COMPUTER ARCHITECTURE ASSIGNMENT – 2

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We have implemented the following programs:

1. Finding the factorial of a number
2. Sorting an array using selection sort
3. Searching a number in an array using Binary Search

FACTORIAL OF A NUMBER

- **INTRODUCTION:**

Factorial of a number is defined as the product of all positive integers less than or equal to a given positive integer (Factorial of 0 is defined as 1).
Our program calculates the factorial of the given number. Assumption:
The input is a non-negative number.

- **PROGRAM EXPLANATION:**

In our program we have four labels : main, check, loop and exit.

main: Stores the necessary values of the input, memory address of input, the value of the iterator $s1 and stores the value 1 in $s2 which will be used to compute factorial. **check:** Check if the iterator is less than our number or not and branch accordingly.

loop: Multiplies the current product value($s2) to the iterator $s1 and then increments the iterator.

exit: Stores the result of factorial in data memory and exits from the program.

Instructions Used:

○ Load Word (lw) ○ Store Word (sw) ○ Add immediate (addi) ○ Multiply (mul) ○ Branch on not equal (bne) ○ Jump (j)

- **ASSEMBLY CODE:**

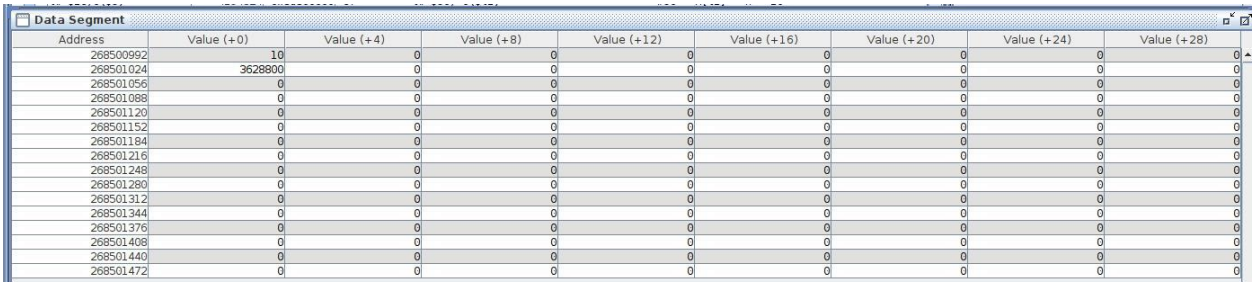
```
1  main:
2
3          addi $t0, $0, 10                    #t0 = n = 10
4          addi $t1, $0, 268500992             #t1 = memory address where n will be stored
5          sw $t0, 0($t1)                      #M[t1] = t0 = 10
6          lw $s0, 0($t1)                      #s0 = M[t1] = n = 10
7          addi $s1, $0, 1                     #s1 = i = 1
8          addi $s2, $0, 1                     #s2 = fact(n) =  1
9          j check
10
11 check:          #checks the loop condition
12
13         bne $s1, $s0, loop              #if (i!=n) jump to loop
14         mul $s2, $s2, $s0               #else fact = fact * n because the loop function will execute only till (n-1)
15         j exit
16
17 loop:
18         mul $s2, $s2, $s1               # fact = fact * i
19         addi $s1, $s1, 1                # i = i+1
20         j check
21
22 exit:
23         addi $t0, $0, 268501024         #t0 = address where the result will be stored
24         sw $s2, 0($t0)                  #M[t0] = s2
25         addi $v0,$0,10                  # return 0
26         syscall
```

- **TEXT SEGMENT:**

Text Segment

Bkpt	Basic	Address	Code		Source	
	addi $8,$0,10	4194304	0x2008000a	3:	addi $t0, $0, 10	#t0 = n = 10
	lui $1,4097	4194308	0x3c011001	4:	addi $t1, $0, 268500992	#t1 = memory address where n will be st...
	ori $1,$1,0	4194312	0x34210000			
	add $9,$0,$1	4194316	0x00014820			
	sw $8,0($9)	4194320	0xad280000	5:	sw $t0, 0($t1)	#M[t1] = t0 = 10
	lw $16,0($9)	4194324	0x8d300000	6:	lw $s0, 0($t1)	#s0 = M[t1] = n = 10
	addi $17,$0,1	4194328	0x20110001	7:	addi $s1, $0, 1	#s1 = i = 1
	addi $18,$0,1	4194332	0x20120001	8:	addi $s2, $0, 1	#s2 = fact(n) = 1
	j 4194340	4194336	0x08100009	9:	j check	
	bne $17,$16,2	4194340	0x16300002	13:	bne $s1, $s0, loop	#if (i!=n) jump to loop
	mul $18,$18,$16	4194344	0x72509002	14:	mul $s2, $s2, $s0	#else fact = fact * n because the loop function...
	j 4194364	4194348	0x0810000f	15:	j exit	
	mul $18,$18,$17	4194352	0x72519002	18:	mul $s2, $s2, $s1	# fact = fact * i
	addi $17,$17,1	4194356	0x22310001	19:	addi $s1, $s1, 1	# i = i+1
	j 4194340	4194360	0x08100009	20:	j check	
	lui $1,4097	4194364	0x3c011001	23:	addi $t0, $0, 268501024	#t0 = address where the result will be stored
	ori $1,$1,32	4194368	0x34210020			
	add $8,$0,$1	4194372	0x00014020			
	sw $18,0($8)	4194376	0xad120000	24:	sw $s2, 0($t0)	#M[t0] = s2
	addi $2,$0,10	4194380	0x2002000a	25:	addi $v0,$0,10	# return 0
	syscall	4194384	0x0000000c	26:	syscall	

- **DATA SEGMENT:**



Data Segment

Address	Value (+0)	Value (+4)	Value (+8)	Value (+12)	Value (+16)	Value (+20)	Value (+24)	Value (+28)
268500992	10	0	0	0	0	0	0	0
268501024	3628800	0	0	0	0	0	0	0
268501056	0	0	0	0	0	0	0	0
268501088	0	0	0	0	0	0	0	0
268501120	0	0	0	0	0	0	0	0
268501152	0	0	0	0	0	0	0	0
268501184	0	0	0	0	0	0	0	0
268501216	0	0	0	0	0	0	0	0
268501248	0	0	0	0	0	0	0	0
268501280	0	0	0	0	0	0	0	0
268501312	0	0	0	0	0	0	0	0
268501344	0	0	0	0	0	0	0	0
268501376	0	0	0	0	0	0	0	0
268501408	0	0	0	0	0	0	0	0
268501440	0	0	0	0	0	0	0	0
268501472	0	0	0	0	0	0	0	0

- **MEMORY:**

Registers | Coproc 1 | Coproc 0

Name	Number	Value
$zero	0	0
$at	1	268501024
$v0	2	10
$v1	3	0
$a0	4	0
$a1	5	0
$a2	6	0
$a3	7	0
$t0	8	268501024
$t1	9	268500992
$t2	10	0
$t3	11	0
$t4	12	0
$t5	13	0
$t6	14	0
$t7	15	0
$s0	16	10
$s1	17	10
$s2	18	3628800
$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		4194388

SELECTION SORT

- **INTRODUCTION:**

Selection sort is a sorting algorithm that works by repeatedly selecting the smallest (or largest) element from the unsorted portion of the array and moving it to the sorted portion of the array.

Our program sorts the array using the selection sort method.

- **PROGRAM EXPLANATION:**

Our program has 5 parts : main, outer_loop, cont_out, inner_loop, cont_in and exit.

main : Stores the necessary values, the integer 4 for alignment, the size of the array, the base address of the array and the iterator for the outer_loop which is $s0.

outer_ loop : Checks if you have iterated till the end of the loop. If yes, then branches to exit, else it stores the index of the minimum value obtained through inner_loop in $s7. It also increments the iterator for the inner_loop which is $s2.

cont_out : This swaps the minimum element to the desired place in the array (which is the outer loop iterator).

inner_loop: It calculates the next minimum element and then goes to cont_out which then swaps it. **cont_in:** Increments the inner iterator which is $s2 and proceeds to inner_loop.

exit: Exits from the program.

Instructions Used:

- Load Word (lw) ○ Store Word (sw) ○ Add immediate (addi) ○ Multiply (mul) ○ Add (add)
- Branch on greater than equal (bge) ○ Jump (j)

- **ASSEMBLY CODE:**

```
.data
        arr: .word 23,31,-9,180,99
.text

addi $s5,$zero,4                        #store value of 4 to be used later for alignment
addi $t0,$0,5                           #store size of array in $t0
la $t1,arr                              #store base address of array

#selection sorting code
            add $s0,$zero,$zero         #counter for outer loop (i=0)
            addi $s1,$t0,-1             # store len-1 in $s1
outer_loop: bge $s0,$s1, exit           #check if i>=len-1 then break
            add $s7,$s0,$zero           #min_pos=i
            addi $s2,$s0,1              #counter for inner loop , j=i+1
            j inner_loop

            #swap min-pos to place
cont_out :  mul $t3,$s5,$s0             #i*4 for alignment
            add $t3,$t3,$t1             #store value of index i
            lw $t4,0($t3)               #tmp= arr[i]

            mul $t6,$s5,$s7             #min_pos*4 for alignment
            add $t6,$t6,$t1             #store min_pos address val
            lw $t5,0($t6)               #tmp2= arr[min_pos]

            sw $t5,0($t3)               #arr[i] = tmp2 = arr[min_pos]
            sw $t4,0($t6)               #arr[min_pos] = tmp = arr[i]

            addi $s0,$s0,1              #i++
            j outer_loop

inner_loop: bge $s2,$t0,cont_out        #j>=n , break

            mul $t3,$s5, $s2            #j*4 for alignment
            add $t3,$t3,$t1             #store index j address
            lw $t4,0($t3)               #tmp= arr[j]

            mul $t6,$s5,$s7             #min_pos*4 for alignment
            add $t6,$t6,$t1             #store min_pos address val
            lw $t5,0($t6)               #tmp2= arr[min_pos]

            bge $t4,$t5,cont_in         #if(arr[j]>=arr[min_pos], no change
            add $s7,$s2,$zero               #min_pos=j;

cont_in:    addi $s2,$s2,1              #j++
            j inner_loop

exit:       addi $v0,$0,10              #exit program
            syscall
```

- **TEXT SEGMENT:**

Text Segment

Bkpt	Basic	Address	Code	Source
	addi $21,$0,4	4194304	0x20150004	5: addi $s5,$zero,4 #store value of 4 to be used later for alig...
	addi $8,$0,5	4194308	0x20080005	6: addi $t0,$0,5 #store size of array in $t0
	lui $1,4097	4194312	0x3c011001	7: la $t1,arr #store base address of array
	ori $9,$1,0	4194316	0x34290000	
	add $16,$0,$0	4194320	0x00008020	10: add $s0,$zero,$zero #counter for outer loop (i=0)
	addi $17,$8,-1	4194324	0x2111ffff	11: addi $s1,$t0,-1 # store len-1 in $s1
	slt $1,$16,$17	4194328	0x0211082a	12: outer_loop: bge $s0,$s1, exit #check if i>=len-1 then break
	beq $1,$0,26	4194332	0x1020001a	
	add $23,$16,$0	4194336	0x0200b820	13: add $s7,$s0,$zero #min_pos=i
	addi $18,$16,1	4194340	0x22120001	14: addi $s2,$s0,1 #counter for inner loop , j=i+1
	j 4194388	4194344	0x08100015	15: j inner_loop
	mul $11,$21,$16	4194348	0x72b05802	18: cont_out : mul $t3,$s5,$s0 #i*4 for alignment
	add $11,$11,$9	4194352	0x01695820	19: add $t3,$t3,$t1 #store value of index i
	lw $12,0($11)	4194356	0x8d6c0000	20: lw $t4,0($t3) #tmp= arr[i]
	mul $14,$21,$23	4194360	0x72b77002	22: mul $t6,$s5,$s7 #min_pos*4 for alignment
	add $14,$14,$9	4194364	0x01c97020	23: add $t6,$t6,$t1 #store min_pos address val
	lw $13,0($14)	4194368	0x8dcd0000	24: lw $t5,0($t6) #tmp2= arr[min_pos]
	sw $13,0($11)	4194372	0xad6d0000	26: sw $t5,0($t3) #arr[i] = tmp2 = arr[min_pos]
	sw $12,0($14)	4194376	0xadcc0000	27: sw $t4,0($t6) #arr[min_pos] = tmp = arr[i]
	addi $16,$16,1	4194380	0x22100001	29: addi $s0,$s0,1 #i++
	j 4194328	4194384	0x08100006	30: j outer_loop
	slt $1,$18,$8	4194388	0x0248082a	32: inner_loop: bge $s2,$t0,cont_out #j>=n , break
	beq $1,$0,-12	4194392	0x1020fff4	
	mul $11,$21,$18	4194396	0x72b25802	34: mul $t3,$s5, $s2 #j*4 for alignment
	add $11,$11,$9	4194400	0x01695820	35: add $t3,$t3,$t1 #store index j address
	lw $12,0($11)	4194404	0x8d6c0000	36: lw $t4,0($t3) #tmp= arr[j]
	mul $14,$21,$23	4194408	0x72b77002	38: mul $t6,$s5,$s7 #min_pos*4 for alignment
	add $14,$14,$9	4194412	0x01c97020	39: add $t6,$t6,$t1 #store min_pos address val
	lw $13,0($14)	4194416	0x8dcd0000	40: lw $t5,0($t6) #tmp2= arr[min_pos]
	slt $1,$12,$13	4194420	0x018d082a	42: bge $t4,$t5,cont_in #if(arr[j]>=arr[min_pos], no change
	beq $1,$0,1	4194424	0x10200001	
	add $23,$18,$0	4194428	0x0240b820	43: add $s7,$s2,$zero #min_pos=j;
	addi $18,$18,1	4194432	0x22520001	45: cont_in: addi $s2,$s2,1 #j++
	j 4194388	4194436	0x08100015	46: j inner_loop
	addi $2,$0,10	4194440	0x2002000a	48: exit: addi $v0,$0,10 #exit program
	syscall	4194444	0x0000000c	49: syscall

- **DATA SEGMENT:**

Data Segment

Address	Value (+0)	Value (+4)	Value (+8)	Value (+12)	Value (+16)	Value (+20)	Value (+24)	Value (+28)
268500992	-9	23	31	99	180	0	0	0
268501024	0	0	0	0	0	0	0	0
268501056	0	0	0	0	0	0	0	0
268501088	0	0	0	0	0	0	0	0
268501120	0	0	0	0	0	0	0	0
268501152	0	0	0	0	0	0	0	0
268501184	0	0	0	0	0	0	0	0
268501216	0	0	0	0	0	0	0	0
268501248	0	0	0	0	0	0	0	0
268501280	0	0	0	0	0	0	0	0
268501312	0	0	0	0	0	0	0	0
268501344	0	0	0	0	0	0	0	0
268501376	0	0	0	0	0	0	0	0
268501408	0	0	0	0	0	0	0	0
268501440	0	0	0	0	0	0	0	0
268501472	0	0	0	0	0	0	0	0

- **MEMORY:**

Registers | Coproc 1 | Coproc 0

Name	Number	Value
$zero	0	0
$at	1	0
$v0	2	10
$v1	3	0
$a0	4	0
$a1	5	0
$a2	6	0
$a3	7	0
$t0	8	5
$t1	9	268500992
$t2	10	0
$t3	11	268501004
$t4	12	180
$t5	13	99
$t6	14	268501008
$t7	15	0
$s0	16	4
$s1	17	4
$s2	18	5
$s3	19	0
$s4	20	0
$s5	21	4
$s6	22	0
$s7	23	4
$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

BINARY SEARCH

- **INTRODUCTION:**

Binary Search is a searching algorithm which is used in a sorted array by repeatedly dividing the search interval in half.

Our program searches for a particular number in an array of integers using binary search.
If the number exists, the result is the corresponding index in the array; if not, the result is -1.

- **PROGRAM EXPLANATION:**

In this program, we have six parts: main, loop, else, found, not_found and exit.

main: Stores the necessary values, i.e., size of the array, the number to be searched (key), base address of array and the length of the array. We also declare lb and ub which is essential to perform the binary search. (NOTE: the boundaries of the array that we are working with at one point is defined by lower-bound and upper-bound).

loop: Checks if the lower-bound (lb) has exceeded upper-bound(ub) or not. If it has, our search is over. If not, it calculates the midpoint of the part of the array we are currently working with and stores the address of it in $t4. If the element at index midpoint is equal to our key, we have found the value and we branch to found. Else if the element is less than key, we update upperbound to be (midpoint-1). Otherwise, we branch to the else label.

else: It changes the lower bound to (mid + 1) and goes back to loop for the next iteration.

found: Stores the index at which the element is found.

not_found: If the number is not there in the array, it stores the result as -1. **exit:**

Exits from the program.

Instructions Used:

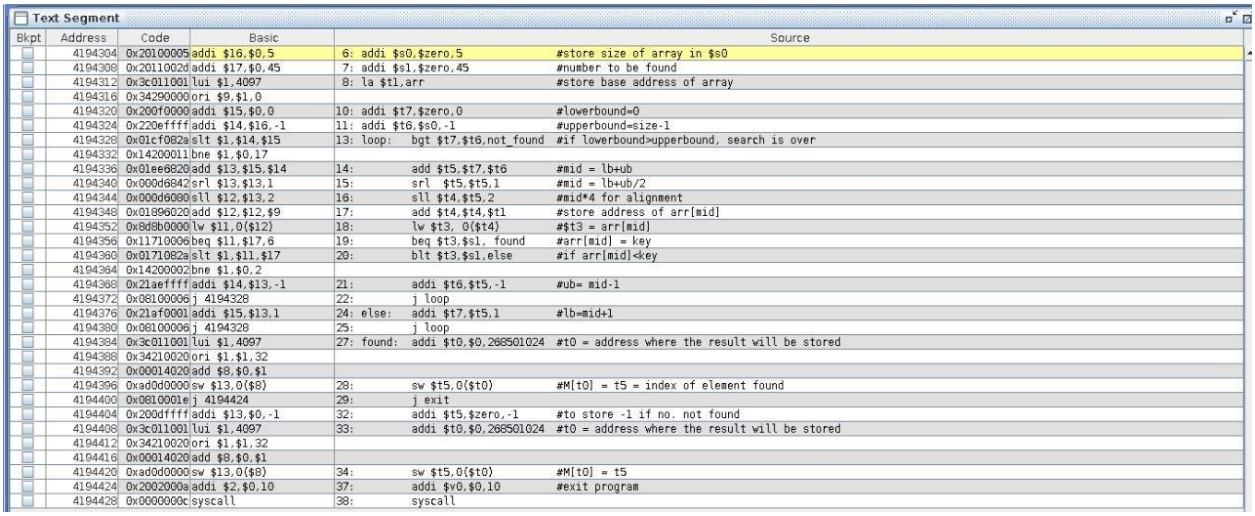
- Load Word (lw) ○ Store Word (sw) ○ Load address (la) ○ Add immediate (addi) ○ Add (add)
- Shift right logical (srl)

- Shift left logical (sll) ○
  Branch on equal (beq) ○
  Branch on less than (blt) ○
  Branch on greater than (bgt)
  ○ Jump (j)

- **ASSEMBLY CODE:**

```
#binary search
.data
        arr: .word 11, 20, 34, 45, 56  #sorted array
.text

addi $s0,$zero,5              #store size of array in $s0
addi $s1,$zero,45             #number to be found
la $t1,arr                    #store base address of array

addi $t7,$zero,0              #lowerbound=0
addi $t6,$s0,-1               #upperbound=size-1

loop:   bgt $t7,$t6,not_found  #if lowerbound>upperbound, search is over
        add $t5,$t7,$t6        #mid = lb+ub
        srl  $t5,$t5,1         #mid = lb+ub/2
        sll $t4,$t5,2          #mid*4 for alignment
        add $t4,$t4,$t1        #store address of arr[mid]
        lw $t3, 0($t4)         #$t3 = arr[mid]
        beq $t3,$s1, found     #arr[mid] = key
        blt $t3,$s1,else       #if arr[mid]<key
        addi $t6,$t5,-1        #ub= mid-1
        j loop

else:   addi $t7,$t5,1         #lb=mid+1
        j loop

found:  addi $t0,$0,268501024  #t0 = address where the result will be stored
        sw $t5,0($t0)          #M[t0] = t5 = index of element found
        j exit

not_found:
        addi $t5,$zero,-1      #to store -1 if no. not found
        addi $t0,$0,268501024  #t0 = address where the result will be stored
        sw $t5,0($t0)          #M[t0] = t5

exit:
        addi $v0,$0,10         #exit program
        syscall
```

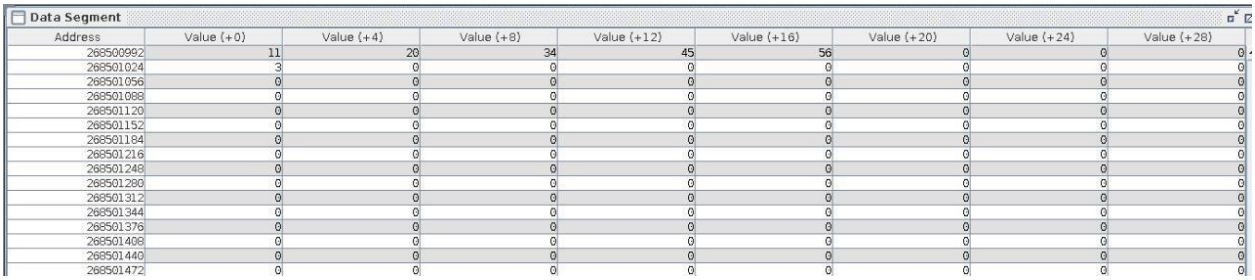
- **TEXT SEGMENT:**



Text Segment

Bkpt	Address	Code	Basic	Source
	4194304	0x20100005	addi $16,$0,5	6: addi $s0,$zero,5 #store size of array in $s0
	4194308	0x2011002d	addi $17,$0,45	7: addi $s1,$zero,45 #number to be found
	4194312	0x3c011001	lui $1,4097	8: la $t1,arr #store base address of array
	4194316	0x34290000	ori $9,$1,0	
	4194320	0x200f0000	addi $15,$0,0	10: addi $t7,$zero,0 #lowerbound=0
	4194324	0x220effff	addi $14,$16,-1	11: addi $t6,$s0,-1 #upperbound=size-1
	4194328	0x01cf082a	slt $1,$14,$15	13: loop: bgt $t7,$t6,not_found #if lowerbound>upperbound, search is over
	4194332	0x14200011	bne $1,$0,17	
	4194336	0x01ee6820	add $13,$15,$14	14: add $t5,$t7,$t6 #mid = lb+ub
	4194340	0x000d6842	srl $13,$13,1	15: srl $t5,$t5,1 #mid = lb+ub/2
	4194344	0x000d6080	sll $12,$13,2	16: sll $t4,$t5,2 #mid*4 for alignment
	4194348	0x01896020	add $12,$12,$9	17: add $t4,$t4,$t1 #store address of arr[mid]
	4194352	0x8d8b0000	lw $11,0($12)	18: lw $t3, 0($t4) #$t3 = arr[mid]
	4194356	0x11710006	beq $11,$17,6	19: beq $t3,$s1, found #arr[mid] = key
	4194360	0x0171082a	slt $1,$11,$17	20: blt $t3,$s1,else #if arr[mid]<key
	4194364	0x14200002	bne $1,$0,2	
	4194368	0x21aeffff	addi $14,$13,-1	21: addi $t6,$t5,-1 #ub= mid-1
	4194372	0x08100006	j 4194328	22: j loop
	4194376	0x21af0001	addi $15,$13,1	24: else: addi $t7,$t5,1 #lb=mid+1
	4194380	0x08100006	j 4194328	25: j loop
	4194384	0x3c011001	lui $1,4097	27: found: addi $t0,$0,268501024 #t0 = address where the result will be stored
	4194388	0x34210020	ori $1,$1,32	
	4194392	0x00014020	add $8,$0,$1	
	4194396	0xad0d0000	sw $13,0($8)	28: sw $t5,0($t0) #M[t0] = t5 = index of element found
	4194400	0x0810001e	j 4194424	29: j exit
	4194404	0x200dffff	addi $13,$0,-1	32: addi $t5,$zero,-1 #to store -1 if no. not found
	4194408	0x3c011001	lui $1,4097	33: addi $t0,$0,268501024 #t0 = address where the result will be stored
	4194412	0x34210020	ori $1,$1,32	
	4194416	0x00014020	add $8,$0,$1	
	4194420	0xad0d0000	sw $13,0($8)	34: sw $t5,0($t0) #M[t0] = t5
	4194424	0x2002000a	addi $2,$0,10	37: addi $v0,$0,10 #exit program
	4194428	0x0000000c	syscall	38: syscall

- **DATA SEGMENT:**



Data Segment

Address	Value (+0)	Value (+4)	Value (+8)	Value (+12)	Value (+16)	Value (+20)	Value (+24)	Value (+28)
268500992	11	20	34	45	56	0	0	0
268501024	3	0	0	0	0	0	0	0
268501056	0	0	0	0	0	0	0	0
268501088	0	0	0	0	0	0	0	0
268501120	0	0	0	0	0	0	0	0
268501152	0	0	0	0	0	0	0	0
268501184	0	0	0	0	0	0	0	0
268501216	0	0	0	0	0	0	0	0
268501248	0	0	0	0	0	0	0	0
268501280	0	0	0	0	0	0	0	0
268501312	0	0	0	0	0	0	0	0
268501344	0	0	0	0	0	0	0	0
268501376	0	0	0	0	0	0	0	0
268501408	0	0	0	0	0	0	0	0
268501440	0	0	0	0	0	0	0	0
268501472	0	0	0	0	0	0	0	0

- **MEMORY:**

Registers | Coproc 1 | Coproc 0

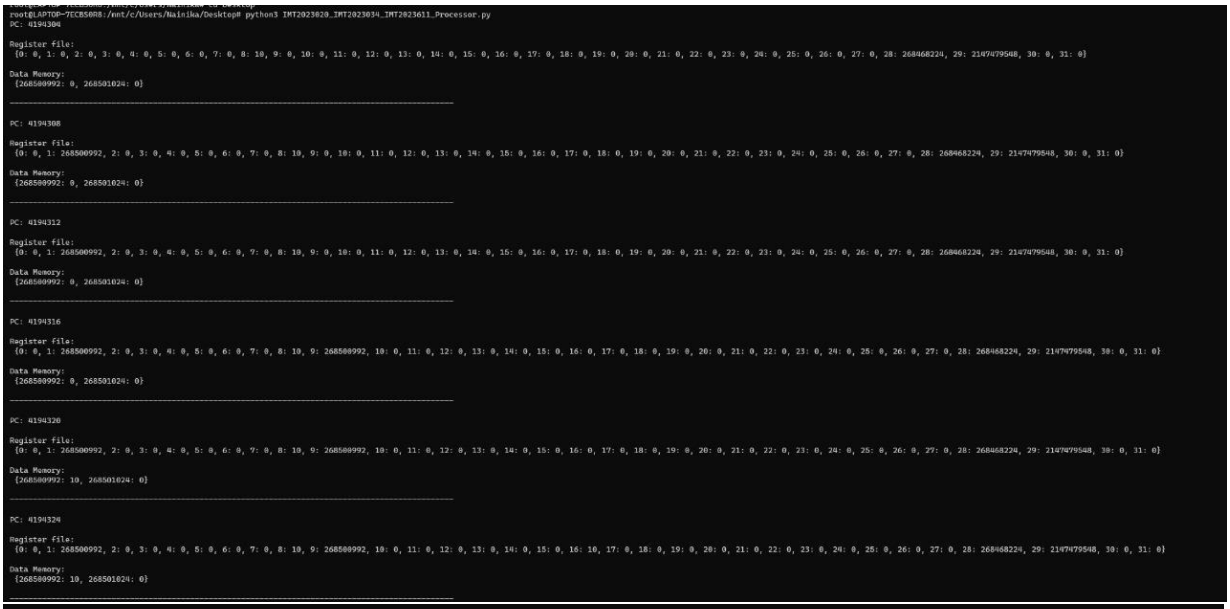
Name	Number	Value
$zero	0	0
$at	1	268501024
$v0	2	10
$v1	3	0
$a0	4	0
$a1	5	0
$a2	6	0
$a3	7	0
$t0	8	268501024
$t1	9	268500992
$t2	10	0
$t3	11	45
$t4	12	268501004
$t5	13	3
$t6	14	4
$t7	15	3
$s0	16	5
$s1	17	45
$s2	18	0
$s3	19	0
$s4	20	0
$s5	21	0
$s6	22	0
$s7	23	0
$t8	24	0
$t9	25	0
$k0	26	0
$k1	27	0
$gp	28	268468224
$sp	29	2147479548
$fp	30	0
$ra	31	0
pc		4194432

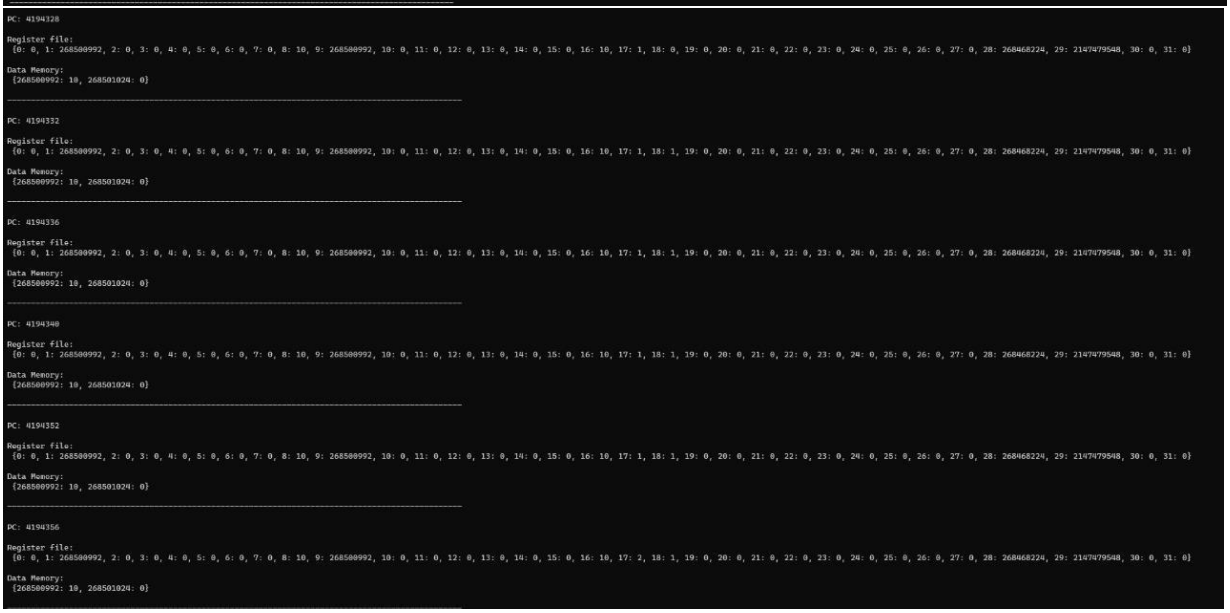
ASSUMPTIONS IN PROCESSOR:

1) We have defined the ALUOp of the bne instruction as 11.
2) We have defined the ALU control input code of srl as ‘101’ and sll as ‘110’.

RESULT (FROM PROCESSOR)

- FACTORIAL



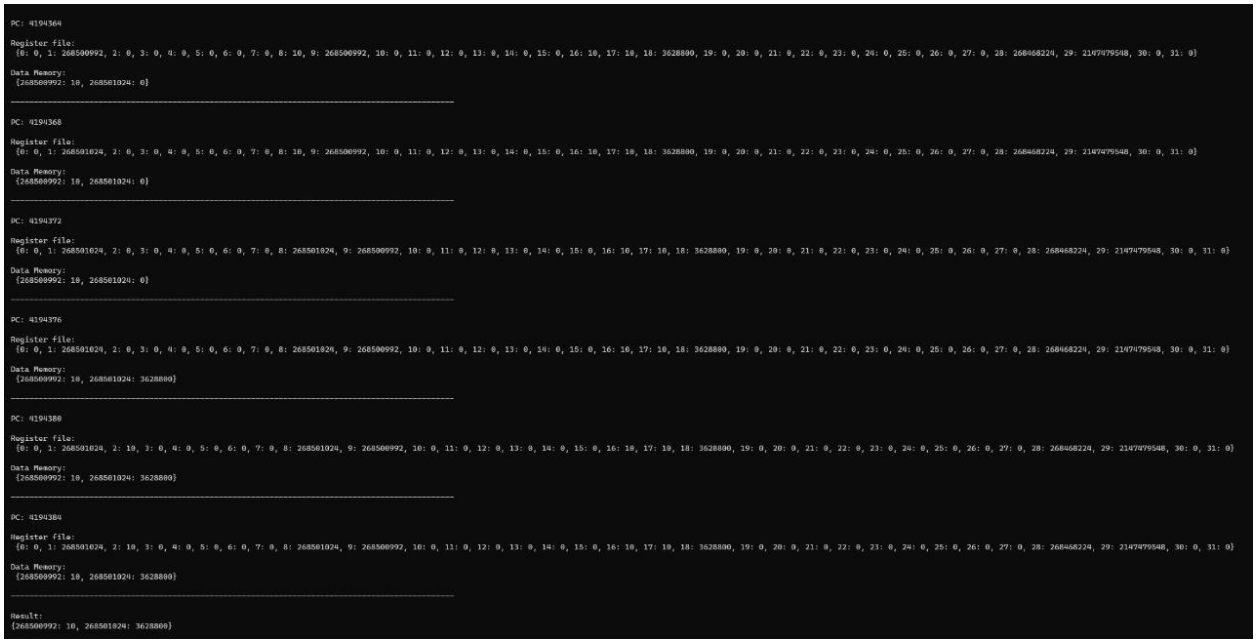


```
PC: 4194360

Register file:
 {0: 0, 1: 268500992, 2: 0, 3: 0, 4: 0, 5: 0, 6: 0, 7: 0, 8: 10, 9: 268500992, 10: 0, 11: 0, 12: 0, 13: 0, 14: 0, 15: 0, 16: 10, 17: 2, 18: 1, 19: 0, 20: 0, 21: 0, 22: 0, 23: 0, 24: 0, 25: 0, 26: 0, 27: 0, 28: 268468224, 29: 2147479548, 30: 0, 31: 0}

Data Memory:
 {268500992: 10, 268501024: 0}

--------------------------------------------------------------------------------

PC: 4194348

Register file:
 {0: 0, 1: 268500992, 2: 0, 3: 0, 4: 0, 5: 0, 6: 0, 7: 0, 8: 10, 9: 268500992, 10: 0, 11: 0, 12: 0, 13: 0, 14: 0, 15: 0, 16: 10, 17: 2, 18: 1, 19: 0, 20: 0, 21: 0, 22: 0, 23: 0, 24: 0, 25: 0, 26: 0, 27: 0, 28: 268468224, 29: 2147479548, 30: 0, 31: 0}

Data Memory:
 {268500992: 10, 268501024: 0}

--------------------------------------------------------------------------------

PC: 4194352

Register file:
 {0: 0, 1: 268500992, 2: 0, 3: 0, 4: 0, 5: 0, 6: 0, 7: 0, 8: 10, 9: 268500992, 10: 0, 11: 0, 12: 0, 13: 0, 14: 0, 15: 0, 16: 10, 17: 2, 18: 2, 19: 0, 20: 0, 21: 0, 22: 0, 23: 0, 24: 0, 25: 0, 26: 0, 27: 0, 28: 268468224, 29: 2147479548, 30: 0, 31: 0}

Data Memory:
 {268500992: 10, 268501024: 0}

--------------------------------------------------------------------------------

PC: 4194356

Register file:
 {0: 0, 1: 268500992, 2: 0, 3: 0, 4: 0, 5: 0, 6: 0, 7: 0, 8: 10, 9: 268500992, 10: 0, 11: 0, 12: 0, 13: 0, 14: 0, 15: 0, 16: 10, 17: 3, 18: 2, 19: 0, 20: 0, 21: 0, 22: 0, 23: 0, 24: 0, 25: 0, 26: 0, 27: 0, 28: 268468224, 29: 2147479548, 30: 0, 31: 0}

Data Memory:
 {268500992: 10, 268501024: 0}

--------------------------------------------------------------------------------

PC: 4194360

Register file:
 {0: 0, 1: 268500992, 2: 0, 3: 0, 4: 0, 5: 0, 6: 0, 7: 0, 8: 10, 9: 268500992, 10: 0, 11: 0, 12: 0, 13: 0, 14: 0, 15: 0, 16: 10, 17: 3, 18: 2, 19: 0, 20: 0, 21: 0, 22: 0, 23: 0, 24: 0, 25: 0, 26: 0, 27: 0, 28: 268468224, 29: 2147479548, 30: 0, 31: 0}

Data Memory:
 {268500992: 10, 268501024: 0}

--------------------------------------------------------------------------------

PC: 4194340

Register file:
 {0: 0, 1: 268500992, 2: 0, 3: 0, 4: 0, 5: 0, 6: 0, 7: 0, 8: 10, 9: 268500992, 10: 0, 11: 0, 12: 0, 13: 0, 14: 0, 15: 0, 16: 10, 17: 3, 18: 2, 19: 0, 20: 0, 21: 0, 22: 0, 23: 0, 24: 0, 25: 0, 26: 0, 27: 0, 28: 268468224, 29: 2147479548, 30: 0, 31: 0}

Data Memory:
 {268500992: 10, 268501024: 0}
```

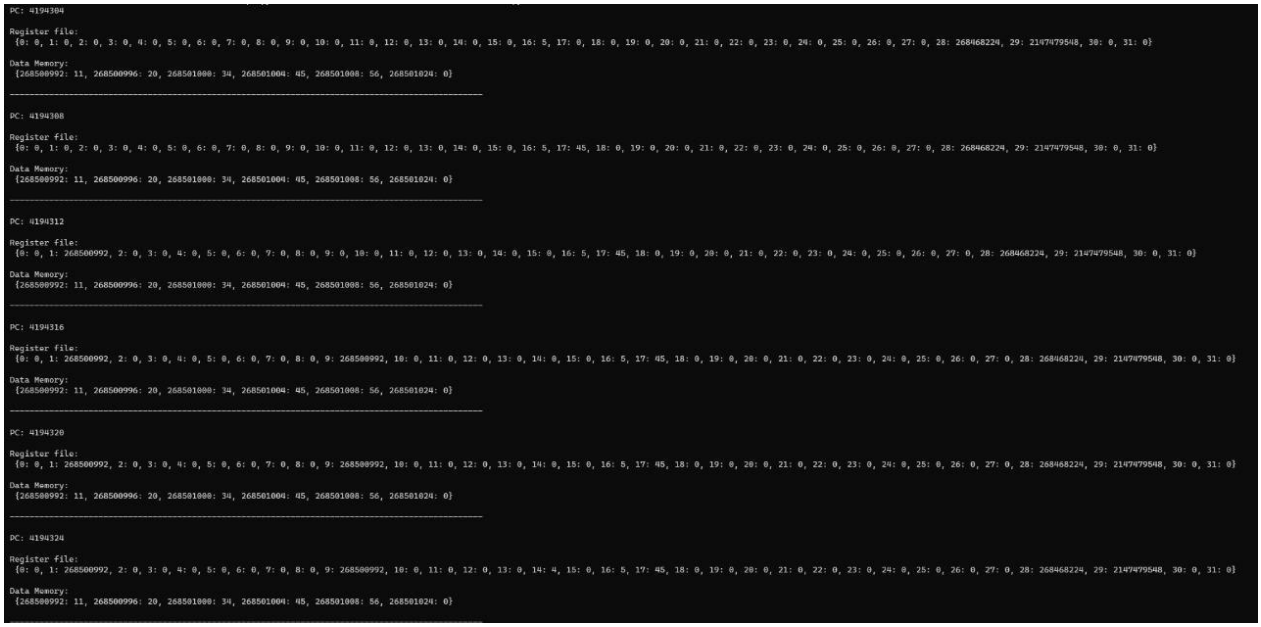
```
PC: 4194352

Register file:
 {0: 0, 1: 268500992, 2: 0, 3: 0, 4: 0, 5: 0, 6: 0, 7: 0, 8: 10, 9: 268500992, 10: 0, 11: 0, 12: 0, 13: 0, 14: 0, 15: 0, 16: 10, 17: 3, 18: 6, 19: 0, 20: 0, 21: 0, 22: 0, 23: 0, 24: 0, 25: 0, 26: 0, 27: 0, 28: 268468224, 29: 2147479548, 30: 0, 31: 0}

Data Memory:
 {268500992: 10, 268501024: 0}

--------------------------------------------------------------------------------

PC: 4194356

Register file:
 {0: 0, 1: 268500992, 2: 0, 3: 0, 4: 0, 5: 0, 6: 0, 7: 0, 8: 10, 9: 268500992, 10: 0, 11: 0, 12: 0, 13: 0, 14: 0, 15: 0, 16: 10, 17: 4, 18: 6, 19: 0, 20: 0, 21: 0, 22: 0, 23: 0, 24: 0, 25: 0, 26: 0, 27: 0, 28: 268468224, 29: 2147479548, 30: 0, 31: 0}

Data Memory:
 {268500992: 10, 268501024: 0}

--------------------------------------------------------------------------------

PC: 4194360

Register file:
 {0: 0, 1: 268500992, 2: 0, 3: 0, 4: 0, 5: 0, 6: 0, 7: 0, 8: 10, 9: 268500992, 10: 0, 11: 0, 12: 0, 13: 0, 14: 0, 15: 0, 16: 10, 17: 4, 18: 6, 19: 0, 20: 0, 21: 0, 22: 0, 23: 0, 24: 0, 25: 0, 26: 0, 27: 0, 28: 268468224, 29: 2147479548, 30: 0, 31: 0}

Data Memory:
 {268500992: 10, 268501024: 0}

--------------------------------------------------------------------------------

PC: 4194340

Register file:
 {0: 0, 1: 268500992, 2: 0, 3: 0, 4: 0, 5: 0, 6: 0, 7: 0, 8: 10, 9: 268500992, 10: 0, 11: 0, 12: 0, 13: 0, 14: 0, 15: 0, 16: 10, 17: 4, 18: 6, 19: 0, 20: 0, 21: 0, 22: 0, 23: 0, 24: 0, 25: 0, 26: 0, 27: 0, 28: 268468224, 29: 2147479548, 30: 0, 31: 0}

Data Memory:
 {268500992: 10, 268501024: 0}

--------------------------------------------------------------------------------

PC: 4194352

Register file:
 {0: 0, 1: 268500992, 2: 0, 3: 0, 4: 0, 5: 0, 6: 0, 7: 0, 8: 10, 9: 268500992, 10: 0, 11: 0, 12: 0, 13: 0, 14: 0, 15: 0, 16: 10, 17: 4, 18: 24, 19: 0, 20: 0, 21: 0, 22: 0, 23: 0, 24: 0, 25: 0, 26: 0, 27: 0, 28: 268468224, 29: 2147479548, 30: 0, 31: 0}

Data Memory:
 {268500992: 10, 268501024: 0}

--------------------------------------------------------------------------------

PC: 4194356

Register file:
 {0: 0, 1: 268500992, 2: 0, 3: 0, 4: 0, 5: 0, 6: 0, 7: 0, 8: 10, 9: 268500992, 10: 0, 11: 0, 12: 0, 13: 0, 14: 0, 15: 0, 16: 10, 17: 5, 18: 24, 19: 0, 20: 0, 21: 0, 22: 0, 23: 0, 24: 0, 25: 0, 26: 0, 27: 0, 28: 268468224, 29: 2147479548, 30: 0, 31: 0}

Data Memory:
 {268500992: 10, 268501024: 0}

--------------------------------------------------------------------------------
```

```
PC: 4194360

Register file:
 {0: 0, 1: 268500992, 2: 0, 3: 0, 4: 0, 5: 0, 6: 0, 7: 0, 8: 10, 9: 268500992, 10: 0, 11: 0, 12: 0, 13: 0, 14: 0, 15: 0, 16: 10, 17: 5, 18: 24, 19: 0, 20: 0, 21: 0, 22: 0, 23: 0, 24: 0, 25: 0, 26: 0, 27: 0, 28: 268468224, 29: 2147479548, 30: 0, 31: 0}

Data Memory:
 {268500992: 10, 268501024: 0}

--------------------------------------------------------------------------------

PC: 4194340

Register file:
 {0: 0, 1: 268500992, 2: 0, 3: 0, 4: 0, 5: 0, 6: 0, 7: 0, 8: 10, 9: 268500992, 10: 0, 11: 0, 12: 0, 13: 0, 14: 0, 15: 0, 16: 10, 17: 5, 18: 24, 19: 0, 20: 0, 21: 0, 22: 0, 23: 0, 24: 0, 25: 0, 26: 0, 27: 0, 28: 268468224, 29: 2147479548, 30: 0, 31: 0}

Data Memory:
 {268500992: 10, 268501024: 0}

--------------------------------------------------------------------------------

PC: 4194352

Register file:
 {0: 0, 1: 268500992, 2: 0, 3: 0, 4: 0, 5: 0, 6: 0, 7: 0, 8: 10, 9: 268500992, 10: 0, 11: 0, 12: 0, 13: 0, 14: 0, 15: 0, 16: 10, 17: 5, 18: 120, 19: 0, 20: 0, 21: 0, 22: 0, 23: 0, 24: 0, 25: 0, 26: 0, 27: 0, 28: 268468224, 29: 2147479548, 30: 0, 31: 0

Data Memory:
 {268500992: 10, 268501024: 0}

--------------------------------------------------------------------------------

PC: 4194356

Register file:
 {0: 0, 1: 268500992, 2: 0, 3: 0, 4: 0, 5: 0, 6: 0, 7: 0, 8: 10, 9: 268500992, 10: 0, 11: 0, 12: 0, 13: 0, 14: 0, 15: 0, 16: 10, 17: 6, 18: 120, 19: 0, 20: 0, 21: 0, 22: 0, 23: 0, 24: 0, 25: 0, 26: 0, 27: 0, 28: 268468224, 29: 2147479548, 30: 0, 31: 0

Data Memory:
 {268500992: 10, 268501024: 0}

--------------------------------------------------------------------------------

PC: 4194360

Register file:
 {0: 0, 1: 268500992, 2: 0, 3: 0, 4: 0, 5: 0, 6: 0, 7: 0, 8: 10, 9: 268500992, 10: 0, 11: 0, 12: 0, 13: 0, 14: 0, 15: 0, 16: 10, 17: 6, 18: 120, 19: 0, 20: 0, 21: 0, 22: 0, 23: 0, 24: 0, 25: 0, 26: 0, 27: 0, 28: 268468224, 29: 2147479548, 30: 0, 31: 0

Data Memory:
 {268500992: 10, 268501024: 0}

--------------------------------------------------------------------------------

PC: 4194340

Register file:
 {0: 0, 1: 268500992, 2: 0, 3: 0, 4: 0, 5: 0, 6: 0, 7: 0, 8: 10, 9: 268500992, 10: 0, 11: 0, 12: 0, 13: 0, 14: 0, 15: 0, 16: 10, 17: 6, 18: 120, 19: 0, 20: 0, 21: 0, 22: 0, 23: 0, 24: 0, 25: 0, 26: 0, 27: 0, 28: 268468224, 29: 2147479548, 30: 0, 31: 0

Data Memory:
 {268500992: 10, 268501024: 0}
```

```
PC: 4194352

Register file:
 {0: 0, 1: 268500992, 2: 0, 3: 0, 4: 0, 5: 0, 6: 0, 7: 0, 8: 10, 9: 268500992, 10: 0, 11: 0, 12: 0, 13: 0, 14: 0, 15: 0, 16: 10, 17: 6, 18: 720, 19: 0, 20: 0, 21: 0, 22: 0, 23: 0, 24: 0, 25: 0, 26: 0, 27: 0, 28: 268468224, 29: 2147479548, 30: 0, 31: 0}

Data Memory:
 {268500992: 10, 268501024: 0}

--------------------------------------------------------------------------------

PC: 4194356

Register file:
 {0: 0, 1: 268500992, 2: 0, 3: 0, 4: 0, 5: 0, 6: 0, 7: 0, 8: 10, 9: 268500992, 10: 0, 11: 0, 12: 0, 13: 0, 14: 0, 15: 0, 16: 10, 17: 7, 18: 720, 19: 0, 20: 0, 21: 0, 22: 0, 23: 0, 24: 0, 25: 0, 26: 0, 27: 0, 28: 268468224, 29: 2147479548, 30: 0, 31: 0}

Data Memory:
 {268500992: 10, 268501024: 0}

--------------------------------------------------------------------------------

PC: 4194360

Register file:
 {0: 0, 1: 268500992, 2: 0, 3: 0, 4: 0, 5: 0, 6: 0, 7: 0, 8: 10, 9: 268500992, 10: 0, 11: 0, 12: 0, 13: 0, 14: 0, 15: 0, 16: 10, 17: 7, 18: 720, 19: 0, 20: 0, 21: 0, 22: 0, 23: 0, 24: 0, 25: 0, 26: 0, 27: 0, 28: 268468224, 29: 2147479548, 30: 0, 31: 0}

Data Memory:
 {268500992: 10, 268501024: 0}

--------------------------------------------------------------------------------

PC: 4194340

Register file:
 {0: 0, 1: 268500992, 2: 0, 3: 0, 4: 0, 5: 0, 6: 0, 7: 0, 8: 10, 9: 268500992, 10: 0, 11: 0, 12: 0, 13: 0, 14: 0, 15: 0, 16: 10, 17: 7, 18: 720, 19: 0, 20: 0, 21: 0, 22: 0, 23: 0, 24: 0, 25: 0, 26: 0, 27: 0, 28: 268468224, 29: 2147479548, 30: 0, 31: 0}

Data Memory:
 {268500992: 10, 268501024: 0}

--------------------------------------------------------------------------------

PC: 4194352

Register file:
 {0: 0, 1: 268500992, 2: 0, 3: 0, 4: 0, 5: 0, 6: 0, 7: 0, 8: 10, 9: 268500992, 10: 0, 11: 0, 12: 0, 13: 0, 14: 0, 15: 0, 16: 10, 17: 7, 18: 5040, 19: 0, 20: 0, 21: 0, 22: 0, 23: 0, 24: 0, 25: 0, 26: 0, 27: 0, 28: 268468224, 29: 2147479548, 30: 0, 31: 0}

Data Memory:
 {268500992: 10, 268501024: 0}

--------------------------------------------------------------------------------

PC: 4194356

Register file:
 {0: 0, 1: 268500992, 2: 0, 3: 0, 4: 0, 5: 0, 6: 0, 7: 0, 8: 10, 9: 268500992, 10: 0, 11: 0, 12: 0, 13: 0, 14: 0, 15: 0, 16: 10, 17: 8, 18: 5040, 19: 0, 20: 0, 21: 0, 22: 0, 23: 0, 24: 0, 25: 0, 26: 0, 27: 0, 28: 268468224, 29: 2147479548, 30: 0, 31: 0}

Data Memory:
 {268500992: 10, 268501024: 0}

--------------------------------------------------------------------------------

PC: 4194360

Register file:
 {0: 0, 1: 268500992, 2: 0, 3: 0, 4: 0, 5: 0, 6: 0, 7: 0, 8: 10, 9: 268500992, 10: 0, 11: 0, 12: 0, 13: 0, 14: 0, 15: 0, 16: 10, 17: 8, 18: 5040, 19: 0, 20: 0, 21: 0, 22: 0, 23: 0, 24: 0, 25: 0, 26: 0, 27: 0, 28: 268468224, 29: 2147479548, 30: 0, 31: 0}

Data Memory:
 {268500992: 10, 268501024: 0}

--------------------------------------------------------------------------------

PC: 4194340

Register file:
 {0: 0, 1: 268500992, 2: 0, 3: 0, 4: 0, 5: 0, 6: 0, 7: 0, 8: 10, 9: 268500992, 10: 0, 11: 0, 12: 0, 13: 0, 14: 0, 15: 0, 16: 10, 17: 8, 18: 5040, 19: 0, 20: 0, 21: 0, 22: 0, 23: 0, 24: 0, 25: 0, 26: 0, 27: 0, 28: 268468224, 29: 2147479548, 30: 0, 31: 0}

Data Memory:
 {268500992: 10, 268501024: 0}

--------------------------------------------------------------------------------

PC: 4194352

Register file:
 {0: 0, 1: 268500992, 2: 0, 3: 0, 4: 0, 5: 0, 6: 0, 7: 0, 8: 10, 9: 268500992, 10: 0, 11: 0, 12: 0, 13: 0, 14: 0, 15: 0, 16: 10, 17: 8, 18: 40320, 19: 0, 20: 0, 21: 0, 22: 0, 23: 0, 24: 0, 25: 0, 26: 0, 27: 0, 28: 268468224, 29: 2147479548, 30: 0, 31: 0}

Data Memory:
 {268500992: 10, 268501024: 0}

--------------------------------------------------------------------------------

PC: 4194356

Register file:
 {0: 0, 1: 268500992, 2: 0, 3: 0, 4: 0, 5: 0, 6: 0, 7: 0, 8: 10, 9: 268500992, 10: 0, 11: 0, 12: 0, 13: 0, 14: 0, 15: 0, 16: 10, 17: 9, 18: 40320, 19: 0, 20: 0, 21: 0, 22: 0, 23: 0, 24: 0, 25: 0, 26: 0, 27: 0, 28: 268468224, 29: 2147479548, 30: 0, 31: 0}

Data Memory:
 {268500992: 10, 268501024: 0}

--------------------------------------------------------------------------------

PC: 4194360

Register file:
 {0: 0, 1: 268500992, 2: 0, 3: 0, 4: 0, 5: 0, 6: 0, 7: 0, 8: 10, 9: 268500992, 10: 0, 11: 0, 12: 0, 13: 0, 14: 0, 15: 0, 16: 10, 17: 9, 18: 40320, 19: 0, 20: 0, 21: 0, 22: 0, 23: 0, 24: 0, 25: 0, 26: 0, 27: 0, 28: 268468224, 29: 2147479548, 30: 0, 31: 0}

Data Memory:
 {268500992: 10, 268501024: 0}

--------------------------------------------------------------------------------

PC: 4194340

Register file:
 {0: 0, 1: 268500992, 2: 0, 3: 0, 4: 0, 5: 0, 6: 0, 7: 0, 8: 10, 9: 268500992, 10: 0, 11: 0, 12: 0, 13: 0, 14: 0, 15: 0, 16: 10, 17: 9, 18: 40320, 19: 0, 20: 0, 21: 0, 22: 0, 23: 0, 24: 0, 25: 0, 26: 0, 27: 0, 28: 268468224, 29: 2147479548, 30: 0, 31: 0}

Data Memory:
 {268500992: 10, 268501024: 0}

--------------------------------------------------------------------------------

PC: 4194352

Register file:
 {0: 0, 1: 268500992, 2: 0, 3: 0, 4: 0, 5: 0, 6: 0, 7: 0, 8: 10, 9: 268500992, 10: 0, 11: 0, 12: 0, 13: 0, 14: 0, 15: 0, 16: 10, 17: 9, 18: 362880, 19: 0, 20: 0, 21: 0, 22: 0, 23: 0, 24: 0, 25: 0, 26: 0, 27: 0, 28: 268468224, 29: 2147479548, 30: 0, 31: 0}

Data Memory:
 {268500992: 10, 268501024: 0}

--------------------------------------------------------------------------------

PC: 4194356

Register file:
 {0: 0, 1: 268500992, 2: 0, 3: 0, 4: 0, 5: 0, 6: 0, 7: 0, 8: 10, 9: 268500992, 10: 0, 11: 0, 12: 0, 13: 0, 14: 0, 15: 0, 16: 10, 17: 10, 18: 362880, 19: 0, 20: 0, 21: 0, 22: 0, 23: 0, 24: 0, 25: 0, 26: 0, 27: 0, 28: 268468224, 29: 2147479548, 30: 0, 31: 0}

Data Memory:
 {268500992: 10, 268501024: 0}

--------------------------------------------------------------------------------

PC: 4194360

Register file:
 {0: 0, 1: 268500992, 2: 0, 3: 0, 4: 0, 5: 0, 6: 0, 7: 0, 8: 10, 9: 268500992, 10: 0, 11: 0, 12: 0, 13: 0, 14: 0, 15: 0, 16: 10, 17: 10, 18: 362880, 19: 0, 20: 0, 21: 0, 22: 0, 23: 0, 24: 0, 25: 0, 26: 0, 27: 0, 28: 268468224, 29: 2147479548, 30: 0, 31: 0}

Data Memory:
 {268500992: 10, 268501024: 0}

--------------------------------------------------------------------------------

PC: 4194340

Register file:
 {0: 0, 1: 268500992, 2: 0, 3: 0, 4: 0, 5: 0, 6: 0, 7: 0, 8: 10, 9: 268500992, 10: 0, 11: 0, 12: 0, 13: 0, 14: 0, 15: 0, 16: 10, 17: 10, 18: 362880, 19: 0, 20: 0, 21: 0, 22: 0, 23: 0, 24: 0, 25: 0, 26: 0, 27: 0, 28: 268468224, 29: 2147479548, 30: 0, 31: 0}

Data Memory:
 {268500992: 10, 268501024: 0}

--------------------------------------------------------------------------------

PC: 4194344

Register file:
 {0: 0, 1: 268500992, 2: 0, 3: 0, 4: 0, 5: 0, 6: 0, 7: 0, 8: 10, 9: 268500992, 10: 0, 11: 0, 12: 0, 13: 0, 14: 0, 15: 0, 16: 10, 17: 10, 18: 3628800, 19: 0, 20: 0, 21: 0, 22: 0, 23: 0, 24: 0, 25: 0, 26: 0, 27: 0, 28: 268468224, 29: 2147479548, 30: 0, 31: 0}

Data Memory:
 {268500992: 10, 268501024: 0}

--------------------------------------------------------------------------------

PC: 4194348

Register file:
 {0: 0, 1: 268500992, 2: 0, 3: 0, 4: 0, 5: 0, 6: 0, 7: 0, 8: 10, 9: 268500992, 10: 0, 11: 0, 12: 0, 13: 0, 14: 0, 15: 0, 16: 10, 17: 10, 18: 3628800, 19: 0, 20: 0, 21: 0, 22: 0, 23: 0, 24: 0, 25: 0, 26: 0, 27: 0, 28: 268468224, 29: 2147479548, 30: 0, 31: 0}

Data Memory:
 {268500992: 10, 268501024: 0}

--------------------------------------------------------------------------------
```



- BINARY SEARCH



PC: 4194328

Register file:
{0: 0, 1: 0, 2: 0, 3: 0, 4: 0, 5: 0, 6: 0, 7: 0, 8: 0, 9: 268500992, 10: 0, 11: 0, 12: 0, 13: 0, 14: 4, 15: 0, 16: 5, 17: 45, 18: 0, 19: 0, 20: 0, 21: 0, 22: 0, 23: 0, 24: 0, 25: 0, 26: 0, 27: 0, 28: 268468224, 29: 2147479548, 30: 0, 31: 0}

Data Memory:
{268500992: 11, 268500996: 20, 268501000: 34, 268501004: 45, 268501008: 56, 268501024: 0}

PC: 4194332

Register file:
{0: 0, 1: 0, 2: 0, 3: 0, 4: 0, 5: 0, 6: 0, 7: 0, 8: 0, 9: 268500992, 10: 0, 11: 0, 12: 0, 13: 0, 14: 4, 15: 0, 16: 5, 17: 45, 18: 0, 19: 0, 20: 0, 21: 0, 22: 0, 23: 0, 24: 0, 25: 0, 26: 0, 27: 0, 28: 268468224, 29: 2147479548, 30: 0, 31: 0}

Data Memory:
{268500992: 11, 268500996: 20, 268501000: 34, 268501004: 45, 268501008: 56, 268501024: 0}

PC: 4194336

Register file:
{0: 0, 1: 0, 2: 0, 3: 0, 4: 0, 5: 0, 6: 0, 7: 0, 8: 0, 9: 268500992, 10: 0, 11: 0, 12: 0, 13: 4, 14: 4, 15: 0, 16: 5, 17: 45, 18: 0, 19: 0, 20: 0, 21: 0, 22: 0, 23: 0, 24: 0, 25: 0, 26: 0, 27: 0, 28: 268468224, 29: 2147479548, 30: 0, 31: 0}

Data Memory:
{268500992: 11, 268500996: 20, 268501000: 34, 268501004: 45, 268501008: 56, 268501024: 0}

PC: 4194340

Register file:
{0: 0, 1: 0, 2: 0, 3: 0, 4: 0, 5: 0, 6: 0, 7: 0, 8: 0, 9: 268500992, 10: 0, 11: 0, 12: 0, 13: 2, 14: 4, 15: 0, 16: 5, 17: 45, 18: 0, 19: 0, 20: 0, 21: 0, 22: 0, 23: 0, 24: 0, 25: 0, 26: 0, 27: 0, 28: 268468224, 29: 2147479548, 30: 0, 31: 0}

Data Memory:
{268500992: 11, 268500996: 20, 268501000: 34, 268501004: 45, 268501008: 56, 268501024: 0}

PC: 4194344

Register file:
{0: 0, 1: 0, 2: 0, 3: 0, 4: 0, 5: 0, 6: 0, 7: 0, 8: 0, 9: 268500992, 10: 0, 11: 0, 12: 0, 13: 2, 14: 4, 15: 0, 16: 5, 17: 45, 18: 0, 19: 0, 20: 0, 21: 0, 22: 0, 23: 0, 24: 0, 25: 0, 26: 0, 27: 0, 28: 268468224, 29: 2147479548, 30: 0, 31: 0}

Data Memory:
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PC: 4194348

Register file:
{0: 0, 1: 0, 2: 0, 3: 0, 4: 0, 5: 0, 6: 0, 7: 0, 8: 0, 9: 268500992, 10: 0, 11: 0, 12: 0, 13: 2, 14: 4, 15: 0, 16: 5, 17: 45, 18: 0, 19: 0, 20: 0, 21: 0, 22: 0, 23: 0, 24: 0, 25: 0, 26: 0, 27: 0, 28: 268468224, 29: 2147479548, 30: 0, 31: 0}

Data Memory:
{268500992: 11, 268500996: 20, 268501000: 34, 268501004: 45, 268501008: 56, 268501024: 0}

PC: 4194352

Register file:
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Data Memory:
{268500992: 11, 268500996: 20, 268501000: 34, 268501004: 45, 268501008: 56, 268501024: 0}

PC: 4194356

Register file:
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Data Memory:
{268500992: 11, 268500996: 20, 268501000: 34, 268501004: 45, 268501008: 56, 268501024: 0}

PC: 4194360

Register file:
{0: 0, 1: 1, 2: 0, 3: 0, 4: 0, 5: 0, 6: 0, 7: 0, 8: 0, 9: 268500992, 10: 0, 11: 34, 12: 268501000, 13: 2, 14: 4, 15: 0, 16: 5, 17: 45, 18: 0, 19: 0, 20: 0, 21: 0, 22: 0, 23: 0, 24: 0, 25: 0, 26: 0, 27: 0, 28: 268468224, 29: 2147479548, 30: 0, 31: 0}

Data Memory:
{268500992: 11, 268500996: 20, 268501000: 34, 268501004: 45, 268501008: 56, 268501024: 0}

PC: 4194364

Register file:
{0: 0, 1: 1, 2: 0, 3: 0, 4: 0, 5: 0, 6: 0, 7: 0, 8: 0, 9: 268500992, 10: 0, 11: 34, 12: 268501000, 13: 2, 14: 4, 15: 0, 16: 5, 17: 45, 18: 0, 19: 0, 20: 0, 21: 0, 22: 0, 23: 0, 24: 0, 25: 0, 26: 0, 27: 0, 28: 268468224, 29: 2147479548, 30: 0, 31: 0}

Data Memory:
{268500992: 11, 268500996: 20, 268501000: 34, 268501004: 45, 268501008: 56, 268501024: 0}

PC: 4194376

Register file:
{0: 0, 1: 1, 2: 0, 3: 0, 4: 0, 5: 0, 6: 0, 7: 0, 8: 0, 9: 268500992, 10: 0, 11: 34, 12: 268501000, 13: 2, 14: 4, 15: 3, 16: 5, 17: 45, 18: 0, 19: 0, 20: 0, 21: 0, 22: 0, 23: 0, 24: 0, 25: 0, 26: 0, 27: 0, 28: 268468224, 29: 2147479548, 30: 0, 31: 0}

Data Memory:
{268500992: 11, 268500996: 20, 268501000: 34, 268501004: 45, 268501008: 56, 268501024: 0}

PC: 4194380

Register file:
{0: 0, 1: 1, 2: 0, 3: 0, 4: 0, 5: 0, 6: 0, 7: 0, 8: 0, 9: 268500992, 10: 0, 11: 34, 12: 268501000, 13: 2, 14: 4, 15: 3, 16: 5, 17: 45, 18: 0, 19: 0, 20: 0, 21: 0, 22: 0, 23: 0, 24: 0, 25: 0, 26: 0, 27: 0, 28: 268468224, 29: 2147479548, 30: 0, 31: 0}

Data Memory:
{268500992: 11, 268500996: 20, 268501000: 34, 268501004: 45, 268501008: 56, 268501024: 0}

PC: 4194328

Register file:
{0: 0, 1: 0, 2: 0, 3: 0, 4: 0, 5: 0, 6: 0, 7: 0, 8: 0, 9: 268500992, 10: 0, 11: 34, 12: 268501000, 13: 2, 14: 4, 15: 3, 16: 5, 17: 45, 18: 0, 19: 0, 20: 0, 21: 0, 22: 0, 23: 0, 24: 0, 25: 0, 26: 0, 27: 0, 28: 268468224, 29: 2147479548, 30: 0, 31: 0}

Data Memory:
{268500992: 11, 268500996: 20, 268501000: 34, 268501004: 45, 268501008: 56, 268501024: 0}

PC: 4194332

Register file:
{0: 0, 1: 0, 2: 0, 3: 0, 4: 0, 5: 0, 6: 0, 7: 0, 8: 0, 9: 268500992, 10: 0, 11: 34, 12: 268501000, 13: 2, 14: 4, 15: 3, 16: 5, 17: 45, 18: 0, 19: 0, 20: 0, 21: 0, 22: 0, 23: 0, 24: 0, 25: 0, 26: 0, 27: 0, 28: 268468224, 29: 2147479548, 30: 0, 31: 0}

Data Memory:
{268500992: 11, 268500996: 20, 268501000: 34, 268501004: 45, 268501008: 56, 268501024: 0}

PC: 4194336

Register file:
{0: 0, 1: 0, 2: 0, 3: 0, 4: 0, 5: 0, 6: 0, 7: 0, 8: 0, 9: 268500992, 10: 0, 11: 34, 12: 268501000, 13: 7, 14: 4, 15: 3, 16: 5, 17: 45, 18: 0, 19: 0, 20: 0, 21: 0, 22: 0, 23: 0, 24: 0, 25: 0, 26: 0, 27: 0, 28: 268468224, 29: 2147479548, 30: 0, 31: 0}

Data Memory:
{268500992: 11, 268500996: 20, 268501000: 34, 268501004: 45, 268501008: 56, 268501024: 0}

PC: 4194340

Register file:
{0: 0, 1: 0, 2: 0, 3: 0, 4: 0, 5: 0, 6: 0, 7: 0, 8: 0, 9: 268500992, 10: 0, 11: 34, 12: 268501000, 13: 3, 14: 4, 15: 3, 16: 5, 17: 45, 18: 0, 19: 0, 20: 0, 21: 0, 22: 0, 23: 0, 24: 0, 25: 0, 26: 0, 27: 0, 28: 268468224, 29: 2147479548, 30: 0, 31: 0}

Data Memory:
{268500992: 11, 268500996: 20, 268501000: 34, 268501004: 45, 268501008: 56, 268501024: 0}

PC: 4194344

Register file:
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Data Memory:
{268500992: 11, 268500996: 20, 268501000: 34, 268501004: 45, 268501008: 56, 268501024: 0}

PC: 4194348

Register file:
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Data Memory:
{268500992: 11, 268500996: 20, 268501000: 34, 268501004: 45, 268501008: 56, 268501024: 0}

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PC: 4194352

Register file:
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Data Memory:
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PC: 4194356

Register file:
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Data Memory:
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--------------------------------------------------------------------------------

PC: 4194384

Register file:
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Data Memory:
 {268500992: 11, 268500996: 20, 268501000: 34, 268501004: 45, 268501008: 56, 268501024: 0}

--------------------------------------------------------------------------------

PC: 4194388

Register file:
 {0: 0, 1: 268501024, 2: 0, 3: 0, 4: 0, 5: 0, 6: 0, 7: 0, 8: 0, 9: 268500992, 10: 0, 11: 45, 12: 268501004, 13: 3, 14: 4, 15: 3, 16: 5, 17: 45, 18: 0, 19: 0, 20: 0, 21: 0, 22: 0, 23: 0, 24: 0, 25: 0, 26: 0, 27: 0, 28: 268468224, 29: 2147479548, 30: 0, 31: 0}

Data Memory:
 {268500992: 11, 268500996: 20, 268501000: 34, 268501004: 45, 268501008: 56, 268501024: 0}

--------------------------------------------------------------------------------

PC: 4194392

Register file:
 {0: 0, 1: 268501024, 2: 0, 3: 0, 4: 0, 5: 0, 6: 0, 7: 0, 8: 268501024, 9: 268500992, 10: 0, 11: 45, 12: 268501004, 13: 3, 14: 4, 15: 3, 16: 5, 17: 45, 18: 0, 19: 0, 20: 0, 21: 0, 22: 0, 23: 0, 24: 0, 25: 0, 26: 0, 27: 0, 28: 268468224, 29: 2147479548, 30: 0, 31: 0}

Data Memory:
 {268500992: 11, 268500996: 20, 268501000: 34, 268501004: 45, 268501008: 56, 268501024: 0}

--------------------------------------------------------------------------------

PC: 4194396

Register file:
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Data Memory:
 {268500992: 11, 268500996: 20, 268501000: 34, 268501004: 45, 268501008: 56, 268501024: 3}

--------------------------------------------------------------------------------

PC: 4194400

Register file:
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Data Memory:
 {268500992: 11, 268500996: 20, 268501000: 34, 268501004: 45, 268501008: 56, 268501024: 3}

--------------------------------------------------------------------------------

PC: 4194424

Register file:
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Data Memory:
 {268500992: 11, 268500996: 20, 268501000: 34, 268501004: 45, 268501008: 56, 268501024: 3}

--------------------------------------------------------------------------------

PC: 4194428

Register file:
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Data Memory:
 {268500992: 11, 268500996: 20, 268501000: 34, 268501004: 45, 268501008: 56, 268501024: 3}

--------------------------------------------------------------------------------

Result:
3
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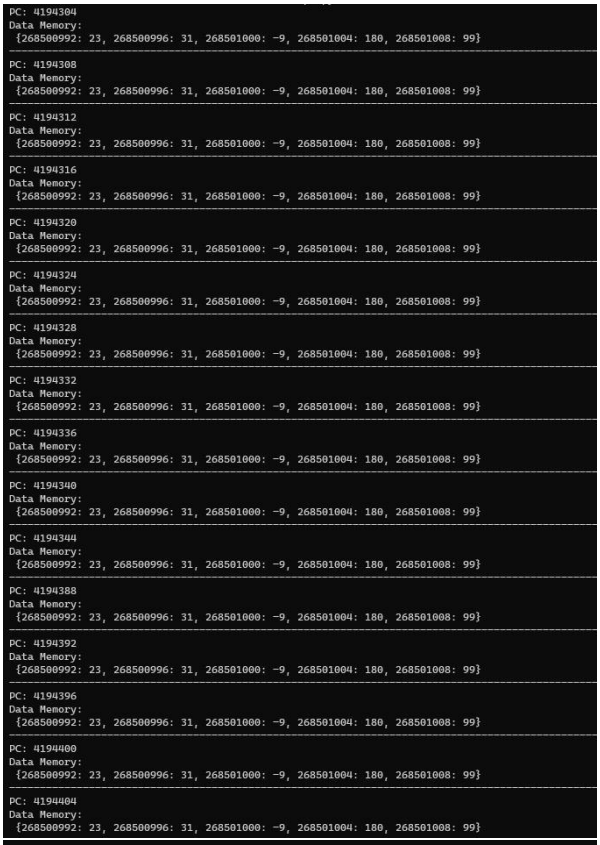
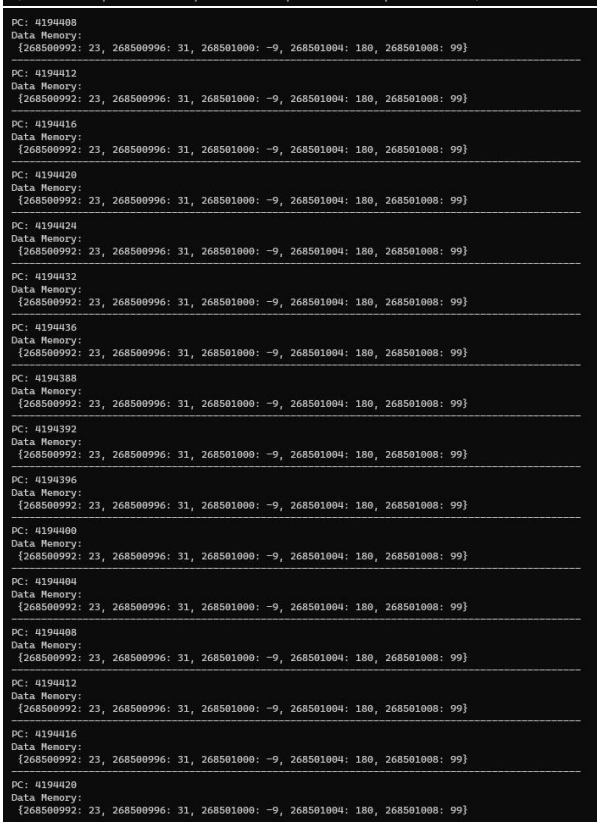
- SELECTION SORT





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Data Memory:
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PC: 4194428
Data Memory:
 {268500992: 23, 268500996: 31, 268501000: -9, 268501004: 180, 268501008: 99}
--------------------------------------------------------------------------------
PC: 4194432
Data Memory:
 {268500992: 23, 268500996: 31, 268501000: -9, 268501004: 180, 268501008: 99}
--------------------------------------------------------------------------------
PC: 4194436
Data Memory:
 {268500992: 23, 268500996: 31, 268501000: -9, 268501004: 180, 268501008: 99}
--------------------------------------------------------------------------------
PC: 4194388
Data Memory:
 {268500992: 23, 268500996: 31, 268501000: -9, 268501004: 180, 268501008: 99}
--------------------------------------------------------------------------------
PC: 4194392
Data Memory:
 {268500992: 23, 268500996: 31, 268501000: -9, 268501004: 180, 268501008: 99}
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PC: 4194396
Data Memory:
 {268500992: 23, 268500996: 31, 268501000: -9, 268501004: 180, 268501008: 99}
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Data Memory:
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PC: 4194404
Data Memory:
 {268500992: 23, 268500996: 31, 268501000: -9, 268501004: 180, 268501008: 99}
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PC: 4194408
Data Memory:
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Data Memory:
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Data Memory:
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Data Memory:
 {268500992: 23, 268500996: 31, 268501000: -9, 268501004: 180, 268501008: 99}
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Data Memory:
 {268500992: 23, 268500996: 31, 268501000: -9, 268501004: 180, 268501008: 99}
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Data Memory:
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Data Memory:
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Data Memory:
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Data Memory:
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Data Memory:
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Data Memory:
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Data Memory:
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PC: 4194328
Data Memory:
 {268500992: -9, 268500996: 31, 268501000: 23, 268501004: 180, 268501008: 99}
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PC: 4194332
Data Memory:
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Data Memory:
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PC: 4194340
Data Memory:
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PC: 4194344
Data Memory:
 {268500992: -9, 268500996: 31, 268501000: 23, 268501004: 180, 268501008: 99}
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PC: 4194388
Data Memory:
 {268500992: -9, 268500996: 31, 268501000: 23, 268501004: 180, 268501008: 99}
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PC: 4194392
Data Memory:
 {268500992: -9, 268500996: 31, 268501000: 23, 268501004: 180, 268501008: 99}
--------------------------------------------------------------------------------
PC: 4194396
Data Memory:
 {268500992: -9, 268500996: 31, 268501000: 23, 268501004: 180, 268501008: 99}
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PC: 4194400
Data Memory:
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PC: 4194404
Data Memory:
 {268500992: -9, 268500996: 31, 268501000: 23, 268501004: 180, 268501008: 99}
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PC: 4194408
Data Memory:
 {268500992: -9, 268500996: 31, 268501000: 23, 268501004: 180, 268501008: 99}
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PC: 4194412
Data Memory:
 {268500992: -9, 268500996: 31, 268501000: 23, 268501004: 180, 268501008: 99}
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PC: 4194416
Data Memory:
 {268500992: -9, 268500996: 31, 268501000: 23, 268501004: 180, 268501008: 99}
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PC: 4194420
Data Memory:
 {268500992: -9, 268500996: 31, 268501000: 23, 268501004: 180, 268501008: 99}
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PC: 4194424
Data Memory:
 {268500992: -9, 268500996: 31, 268501000: 23, 268501004: 180, 268501008: 99}
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PC: 4194428
Data Memory:
 {268500992: -9, 268500996: 31, 268501000: 23, 268501004: 180, 268501008: 99}
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PC: 4194432
Data Memory:
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PC: 4194436
Data Memory:
 {268500992: -9, 268500996: 31, 268501000: 23, 268501004: 180, 268501008: 99}
--------------------------------------------------------------------------------
PC: 4194388
Data Memory:
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PC: 4194392
Data Memory:
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PC: 4194396
Data Memory:
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PC: 4194400
Data Memory:
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