

605.204 - Computer Organization

Module 9: Assignment

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Brief Introduction

This assignment involves branching and looping within various assembly files in armv7l. All of my resulting code can be found at this *GitHub link* and can be cloned (along with pre-built binaries in a *bin/* folder) and viewed using the following commands:

```
git clone https://github.com/nhinke/computer-organization-repo.git
cd computer-organization-repo/assignments/module09/
```

The pre-built binaries can then be run using the following commands:

```
cd bin/
./checkCharLogical
./checkCharNoLogicals
./checkGrade
./maxInt
```

Note that each of the pre-built binaries will print out an example input-output sequence to the active terminal.

Problem 1

1. Write and test a function to check if a user input value is a character or not. Implement it in two ways:
 - a. As a logical variable.
 - b. Any way that does not use logical values.

Using Logical Vars

Program:

```
1 # Nick Nino
2 # 10/26/2022
3 # 601.004 Computer Organization
4 # Module 9 Assignment - Problem 1a
5 #
6 # Program to check if data in r1 is a character using logical variables
7 #
8 # Program can be implemented by checking the following:
9 # IF ((r1 >= 0x41 && r1 <= 0x5a) || (r1 >= 0x61 && r1 <= 0x7a)) --> char in r1
10 #
11
12 .global main
13 .global checkChar
14 .global printf
15
16 .text
17 main:
18
19 # push stack
20 SUB SP, SP, #4
21 STR LR, [SP, #0]
22
23 # check if 0x42 is a char
24 MOV R1, #0x42
25 MOV R7, R1
26 BL checkChar
27 MOV R8, R0
28 LDR R9, #output
29 MOV R1, R7
30 MOV R2, R8
31 BL printf
32
33 # print if 0x42 is a char
34 CMP R8, #0
35 BEQ endif1
36 MOV R1, R7
37 BL printfChar
38 endif1:
39
40 # check if 0x5a is a char
41 MOV R1, #0x5a
42 MOV R7, R1
43 BL checkChar
44 MOV R8, R0
45 LDR R9, #output
46 MOV R1, R7
47 MOV R2, R8
48 BL printf
49
50
51 # print if 0x42 is a char
52 MOV R1, #0x42
53 MOV R7, R1
54 BL checkChar
55 MOV R8, R0
56 LDR R9, #output
57 MOV R1, R7
58 MOV R2, R8
59 BL printf
60
61 # print if 0x5a is a char
62 MOV R1, #0x5a
63 MOV R7, R1
64 BL checkChar
65 MOV R8, R0
66 LDR R9, #output
67 MOV R1, R7
68 MOV R2, R8
69 BL printf
70
71 # print if 0x42 is a char
72 MOV R1, #0x42
73 MOV R7, R1
74 BL checkChar
75 MOV R8, R0
76 LDR R9, #output
77 MOV R1, R7
78 MOV R2, R8
79 BL printf
80
81 # print if 0x5a is a char
82 MOV R1, #0x5a
83 MOV R7, R1
84 BL checkChar
85 MOV R8, R0
86 LDR R9, #output
87 MOV R1, R7
88 MOV R2, R8
89 BL printf
90
91 # print newline
92 LDR R9, #line
93 BL printf
94
95 # pop stack and return
96 LDR LR, [SP, #0]
97 ADD SP, SP, #4
98 MOV PC, LR
99
100 .data
101 output: .ascii "\nValue: %d isChar: %d"
102 line: .ascii "\n"
103 # end main
```

Figure 1: Screenshot of program to check if data is a char using logicals

Example:

```
root@rpi1:~/Documents/JHU/Computer-Organization/computer-organization-repo/assignments/module09 $ ./bin/checkCharLogical
Value: 66 isChar: 1 Char: B
Value: 94 isChar: 0
Value: 113 isChar: 1 Char: q
Value: 130 isChar: 0
```

Figure 2: Screenshot of program output

Without Using Logical Vars

Program:

```

1  # Task Name
2  # Date/Time
3  # 300.304 Computer Organization
4  # Module & Assignment - Problem 20
5  #
6  # Program to check if data in r1 is a character without using logical variables
7  #
8  # Program can be implemented by checking the following
9  # IF ((r1 >= 0x41 && r1 <= 0x5A) || (r1 >= 0x61 && r1 <= 0x7A)) -> char in r1
10 #
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12 global main
13 global checker
14 global printer
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Problem 2

2. Implement a grading program as follows. It should follow the proper style for assembly.

1. Prompt for a name and an average.
2. If the average is not on range $[0,100]$, print an error.
3. Calculate a grade as 90-100 as A, 80-90 as B, 70-80 as C, else F.
4. Print out the student's name and grade.

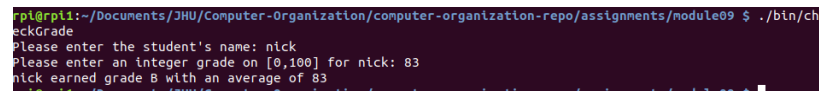
Program *main* label:

```
9  .global main
10 .global checkGradeValid
11 .global printLetterGrade
12
13
14 .text
15 main:
16
17     # push stack
18     SUB sp, sp, #4
19     STR lr, [sp, #0]
20
21     # prompt and read student name from user
22     LDR r0, =promptName
23     BL printf
24     LDR r0, =formatName
25     LDR r1, =name
26     BL scanf
27
28     # prompt and read number grade for student from user
29     LDR r0, =promptGrade
30     LDR r1, =name
31     BL printf
32     LDR r0, =formatGrade
33     LDR r1, =grade
34     BL scanf
35
36     # check number grade valid using checkGradeValid function (result returned in r0)
37     LDR r0, =grade
38     LDR r0, [r0, #0]
39     BL checkGradeValid
40
41     # if number grade valid, print letter grade using printLetterGrade function
42     CMP r0, #1
43     BNE endMain
44     LDR r0, =name
45     LDR r1, =grade
46     LDR r1, [r1, #0]
47     BL printLetterGrade
48
49 endMain:
50
51     # pop stack and return
52     LDR lr, [sp, #0]
53     ADD sp, sp, #4
54     MOV pc, lr
55
56 .data
57 promptName: .asciz "Please enter the student's name: "
58 promptGrade: .asciz "Please enter an integer grade on [0,100] for %s: "
59 formatName: .asciz "%s"
60 formatGrade: .asciz "%d"
61 name: .space 32
62 grade: .word 0
```

Figure 5: Screenshot of main label within grade conversion program

Visit *this link* to see the rest of the program (it is too long to paste screenshots in a meaningful way).

Example:

A screenshot of a terminal window with a dark background and light-colored text. The text shows a user running a program, entering a name 'nick', and entering a grade '83'. The program then outputs the grade and average.

```
rpig@rpig:~/Documents/JHU/Computer-Organization/computer-organization-repo/assignments/module09 $ ./bin/ch  
eckGrade  
Please enter the student's name: nick  
Please enter an integer grade on [0,100] for nick: 83  
nick earned grade 8 with an average of 83
```

Figure 6: Screenshot of sample program output

Problem 3

3. Implement a function to find the largest of 3 values. The function signature is “`findMaxOf3(int val1, int val2, int val3)`”. The function should compare the 3 values, and return the largest. Be sure to use the ABI standards for all arguments and return values. Write a program to prompt for 3 values, call this function to find the maximum value, and print out the maximum value. Follow proper style for assembly.

Program *main* and *findMaxOf3* labels:

```
1 # Nick Nicks
2 # 10/23/2022
3 # 605.204 Computer Organization
4 # Module 9 Assignment - Problem 3
5 #
6 # Program to find the largest of three integer values
7 #
8
9 .global main
10 .global promptForInteger
11 .global findMaxOf3
12
13 .text
14 main:
15
16     # push the stack
17     SUB sp, sp, #4
18     STR lr, [sp, #0]
19
20     # print welcome string
21     LDR r0, =numIntsStr
22     BL printf
23
24     # prompt user for three integers and store in r5-r7
25     BL promptForInteger
26     MOV r5, r0
27     BL promptForInteger
28     MOV r6, r0
29     BL promptForInteger
30     MOV r7, r0
31
32     # move integers into r8-r2 and branch to comparison function
33     MOV r8, r5
34     MOV r1, r6
35     MOV r2, r7
36     BL findMaxOf3
37
38     # print result stored in r0
39     MOV r1, r0
40     LDR r0, =endLoopStr
41     BL printf
42
43     # pop stack and return
44     LDR lr, [sp, #0]
45     ADD sp, sp, #4
46     MOV pc, lr
47
48 .data
49 numIntsStr: .ascii "Hello! Program ready to compare 3 integers...\n"
50 endLoopStr: .ascii "\nMaximum integer found: %d\n"
51 # end main
52
53 findMaxOf3:
54
55     # push the stack
56     SUB sp, sp, #4
57     STR lr, [sp, #0]
58
59     # use r3 to contain maximum --> initially set to minimum possible int
60     MOV r3, #1
61     ROR r3, #1
62
63     B CompareInt1
64
65     # compare first integer to current maximum
66     CompareInt1:
67     CMP r0, r3
68     BLE CompareInt2
69     MOV r3, r0
70     B CompareInt2
71
72     # compare second integer to current maximum
73     CompareInt2:
74     CMP r1, r3
75     BLE CompareInt3
76     MOV r3, r1
77     B CompareInt3
78
79     # compare third integer to current maximum
80     CompareInt3:
81     CMP r2, r3
82     BLE endComparisons
83     MOV r3, r2
84     B endComparisons
85
86     # store result in r0
87     endComparisons:
88     MOV r0, r3
89
90     # pop stack and return
91     LDR lr, [sp, #0]
92     ADD sp, sp, #4
93     MOV pc, lr
94
95 .data
96 # end findMaxOf3
```

Figure 7: Screenshot of main and findMaxOf3 labels within program

Visit [this link](#) to see the rest of the program (it is too long to paste screenshots in a meaningful way).

Example:

```
maxInt = 32768; minInt = -32768;
rpi@rpi1:~/Documents/JHU/Computer-Organization/computer-organization-repo/assignments/module09 $ ./bin/na
xInt
Hello! Program ready to compare 3 integers...
Please enter an integer: -9
Please enter an integer: 83
Please enter an integer: 16
Maximum integer found: 83
```

Figure 8: Screenshot of sample program output