Midterm (15 Marks) Oct 23rd, 2020

Dept. of Electrical Engineering, IIT Madras
EE2016 - Microprocessor Theory and Lab

- Please ensure that your email and your id contain your roll number. When I download your submission I need to know whose submsision it is!
- Comments are required! If something is wrong with the code, your explanations will help me give partial credit.
- Since you are only submitting your codes, all responses to questions I have asked must be answered in the code as comments.
- Please do not copy. The Assignment was meant to be collaborative. An exam is meant to be done by you alone. I will check for cheating, and if I find cases, I will punish both the one who shared their code and the one who copied.
- Lines in blue were added on Sunday evening to clarify the questions.

Note: For this exam, assume the LDM and STM instructions cost as many cycles per register as LDR and STR. These per register costs are different in the two questions.

Note: For both questions, create a main program and function in C. Once you get that working, convert the C function to ARM assembly language and optimize it. Submit the main program in C and the assembly language codes for the two cases. Note: The C compiler will not optimize the two cases, since it makes different assumptions than those given here. You have to do the optimization. When submitting, the file containing the main program should have precise instructions on how to compile and run the code, and should also specify the platform and the OS details.

1. [8 marks] Create a function that is passed the address and the dimension of a sorted array of integers, and should return the index of the element in the array that minimizes

$$\begin{aligned} S_i =& (a_{i+5} - a_i) - (a_{i+4} - a_{i+1}) + (a_{i+3} - a_{i+2}) \\ =& a_{i+5} - a_{i+4} + a_{i+3} - a_{i+2} + a_{i+1} - a_i \end{aligned}$$

Your solution should minimize the number of load or store instructions used to find this answer, *assuming load and store instructions cost 5 cycles each*. (Try to load only one register per iteration.) Compute the number of cycles required by this code for a 100 element array. Note that the cost also affects the push and pop commands which must be taken into account in your calculation. How many registers need to be saved and restored?

2. **[7 marks] Suppose *load and store instructions are as fast as other instructions*. Can you develop a faster algorithm? What is the cycle count now? How many registers need to be saved and restored? Why couldn't this scheme be used in the 1st problem?**

   Calculate and present in a table, the clock cycles required by the two methods for the case of LDR/STR instructions being 1, 5, 10, and 20 times as slow as other instructions.

   Hint: Express $S_i$in terms of S_{i-1} and explore if it can speed up the code.