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ECE 366 Project 1 Report

i) PROGRAM 1

1) For Program 1, my project achieved Level 1

2) For P=5, R=7.

C:\Users\Tom\Desktop\Project1-1.asm - MARS 4.5

File Edit Run Settings Tools Help

Run speed at max (no interaction)

Edit Execute

Text Segment

Program Arguments:

Bkpt	Address	Code	Basic	Source
	0x00000000	0x8c082000	lw \$8, 0x00002000(\$0)	8: lw \$8, 0x2000 #S=P
	0x00000004	0x20090006	addi \$9, \$0, 0x00000006	9: addi \$9, \$0, 6 #S=6
	0x00000008	0x200a0001	addi \$10, \$0, 0x00000001	10: addi \$10, \$0, 1 #Temp=1 for ^
	0x0000000c	0x200d0001	addi \$13, \$0, 0x00000001	11: addi \$13, \$0, 1 #Temp=1 for %
	0x00000010	0x200e0011	addi \$14, \$0, 0x00000011	12: addi \$14, \$0, 17 #%17
	0x00000014	0x110a0005	beq \$8, \$10, 0x00000005	15: beq \$8, \$10, div
	0x00000018	0x00095880	sll \$11, \$9, 0x00000002	16: sll \$11, \$9, 2

Data Segment

Address	Value (+0)	Value (+4)	Value (+8)	Value (+c)	Value (+10)	Value (+14)	Value (+18)	Value (+1)
0x00002000	0x00000000	0x00000007	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000
0x00002020	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000
0x00002040	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000
0x00002060	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000
0x00002080	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000
0x000020a0	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000
0x000020c0	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000

Mars Messages

Run I/O

-- program is finished running (dropped off bottom) --

Clear

-- program is finished running (dropped off bottom) --

Registers

Name	Number	Value
\$8 (\$addr)	8	0x00000000
\$12 (status)	12	0x0000ff11
\$13 (cause)	13	0x00000000
\$14 (epc)	14	0x00000000

Instruction Counter, Version 1.0 (Felipe Lessa)

Counting the number of instructions executed

Instructions so far: 2320

R-type: 1385 59%

I-type: 473 20%

J-type: 461 19%

Tool Control

Disconnect from MIPS Reset Close

P=5

For P=8, R=16.

C:\Users\Tom\Desktop\Project1-1.asm - MARS 4.5

File Edit Run Settings Tools Help

Run speed at max (no interaction)

Edit Execute

Text Segment

Program Arguments:

Bkpt	Address	Code	Basic	Source
	0x00000000	0x8c082000	lw \$8, 0x00002000(\$0)	8: lw \$8, 0x2000 #S=P
	0x00000004	0x20090006	addi \$9, \$0, 0x00000006	9: addi \$9, \$0, 6 #S=6
	0x00000008	0x200a0001	addi \$10, \$0, 0x00000001	10: addi \$10, \$0, 1 #Temp=1 for ^
	0x0000000c	0x200d0001	addi \$13, \$0, 0x00000001	11: addi \$13, \$0, 1 #Temp=1 for %
	0x00000010	0x200e0011	addi \$14, \$0, 0x00000011	12: addi \$14, \$0, 17 #%17
	0x00000014	0x110a0005	beq \$8, \$10, 0x00000005	15: beq \$8, \$10, div
	0x00000018	0x00095880	sll \$11, \$9, 0x00000002	16: sll \$11, \$9, 2

Data Segment

Address	Value (+0)	Value (+4)	Value (+8)	Value (+c)	Value (+10)	Value (+14)	Value (+18)	Value (+1)
0x00002000	0x00000000	0x00000010	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000
0x00002020	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000
0x00002040	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000
0x00002060	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000
0x00002080	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000
0x000020a0	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000
0x000020c0	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000

Mars Messages

Run I/O

-- program is finished running (dropped off bottom) --

Clear

-- program is finished running (dropped off bottom) --

Registers

Name	Number	Value
\$8 (\$addr)	8	0x00000000
\$12 (status)	12	0x0000ff11
\$13 (cause)	13	0x00000000
\$14 (epc)	14	0x00000000

Instruction Counter, Version 1.0 (Felipe Lessa)

Counting the number of instructions executed

Instructions so far: 494053

R-type: 296423 59%

I-type: 98822 20%

J-type: 98807 19%

Tool Control

Disconnect from MIPS Reset Close

P=8

For P=11, R=5

The screenshot shows the MARS MIPS simulator interface. The main window displays the assembly code in the 'Text Segment' and the 'Data Segment'. The 'Registers' window on the right shows the state of registers \$8 through \$14. A 'Counting the number of instructions executed' dialog box is open, showing 39893517 instructions. A 'Mars Messages' window at the bottom shows the program completion message. A box in the bottom right corner displays 'P=11'.

Name	Number	Value
\$8 (vaddr)	8	0x00000000
\$12 (status)	12	0x0000ff11
\$13 (cause)	13	0x00000000
\$14 (epc)	14	0x00000000

Address	Value (+0)	Value (+4)	Value (+8)	Value (+c)	Value (+10)	Value (+14)	Value (+18)	Value (+1)
0x00002000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000
0x00002020	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000
0x00002040	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000
0x00002060	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000
0x00002080	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000
0x000020a0	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000
0x000020c0	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000

Counting the number of instructions executed

Instructions so far: 39893517

R-type: 23936100 -47%

I-type: 7978716 20%

J-type: 7978700 19%

P=11

- First, my program loads in the value of (P) into a register. It multiplies 6 (P) number of times. It uses sll to shift the correct amount of times for the binary of 6. It then moves on to modulo, where 17 is subtracted from the correct value of 6^P right before a negative number is reached. That number is the remainder of $6^P \% 17$ and is stored into (R).
- Registers \$0, \$8 - \$15 are used. The program uses the following instructions: lw, sw, add, addi, sub, sll, slt, beq, and j.

PROGRAM 2

- 5) For Program 2, my project achieved Level 2
- 6) Example A: **Best Match Score=19, Best Match Count=5**

Text Segment

Bkpt	Address	Code	Basic	Source
0x00000000	0x2016200c	addi \$22,\$0,8204	8: addi \$22, \$0, 0x200c #22=Address Cou..	
0x00000004	0x8c082000	lw \$8,8192(\$0)	9: lw \$8, 0x2000	
0x00000008	0x20120020	addi \$18,\$0,32	10: addi \$18, \$0, 32	
0x0000000c	0x20140000	addi \$20,\$0,0	11: addi \$20, \$0, 0 #Value of best score	
0x00000010	0x8ec90000	lw \$9,0(\$22)	14: lw \$9, (\$22) #59=value of address \$22	
0x00000014	0x200b0000	addi \$11,\$0,0	15: addi \$11, \$0, 0 #Counter of 1 bits	
0x00000018	0x01095026	xor \$10,\$8,\$9	16: xor \$10, \$8, \$9 #Xor to get number o..	

Data Segment

Address	Value (+0)	Value (+4)	Value (+8)	Value (+c)	Value (+10)	Value (+14)	Value (+18)	Value (+1c)
0x00002000	-1412567296	19	5	0	1	2	3	4
0x00002020	-1	-2	-3	-4	-5	-286331154	1145342088	2004318071
0x00002040	858993459	-143165766	-65536	65535	-858993460	1717986919	-1717986919	0
0x00002060	0	0	0	0	0	0	0	0
0x00002080	0	0	0	0	0	0	0	0
0x000020a0	0	0	0	0	0	0	0	0
0x000020c0	0	0	0	0	0	0	0	0

Registers

Name	Number	Value
\$8 (vaddr)	8	0
\$12 (status)	12	65297
\$13 (cause)	13	0
\$14 (epc)	14	0

Instruction Counter, Version 1.0 (Felipe Lessa)

Counting the number of instructions executed

Instructions so far: 5968

R-type: 687 12%

I-type: 4234 75%

J-type: 686 12%

Tool Control: Disconnect from MIPS, Reset, Close

Mars Messages: -- program is finished running (dropped off bottom) --

Example B: **Best Match Score=32, Best Match Count=3**

Text Segment

Bkpt	Address	Code	Basic	Source
0x00000000	0x2016200c	addi \$22,\$0,8204	8: addi \$22, \$0, 0x200c #22=Address Cou..	
0x00000004	0x8c082000	lw \$8,8192(\$0)	9: lw \$8, 0x2000	
0x00000008	0x20120020	addi \$18,\$0,32	10: addi \$18, \$0, 32	
0x0000000c	0x20140000	addi \$20,\$0,0	11: addi \$20, \$0, 0 #Value of best score	
0x00000010	0x8ec90000	lw \$9,0(\$22)	14: lw \$9, (\$22) #59=value of address \$22	
0x00000014	0x200b0000	addi \$11,\$0,0	15: addi \$11, \$0, 0 #Counter of 1 bits	
0x00000018	0x01095026	xor \$10,\$8,\$9	16: xor \$10, \$8, \$9 #Xor to get number o..	

Data Segment

Address	Value (+0)	Value (+4)	Value (+8)	Value (+c)	Value (+10)	Value (+14)	Value (+18)	Value (+1c)
0x00002000	-5	32	3	1	-2	3	-4	5
0x00002020	-6	7	-8	9	-10	-5	5	-5
0x00002040	5	-5	1	-2	3	-4	5	0
0x00002060	0	0	0	0	0	0	0	0
0x00002080	0	0	0	0	0	0	0	0
0x000020a0	0	0	0	0	0	0	0	0
0x000020c0	0	0	0	0	0	0	0	0

Registers

Name	Number	Value
\$8 (vaddr)	8	0
\$12 (status)	12	65297
\$13 (cause)	13	0
\$14 (epc)	14	0

Instruction Counter, Version 1.0 (Felipe Lessa)

Counting the number of instructions executed

Instructions so far: 3382

R-type: 403 11%

I-type: 2586 76%

J-type: 402 11%

Tool Control: Disconnect from MIPS, Reset, Close

Mars Messages: -- program is finished running (dropped off bottom) --

Example C: Best Match Score=32, Best Match Count=1

Text Segment

Bkpt	Address	Code	Basic	Source
0x00000000	0x2016200c	addi	\$22,\$0,8204	8: addi \$22, \$0, 0x200c #22=Address Cou...
0x00000004	0x8c082000	lw	\$8,8192(\$0)	9: lw \$8, 0x2000
0x00000008	0x20120020	addi	\$18,\$0,32	10: addi \$18, \$0, 32
0x0000000c	0x20140000	addi	\$20,\$0,0	11: addi \$20, \$0, 0 #Value of best score
0x00000010	0x8ec90000	lw	\$9,0(\$22)	14: lw \$9, (\$22) #59=value of address \$22
0x00000014	0x200b0000	addi	\$11,\$0,0	15: addi \$11, \$0, 0 #Counter of 1 bits
0x00000018	0x01095026	xor	\$10,\$8,\$9	16: xor \$10, \$8, \$9 #Xor to get number o...

Data Segment

Address	Value (+0)	Value (+4)	Value (+8)	Value (+c)	Value (+10)	Value (+14)	Value (+18)	Value (+1c)
0x00002000	-1	32	-1	-10	-9	-8	-7	-6
0x00002020	-5	-4	-3	-2	-1	0	1	2
0x00002040	3	4	5	6	7	8	9	0
0x00002060	0	0	0	0	0	0	0	0
0x00002080	0	0	0	0	0	0	0	0
0x000020a0	0	0	0	0	0	0	0	0
0x000020c0	0	0	0	0	0	0	0	0

Registers

Name	Number	Value
\$8 (vaddr)	8	0
\$12 (status)	12	65297
\$13 (cause)	13	0
\$14 (epc)	14	0

Counting the number of instructions executed

Instructions so far: 3440

R-type: 408 11%

I-type: 2624 76%

J-type: 407 11%

T= 0xFFFFFFFF

Pattern: -10, -9, -8, -7, -6, -5, -4, -3, -2, -1, 0, 1, 2, 3, 4, 5, 6, 7, 8, 9

Mars Messages: -- program is finished running (dropped off bottom) --

- 7) My program finds the count of best matchings by using a counter. The initial best matching score is set to zero. Any value that has a greater best matching score is then placed in a temp register. The counter will increase by one any time a matching score is found. If a value has a higher matching score than the previous highest, that value will be placed in the temp register and the count will be reset. Once the program has finished running, the best matching score and best matching counts are stored in the correct addresses.
- 8) Registers \$0, \$8 - \$13, \$18-\$23 are used. The program uses the following instructions: add, addi, lw, sw, beq, srl, xor, andi, sub, slt, and j.
- 9) I have spent about 20 hours on this project. Most of the time was spent trying to achieve level 2 for each program after reaching level 1.
- 10) I would improve my program by trying to achieve level 2 for both programs and optimize the speed and DIC for each program.

ii) **Program 1 Assembly Code:**

.data

P: .word 11

R: .word -1

$\#(6^P)\%17=R$

.text

lw \$8, 0x2000 # \$8=P

addi \$9, \$0, 6 # \$9=6

addi \$10, \$0, 1 #Temp=1 for ^

addi \$13, \$0, 1 #Temp=1 for %

addi \$14, \$0, 17 #%17

mul:

beq \$8, \$10, div #Finished when (number of loops)=P

sll \$11, \$9, 2 # $6=(1*2^2)+(1*2^1)+(0*2^0)$

sll \$12, \$9, 1

add \$9, \$11, \$12

addi \$10, \$10, 1 #Counter for number of multiplications

j mul

div:

sub \$15, \$9, \$14 #Subtract 17 from value of \$9

slt \$13, \$0, \$15 #Check for negative

beq \$13, \$0, store

add \$9, \$0, \$15 #New number to subtract from

j div

store:

sw \$9, 0x2004 #Store remainder

iii) Program 2 Assembly Code:

.data

T: .word 0xFFFFFFFF # 0x2000

best_matching_scre: .word -1 # best score = ? within [0, 32] 0x2004

best_matching_count: .word -1 # how many patterns achieve the best score? #2008

Pattern_Array: .word -10, -9, -8, -7, -6, -5, -4, -3, -2, -1, 0, 1, 2, 3, 4, 5, 6, 7, 8, 9 #start 0x200c

.text

addi \$22, \$0, 0x200c #\$22=Adress Counter

lw \$8, 0x2000

addi \$18, \$0, 32

addi \$20, \$0, 0 #Value of best score

setup:

lw \$9, (\$22) #\$9=value of address \$22

addi \$11, \$0, 0 #Counter of 1 bits

xor \$10, \$8, \$9 #Xor to get number of matching 1 bits

j loop

loop:

xor \$13, \$10, 0 #Xor to know when to exit loop

beq \$13, 0, done

andi \$12, \$10, 1 #Matching ones

beq \$12, 1, one

srl \$10, \$10, 1 #Shift to calculate next bit

j loop

one:

addi \$11, \$11, 1 #Add matching bit to counter

srl \$10, \$10, 1 #Shift to calculate next bit

j loop

done:

sub \$19, \$18, \$11 #32-number of matching bits

slt \$21, \$20, \$19 #Find best score

beq \$21, 1, best

beq \$19, \$20, best2

j finish

best:

sw \$19, 0x2004 #Store best score

add \$20, \$0, \$19 #Store value of best score

addi \$23, \$0, 0 #Reset counter for best scores

j best2

best2:

addi \$23, \$23, 1 #Number of best scores

j finish

finish:

addi \$22, \$22, 4 #Shift address of array by 4

beq \$22, 0x205c, exit #20th number in array

j setup

exit:

sw \$23, 0x2008 #Store number of best scores