HACETTEPE UNIVERSITY

Department of Computer Engineering

BBM234 – MIPS Project

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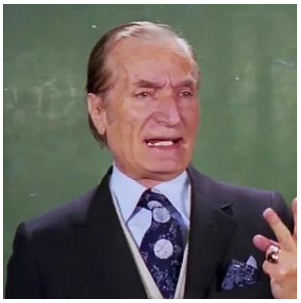
Hababam

Problem Definition



He is the last stronghold in defense of justice. He is the one who thinks teaching is the secret of the world. He is **Külyutmaz Necmi.**

He, who thinks that his students are cheating, wants to find a solution.

Hababam Sınıfı - the Chaos Class Tries to Cheat

For this, he creates a system using Mips technology. The teacher, who encrypts the notes, first wants to decrypt the notes. Even notes are divided by 8, single notes are multiplied by 5.

```
int datasize; // May vary with each different input
int data[datasize]; // Will be given for each run. Must be stored in memory
for(int i = 0; i < datasize; i++){
    if(data[i]%2 == 0)
        data[i] = data[i]/8; // It is forbidden to use div instructions
    else
        data[i] = data[i]*5; // It is forbidden to use mul/mult instructions
}
```

After that, it finds the average of the grades with its own system.

```
int average_recursive(int *data, int n){
    int sum, avg;
    if(n == 1)
        sum = data[0];
    else
        sum = data[n-1] + ((n-1) * average_recursive(data, n-1));
    avg = sum / n;
    return avg;
}
```

Külyutmaz thinks that students who get 80 and above are cheating and wants to find them.

We will help him.

MIPS Project

```
        .data
num_student :   .asciiz         "num_students = "
datasize :      .asciiz         "datasize     = "
# Test case 1  array = 720, 480, 80, 3, 1, 0                                    ----
# Test case 2  array = 0, 1, 5, 400, 112, 17, 7, 0, 560, 13, 0, 11, 3, 5, 0     ----
A:              .word           0, 1, 5, 400, 112, 17, 7, 0, 560, 13, 0, 11, 3, 5, 0
string:         .asciiz         "data[] = "
newline:        .asciiz         "\n"
result:         .asciiz         "average = "
bonus:          .asciiz         "Bonus: Cheaters IDs  "
space:          .asciiz         " "
and:            .asciiz         " and "
one :           .asciiz         "Inek Saban"
two:            .asciiz         "Güdük Necmi"
three:          .asciiz         "Damat Ferit"
four:           .asciiz         "Domdom Ali"
five:           .asciiz         "Tulum Hayri"
six :           .asciiz         "Hayta İsmail"

        .text
        .globl main
main:
```

This is the beginning part of my project. I have defined all the strings here. A statement is where I define array. In the lower part, I have defined the names of the students.

This part is the beginning of the main function. In chunks, this function continues. I get the number of students and data size from the command line here.

I have defined a counter for the for loop. I printed some words on the command line for the next process.

```
main:
        # this block takes the value num_student from the user
        li      $v0, 4
        la      $a0, num_student
        syscall
        li      $v0, 5
        syscall
        move $s0, $v0
        #-----------------------------------------------------
        # this block takes the value data size from the user
        li      $v0, 4
        la      $a0, datasize
        syscall
        li      $v0, 5
        syscall
        move $s1, $v0
        #-----------------------------------------------------

        la      $s2, A                  # $s2 =  array base address
        add     $t0, $0, $0             # $t0 = counter for "for loop"
        add     $t1, $0, $s2            # temporary base address
        # display string expression to terminal to make the answer readable
        li $v0, 4
        la $a0, newline
        syscall
        li $v0, 4
        la $a0, string
        syscall
        #-------------------------------------------------------------------
```

Part 1

```
# this is Part 1
for:
        slt     $t2, $t0, $s1           # for loops control statement => Less Than Comparision(use substraction)
        beq     $t2, $0, continue_main  # if counter - datasize is not equal 0, move on to the next instruction; otherwise go main
        lw      $s3, 0($t1)             # s3 holds array base value to navigate within array
        andi    $t3, $s3, 1             # holds "LSB value" of value for number is odd or even
        beq     $t3, $0, if_even        # if $t1 = 0, jump to if_even
        j       if_odd                  # else $t1 = 1, jump to if_odd
if_even:
        srl     $s3, $s3, 3             # shift to right for dividing 8
        j       inside_loop             # continue from loop body
if_odd:
        add     $t4, $s3, $0            # temporarily keep the initial of the value
        sll     $s3, $s3, 2             # shift to the left 2 times, so the value will be multiplied by 4
        add     $s3, $s3, $t4           # add temp valua and the value will be multiplied by 5
        j       inside_loop             # continue from loop body
inside_loop:
        sw      $s3, 0($t1)             # replace the changed value in array
        addi    $t0, $t0, 1             # counter += 1
        addi    $t1, $t1, 4             # switch the next value address of the array
        j               for             # continue for loop
#-------------------------------------------------------------------------------------------------
```

In this section I have deciphered the notes. Divide the even notes by 8 and multiply the odd notes by 5. While doing this, I did not use functions such as mul or div.

Test Case 1

Address	Value (+0)	Value (+4)	Value (+8)	Value (+c)	Value (+10)	Value (+14)
0x10010000	1601009006	1685419123	1937010277	2112800	1635017060	1702521203
0x10010020	720	480	80	3	1	0

Address	Value (+0)	Value (+4)	Value (+8)	Value (+c)	Value (+10)	Value (+14)
0x10010000	1601009006	1685419123	1937010277	2112800	1635017060	1702521203
0x10010020	90	60	10	15	5	0

Test Case 2

Address	Value (+0)	Value (+4)	Value (+8)	Value (+c)	Value (+10)	Value (+14)	Value (+18)	Value (+1c)
0x10010000	1601009006	1685419123	1937010277	2112800	1635017060	1702521203	538976288	2112800
0x10010020	0	1	5	400	112	17	7	0
0x10010040	560	13	0	11	3	5	0	1635017060

Address	Value (+0)	Value (+4)	Value (+8)	Value (+c)	Value (+10)	Value (+14)	Value (+18)	Value (+1c)
0x10010000	1601009006	1685419123	1937010277	2112800	1635017060	1702521203	538976288	2112800
0x10010020	0	5	25	50	14	85	35	0
0x10010040	70	65	0	55	15	25	0	1635017060

```
continue_main:
        sub     $t0, $t0, $t0           # empty register
        add     $t8, $0, $s2            # temporary base address of array
        j       loop1


# this part display all variable in array
loop1:
    bge     $t0, $s1, main_continue
    # load word from array and go next array
    lw      $t2, 0($t8)
    addi    $t8, $t8, 4
    # syscall to print value
    li      $v0, 1
    move    $a0, $t2
    syscall
    # spaces between numbers
    li      $a0, 32
    li      $v0, 11
    syscall
    #increment counter
    addi    $t0, $t0, 1
    j       loop1
#---------------------------------------
```

I printed the output on the screen by visiting the whole array

```
main_continue:
        # newline
        li $v0, 4
        la $a0, newline
        syscall
        #---------
        sub     $t8, $t8, $t8           # empty register
        add     $t1, $0, $s2            # temp base address ,again
        add     $t0, $0, $s1            # temp N
        addi    $t4, $t0, -1            # N-1
        sll     $t2, $t4, 2             # hold N-1 stack location value  **stack is used in this section **
        sub     $sp, $sp, $t2           # hold N-1 stack location       **Stack was used to remember where we came from **
        add     $a0, $0, $t1            #argument 1 = data
        add     $a1, $0, $t0            #argument 2 = N
        jal     AVG                     # function call
        add     $v1, $v0, $0            # save return(result) value to register
        j       main_continue_2
```

This is the preparatory part for Part 2. I updated some registers. I have defined the arguments. I used stack to use it in recursive function. I recorded them on the other side so as not to forget the places of return. I called the function. I saved the result at the end of the function in "$ v1".

Part 2

```
# this is Part 2
AVG:
        add     $s5, $0, $0             # $s5 = sum
        add     $s6, $0, $0             # $s6 = avg
        addi    $t3, $0, 1              # 1 for equality
        addi    $t4, $a1, -1            #N-1
        bne     $a1, $t3, else_AVG      #condition
        j       if_AVG
if_AVG:
        lw      $t5, 0($a0)
        add     $s5, $s5, $t5           # sum equal to first index of array
        j       inside_AVG              # continue loop
else_AVG:
        addi    $a1, $a1, -1            # recursive argument
        sw      $ra, 0($sp)             # remember called address
        addi    $sp, $sp, 4             # next stack address
        jal     AVG                     # recursion called
        addi    $sp, $sp, -4            # pevious stack address
        lw      $ra, 0($sp)             # remember called address
        add     $t8, $0, $v0            # take recursive return value
        addi    $t4, $t4, 1             # fix N-1
        mul     $t2, $t8, $t4           # temp value => recurs * (n-1)
        add     $s5, $s5, $t2           # add value to sum (complete else summing)
        add     $t6, $0, $a0            # temp data base
        sll     $t7, $t4, 2             # value for data[n-1] index
        add     $t6, $t6, $t7           # data[n-1]
        lw      $t9, 0($t6)             # value of data[n-1]
        add     $s5, $s5, $t9           # add data[n-1] to sum
        addi    $a1, $a1, 1
        j       inside_AVG
inside_AVG:

        div     $s6, $s5, $a1           # avg = sum / N
        sub     $s5, $s5, $s5           # sum = 0 for other function
        move    $v0, $s6                # save return value
        jr      $ra                     # go back

#-------------------------------------------------------------------------------------------------
```

I defined my recursive function according to the given system. With the help of the stack, I did not have any errors in "jr $ ra" instruction. If I hadn't used it, it would be overwritten and I wouldn't be able to access it.

Test 1

```
num_students = 4
datasize     = 6

data[] = 90 60 10 15 5 0
average = 29
Bonus: Cheaters IDs  1 Inek Saban and 2 Güdük Necmi
-- program is finished running --
```

$zero	0	0
$at	1	268500992
$v0	2	10
$v1	3	29

Test 2

```
num_students = 6
datasize     = 15

data[] = 0 5 25 50 14 85 35 0 70 65 0 55 15 25 0
average = 27
Bonus: Cheaters IDs  2 Güdük Necmi and 3 Damat Ferit
-- program is finished running --
```

$zero	0	0
$at	1	268500992
$v0	2	10
$v1	3	27

```
main_continue_2:
        # display result (final average)
        li $v0, 4
        la $a0, result
        syscall
        li $v0, 1
        move $a0, $v1
        syscall
        #--------------
```

In this section I printed the result on the screen.

Part 3 Bonus

```
#this is Part 3 ----- Bonus Part
        addi    $s6, $0, 1              # first cheater
        addi    $s7, $0, 2              # second cheater
        add     $t3, $0, $s2            # temp base address
        addi    $t4, $0, 0              # counter
        addi    $t6, $0, 79             # control score  (80 or higher)

for_loop_1:
        slt     $t5, $t4, $s1           # for loops control statement => Less Than Comparision(use substraction)
        beq     $t5, $0, done           # actually this is never execute; maybe if no one is cheater, it will go to finish point.
        lw      $t7, 0($t3)             # array value
        bge     $t7, $t6, print         # if array value > 79, go print else continue
        # this is helpful for find index of cheater
        addi    $t4,$t4,1
        addi    $t3, $t3, 4
        slt     $t5, $s7, $s0
        beq     $t5, $0, else
if:
        addi    $s7, $s7, 1
        j for_loop_1
else:
        addi    $s6, $s6, 1
        add     $s7, $s6, 1
        j for_loop_1
        #----------------------------------------
```

Using Array, I found the result above 79 and recorded that they have their indexes. I saved cheater index in $s6 and $s7.

```
print:
        li $v0, 4
        la $a0, newline # newline for readability
        syscall

        li $v0, 4
        la $a0, bonus   # bonus title
        syscall

        li $v0, 1
        move $a0, $s6   # index of first cheater
        syscall

        li $v0, 4
        la $a0, space   # space
        syscall

        add $a0, $0, $s6# for find name of first cheater
        jal equal

        li $v0, 4
        la $a0, and     # and
        syscall

        li $v0, 1
        move $a0, $s7   # index of second cheater
        syscall

        li $v0, 4
        la $a0, space   # space
        syscall

        add $a0 , $0, $s7
        jal equal       # for find name of second cheater

        j done  #finish task
# this part is helpful for find which index have which name
```

```
# this part is helpful for find which index have which name
equal:
        addi $t8, $0, 1
        beq $t8, $a0, print_inek
        addi $t8, $t8, 1
        beq $t8, $a0, print_necmi
        addi $t8, $t8, 1
        beq $t8, $a0, print_ferit
        addi $t8, $t8, 1
        beq $t8, $a0, print_ali
        addi $t8, $t8, 1
        beq $t8, $a0, print_hayri
        addi $t8, $t8, 1
        beq $t8, $a0, print_ismail
        jr $ra

print_inek:
        li $v0, 4
        la $a0, one
        syscall
        jr $ra
print_necmi:
        li $v0, 4
        la $a0, two
        syscall
        jr $ra
```

Test 1

$zero	0	0
$at	1	268500992
$v0	2	10
$v1	3	29
$a0	4	268501112
$a1	5	6
$a2	6	0
$a3	7	0
$t0	8	6
$t1	9	268501024
$t2	10	175
$t3	11	268501024
$t4	12	0
$t5	13	1
$t6	14	79
$t7	15	90
$s0	16	4
$s1	17	6
$s2	18	268501024
$s3	19	0
$s4	20	0
$s5	21	0
$s6	22	1
$s7	23	2
$t8	24	2
$t9	25	0
$k0	26	0
$k1	27	0
$gp	28	268468224
$sp	29	2147479528
$fp	30	0
$ra	31	4194948
pc		4195132
hi		1
lo		29

Test 2

$zero	0	0
$at	1	268500992
$v0	2	10
$v1	3	27
$a0	4	268501160
$a1	5	15
$a2	6	0
$a3	7	0
$t0	8	15
$t1	9	268501024
$t2	10	406
$t3	11	268501044
$t4	12	5
$t5	13	1
$t6	14	79
$t7	15	85
$s0	16	6
$s1	17	15
$s2	18	268501024
$s3	19	0
$s4	20	0
$s5	21	0
$s6	22	2
$s7	23	3
$t8	24	3
$t9	25	0
$k0	26	0
$k1	27	0
$gp	28	268468224
$sp	29	2147479492
$fp	30	0
$ra	31	4194948
pc		4195132
hi		1
lo		27

```
num_students = 4
datasize     = 6

data[] = 90 60 10 15 5 0
average = 29
Bonus: Cheaters IDs  1 Inek Saban and 2 Güdük Necmi
-- program is finished running --
```

```
num_students = 6
datasize     = 15

data[] = 0 5 25 50 14 85 35 0 70 65 0 55 15 25 0
average = 27
Bonus: Cheaters IDs  2 Güdük Necmi and 3 Damat Ferit
-- program is finished running --
```

Finish

```
done:
        li $v0, 10
        syscall
```

References

MIPS Tutorial - https://chortle.ccsu.edu/assemblytutorial/index.html

Amell Peralta - https://www.youtube.com/watch?v=B0GAXDjfdbQ

Quick Tutorial - https://minnie.tuhs.org/CompArch/Resources/mips_quick_tutorial.html

Stackoverflow - https://stackoverflow.com/questions/19748054/reading-and-printing-an-integer-in-mips