

      # print a newline
      jal print_newline
```

```
    # issue the map call
    add a0, s0, x0          # load the address of the first node into a0
    la   a1, mystery        # load the address of the function into a1

    jal map

    # print "lists after: "
    la a1, end_msg
    li a0, 4
    ecall

    # print the list
    add a0, s0, x0
    jal print_list

    li a0, 10
    ecall

map:
    addi sp, sp, -12
    sw ra, 0(sp)
    sw s1, 4(sp)
    sw s0, 8(sp)

    beq a0, x0, done       # if we were given a null pointer, we're done.

    add s0, a0, x0         # save address of this node in s0
    add s1, a1, x0         # save address of function in s1
    add t0, x0, x0         # t0 is a counter

    # remember that each node is 12 bytes long:
    # - 4 for the array pointer
    # - 4 for the size of the array
    # - 4 more for the pointer to the next node

    # also keep in mind that we should not make ANY assumption on which registers
    # are modified by the callees, even when we know the content inside the functions
    # we call. this is to enforce the abstraction barrier of calling convention.
mapLoop:
    lw t1, 0(s0)          # load the address of the array of current node into t1
    lw t2, 4(s0)          # load the size of the node's array into t2

    slli t3, t0, 2
```

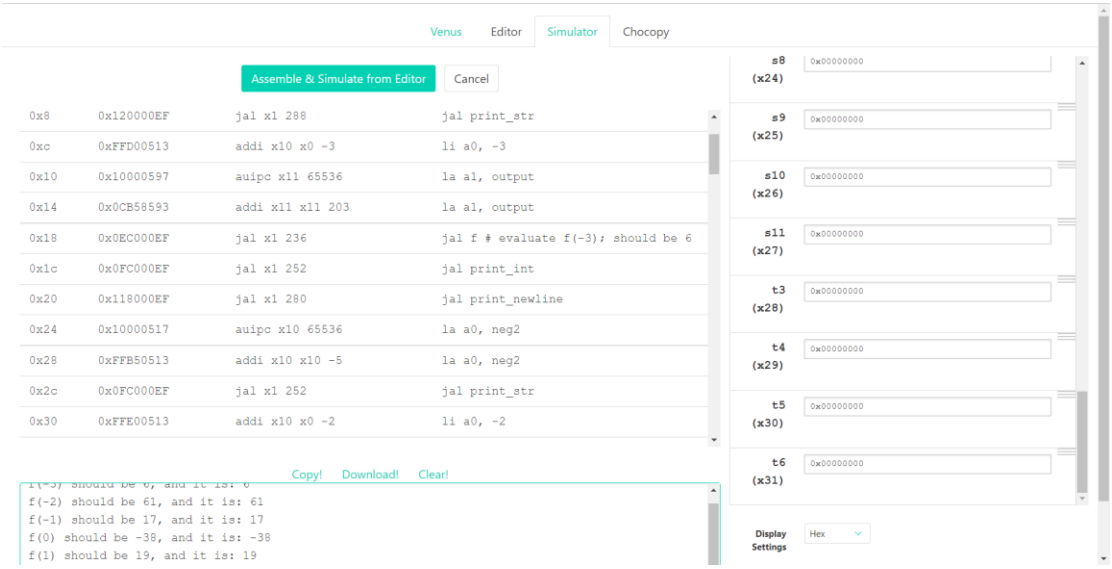
```
        add t1, t1, t3          # offset the array address by the count

        lw a0, 0(t1)            # load the value at that address into a0

        addi sp, sp, -4
        sw t1, 0(sp)

        jalr s1                 # call the function on that value.

        lw t1, 0(sp)
        addi sp, sp, 4

        sw a0, 0(t1)            # store the returned value back into the array
        addi t0, t0, 1          # increment the count
        bne t0, t2, mapLoop # repeat if we haven't reached the array size yet

        lw a0, 8(s0)            # load the address of the next node into a0
        add a1, s1, x0          # put the address of the function back into a1 to prepare for
the recursion

        jal    map              # recurse
done:
        lw s0, 8(sp)
        lw s1, 4(sp)
        lw ra, 0(sp)
        addi sp, sp, 12
        jr ra

print_newline:
        li a1, '\n'
        li a0, 11
        ecall
        jr ra

mystery:
        mul t1, a0, a0
        add a0, t1, a0
        jr ra

create_default_list:
        addi sp, sp, -24
        sw ra, 0(sp)
        sw s0, 4(sp)
        sw s1, 8(sp)
```

```
        sw s2, 12(sp)
        sw s3, 16(sp)
        sw s4, 20(sp)
        li s0, 0    # pointer to the last node we handled
        li s1, 0    # number of nodes handled
        li s2, 5    # size
        la s3, arrays
loop: #do...
        li a0, 12
        jal malloc          # get memory for the next node
        mv s4, a0
        li a0, 20
        jal    malloc        # get memory for this array

        sw a0, 0(s4)       # node->arr = malloc
        lw a0, 0(s4)
        mv a1, s3
        jal fillArray     # copy ints over to node->arr

        sw s2, 4(s4)       # node->size = size (4)
        sw    s0, 8(s4)     # node-> next = previously created node

        add s0, x0, s4    # last = node
        addi s1, s1, 1    # i++
        addi s3, s3, 20 # s3 points at next set of ints
        li t6 5
        bne s1, t6, loop # ... while i!= 5
        mv a0, s4
        lw ra, 0(sp)
        lw s0, 4(sp)
        lw s1, 8(sp)
        lw s2, 12(sp)
        lw s3, 16(sp)
        lw s4, 20(sp)
        addi sp, sp, 24
        jr ra

fillArray: lw t0, 0(a1) #t0 gets array element
        sw t0, 0(a0) #node->arr gets array element
        lw t0, 4(a1)
        sw t0, 4(a0)
        lw t0, 8(a1)
        sw t0, 8(a0)
        lw t0, 12(a1)
```

```
        sw t0, 12(a0)
        lw t0, 16(a1)
        sw t0, 16(a0)
        jr ra

print_list:
        bne a0, x0, printMeAndRecurse
        jr ra      # nothing to print
printMeAndRecurse:
        mv t0, a0 # t0 gets address of current node
        lw t3, 0(a0) # t3 gets array of current node
        li t1, 0    # t1 is index into array
printLoop:
        slli t2, t1, 2
        add t4, t3, t2
        lw a1, 0(t4) # a0 gets value in current node's array at index t1
        li a0, 1    # preparte for print integer ecall
        ecall
        li a1, ' ' # a0 gets address of string containing space
        li a0, 11    # prepare for print string ecall
        ecall
        addi t1, t1, 1
    li t6 5
        bne t1, t6, printLoop # ... while i!= 5
        li a1, '\n'
        li a0, 11
        ecall
        lw a0, 8(t0) # a0 gets address of next node
        j print_list # recurse. We don't have to use jal because we already have where we want
to return to in ra

malloc:
        mv a1, a0 # Move a0 into a1 so that we can do the syscall correctly
        li a0, 9
        ecall
        jr ra
```

练习 5

结果截图：



代码：

```
.globl f

.data
neg3:    .asciiz "f(-3) should be 6, and it is: "
neg2:    .asciiz "f(-2) should be 61, and it is: "
neg1:    .asciiz "f(-1) should be 17, and it is: "
zero:    .asciiz "f(0) should be -38, and it is: "
pos1:    .asciiz "f(1) should be 19, and it is: "
pos2:    .asciiz "f(2) should be 42, and it is: "
pos3:    .asciiz "f(3) should be 5, and it is: "

output: .word    6, 61, 17, -38, 19, 42, 5
.text
main:
    la a0, neg3
    jal print_str
    li a0, -3
    la a1, output
    jal f                    # evaluate f(-3); should be 6
    jal print_int
    jal print_newline

    la a0, neg2
    jal print_str
    li a0, -2
    la a1, output
    jal f                    # evaluate f(-2); should be 61
    jal print_int
```

```
    jal print_newline

    la a0, neg1
    jal print_str
    li a0, -1
    la a1, output
    jal f                   # evaluate f(-1); should be 17
    jal print_int
    jal print_newline

    la a0, zero
    jal print_str
    li a0, 0
    la a1, output
    jal f                   # evaluate f(0); should be -38
    jal print_int
    jal print_newline

    la a0, pos1
    jal print_str
    li a0, 1
    la a1, output
    jal f                   # evaluate f(1); should be 19
    jal print_int
    jal print_newline

    la a0, pos2
    jal print_str
    li a0, 2
    la a1, output
    jal f                   # evaluate f(2); should be 42
    jal print_int
    jal print_newline

    la a0, pos3
    jal print_str
    li a0, 3
    la a1, output
    jal f                   # evaluate f(3); should be 5
    jal print_int
    jal print_newline

    li a0, 10
    ecall
```

```
# f takes in two arguments:
# a0 is the value we want to evaluate f at
# a1 is the address of the "output" array (defined above).
# Think: why might having a1 be useful?
f:
    # YOUR CODE GOES HERE!
    addi t0 a0 3
    slli t1 t0 2
    add a1 a1 t1
    lw a0 0(a1)
    jr ra                   # Always remember to jr ra after your function!

print_int:
    mv a1, a0
    li a0, 1
    ecall
    jr    ra

print_str:
    mv a1, a0
    li a0, 4
    ecall
    jr    ra

print_newline:
    li a1, '\n'
    li a0, 11
    ecall
    jr    ra
```