Digital Design and Computer Architecture (E85)

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I) Problems

0. Finish problem 4 from homework 6. The question is repeated here for your convenience: Write a C program to count from one to 50. Use ‘i’ as the counting variable. Convert that program to ARM assembly with ‘i’ held in register R4.

1. Convert the following ARM assembly into machine code. Write your answers in Hexadecimal.

a)

```
AND R0, R0, #0
ADD R2, R0, #5
ADD R3, R2, #2
SUB R0, R3, R2
```

b)

```
AND R0, R0, #0
ADD R2, R0, #7
ADD R3, R2, #1
ADD R4, R2, R3
ORR R0, R3, R4
```

c)

```
AND R0, R0, #0
SUB R2, R0, #1
ADD R3, R0, #11
AND R0, R3, R2
```

d)

```
AND R1, R1, #0
SUB R2, R1, #1
ADD R3, R1, #11
EOR R0, R3, R2
```

2. Implement the following high-level code segments using the `CMP` instruction and conditional execution. Assume the integer variables g and h are in registers R1 and R2, respectively.

a)

```
if (g > h)
     g = g + h;
else
     g = g – h;
```

b)

```
if (g >= h)
     g = g + 1;
else
     h = h – 1;
```

c)

```
if (g <= h)
     g = 0;
else
     h = 0;
```

3. The strcpy function copies the character string from src to dst.

```
// high-level code
void strcpy(char x[], char y[]) {

  int i = 0;
  while (x[i] != 0) {
    y[i] = x[i];
    i = i + 1;
  }
  y[i] = '\0';
}
```

a) Implement the strcpy function in ARM assembly code. Use R1 for i. Recall that the calling convention enforces that x should be in R0 and y should be in R1.

b) Draw a picture of the stack before, during, and after the strcpy function call. Assume the stack pointer is at 0x7FFFFF00 just before strcpy is called.

4. Consider the following high-level function.

```
// high-level code
int f(int n, int k) {
     int b;

     b = k + 2;
     if (n == 0) b = 10;
     else b = b + (n * n) + f(n – 1, k + 1);
     return b * k;
}
```

a) Translate the high-level function into ARM assembly language. Clearly comment your code. You can use the multiply instruction. Keep local variable b in R4.

b) Step through your function from part (a) by hand for the case of f(2, 4). Draw a picture of the stack. Write the register name and data value stored at each location in the stack and keep track of the stack pointer value (SP). Clearly mark each stack frame. Assume that when f is called, R4 = 0xABCD and LR = 0x400004. What is the final value of R0?

II) Time

Please indicate how many hours you spent on this problem set. This will not affect your grade (unless you omit it completely), but will be helpful for calibrating the workload for next semester's class.