Assignment 7, Part A

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April 13, 2023

1

Independent

2

Write a RISC-V assembly function to search a specified integer in an integer array. The function should take the base address of the array, the number of elements in the array, and the specified integer as function arguments. The function should return the index number of the first array entry that holds the specified value. If no array element is the specified value, it should return the value -1.

```
# a0 is is the base of the array.
# a1 is the number of elements in the array.
# a2 is the number that the function searches for.

# The function returns the index in a0 (if found), otherwise -1.

find_int:
        addi t0, x0, 1 # t0 is 1.
        if:
            blt a1, t0, return_1 # If size < 1 return -1
        add t0, a0, x0 # t0 is a pointer to a0.
        slli t3, a1, 2 # t3 is the size of the array in bytes.
        add t1 a0, t3 # t1 is a pointer to the last element of the array.

        loop:
            blt t1, t0, return_1 # t1 < t0
            lw t2, 0(t0) # t2 = *t0
            if_equal:
                    beq t2, a2, return_found # If t2 == a2 return the index.
            addi t0, t0, 4 # t0++
            jal x0, loop

        return_found:
                    sub a0, t0, a0 # Calculate the index.
                    srai a0, a0, 2
                    jalr x0, x1, 0
        return_1:
                addi a0, x0, -1 # Return -1.
                jalr x0, x1, 0
```

3

Consider a RISC-V assembly function func1. func1 has three passing arguments stored in registers a0, a1 and a2, uses temporary registers t0-t3 and saved registers s4-s10. func1 needs to call func2 and other functions may call func1 also. func2 has two passing arguments stored in registers a0 and a1, respectively. In func1, after the program returns to func1 from func2, the code needs the original values stored in registers t1 and a0 before it calls func2.

a. Ten words need to be stored in the stack.
b. Funct1 needs to store the values inside a0, t1, s4-s10, ra in the stack.

4

Implement the C code snippet in RISC-V assembly language. Use s0-s2 to hold the variables i, j, and min$_idx in the fucntion selectionSort. Be sure to hangle the stack pointer appropriatly. The array is store
a)

```
        # selectionSort takes a0 (base address) and a1 (number
           of elements).
        selectionSort:
                        # s0 is i
                        # s1 is j
                        # s2 is min_idx
                        # s4 is a0
                        # s5 is a1
                        # s6 si a1 - 1 (size)


                        # Save the s registers into the stack:
                        addi sp, sp, -28
                        sw s0, 0(sp)
                        sw s1, 4(sp)
                        sw s2, 8(sp)
                        sw s4, 12(sp)
                        sw s5, 16(sp)
                        sw s6, 20(sp)
                        sw x1, 24(sp)

                        # Store a0 and a1:
                        add s4, a0, x0
                        add s5, a1, x0

                        # Sort the array:
                        addi s6, a1, -1 # n - 1
                        add s0, x0, x0 # i = 0
                        for:
                            bge s0, s6, end_loop # i > n

                            # Call findMinimum function:
                            slli t0, s0, 2
                            add a0, s4, t0
                            sub a1, s5, s0
                            jal x1, findMinimum

                            # Set min_idx to the value in a0:
                            add s2, a0, x0
```

```
39
40                          if_swap:
41                              beq s2, s0, continue
42                              # Call the swap function:
43                              add t0, s2, s0
44                              slli t0, t0, 2
45                              add a0, s4, t0
46                              slli t0, s0, 2
47                              add a1, s4, t0
48                              jal x1, swap
49
50                          continue:
51
52                          # Increment i:
53                          addi s0, s0, 1
54
55                          # Jump to Loop:
56                          jal x0, for
57
58                      end_loop:
59
60                      # Restore the s registers:
61                      lw s0, 0(sp)
62                      lw s1, 4(sp)
63                      lw s2, 8(sp)
64                      lw s4, 12(sp)
65                      lw s5, 16(sp)
66                      lw s6, 20(sp)
67                      lw x1, 24(sp)
68
69                      # Empty the stack:
70                      addi sp, sp, 28
71
72                      # Return:
73                      jalr x0, x1, 0
74
75
76          # findMinimum takes a0 (base address) and a1 (number
               of elements).
77          findMinimum:
78                      # t0 is min_idx
79                      # t1 is min_E
80
81                      # Initialize min_idx and min_E:
82                      add t0, x0, x0
```

```
                    add t2, a0, t0
                    lw t1, 0(t2)

                    # Loop through the array:
                    # t3 is i
                    addi t3, x0, 1
                    for_loop_2:
                        # Condition:
                        bge t3, a1, end_loop_2
                        # Body:
                        slli t4, t3, 2
                        add t4, a0, t4
                        # t5 = arr[i]
                        lw t5, 0(t4)
                        if_2:
                            bge t5, t1, continue_2
                            add t0, t3, x0
                            slli t6, t0, 2
                            add t6, a0, t6
                            lw t1, 0(t6)

                        continue_2:

                        # Increment i:
                        addi t3, t3, 1

                        # Jump to Loop:
                        jal x0, for_loop_2

                    end_loop_2:
                    # Return min_idx:
                    add a0, t0, x0
                    # Return:
                    jalr x0, x1, 0

    # swap takes a0 (address of first element) and a1
       (address of second element).
    swap:
            # t0 is temp
            # t1 is a0

            # Interchange the values:
            lw t0, 0(a0) # temp = a0
            lw t1, 0(a1) # a0 = a1
            sw t1, 0(a0)
```

```
127                     sw  t0, 0(a1)
128
129                     # Return:
130                     jalr  x0, x1, 0
```

b)

Assume that the selectionSort is the function called. Draw the status of the stack before calling selectionSort and during each function call. Indicate stack addresses and names of registers and variables stored on the stack; mark the location of sp; and clearly mark each stack frame. Assume the sp starts at 0x8000.

Addresses	*Registers*	*Variables*	*Stack_Pointer*
0x8000	$s0$	i	
0x7FFC	$s1$	j	
0x7FF8	$s2$	min_idx	
0x7FF0	$s4$	arr	
0x7FEC	$s5$	n	
0x7FE8	$s6$	$n-1$	
0x7FE0	$x1$	ra	sp