**Brown University**
**Division of Engineering**
**EN2911X. Reconfigurable Computing. Fall'14**
**Prof. Sherief Reda**
**HW/Lab 08 (100 points). Due Date Fri Nov 14 and Fri Nov 21.**


## No teamwork allowed.

The assignment is to count the number of number palindromes between 0 and 1 billion. A *number palindrome* is a number that reads the same in both directions. For example, 1221 and 4396934 are number palindromes. While there are formulas that give you the number of palindromes within a specified range, the objective of this exercise is to code a function that given a number, it should return whether the number is a palindrome by comparing digits from left and right. You can then use this function within a loop to count the number of palindromes between 0 and 1 billion.

1. [Due date Nov 14 - 10 points] Code the program using any language (preferably C) on any PC workstation. Make sure the code is working correctly, i.e., counting the right number of palindromes. Calculate the runtime to use as a reference.
2. [Due date Nov 14 - 10 points] Using Qsys builder, create a Nios II based system and download it to the Cyclone II FPGA. Then compile your program (from step 1) on the Nios II processor and then run it on the system you downloaded to the FPGA. Push the frequency and throughput of the Nios II processor as high as you can get. Calculate the runtime and make sure you are still getting the right count of palindromes. What is the runtime? How much slow is the Nios II system compared to your PC? Note that you might like to valuate the system by counting the palindromes in 0-1000 and in 0-1000000 and extrapolate to 1 billion.
3. [Due date Nov 14 - 30 points] Code in Verilog a module that when given a number, it should return 1 or 0 to indicate whether the number is a palindrome or not. Test the module by using simulation vectors in the Quartus II tool.
4. [Due date Nov 21 – 30 points] Use the module from step 3 to create an accelerator for the system built in step 2. You can implement the accelerator as a custom instruction, as a memory-mapped IO component, or a QSys component that communicates with the Avalon bus to the processor. Rerun your program using the accelerator and verify that it is still reporting the correct count and measure the runtime. Contrast the runtime against that step 2 and measure the speedup. How does the runtime compare to step 0?
5. [Due date Nov 21 – 20 points] In this exercise your goal is beat the improvement in question (4) by deploying multiple accelerators to evaluate more palindromes simultaneously. You will need to work on optimizing your code, HW and total runtime to get full credit. Here are the ranges
   - You score will be 0/20 if your runtime is between 500-1000 seconds.
   - You score will be 5/20 if your runtime is between 200-500 seconds.
   - You score will be 10/20 if your runtime is between 100-200 seconds.
   - You score will be 15/20 if your runtime is between 20-100 seconds.
   - Your score will be 20/20 if your runtime is less than 20 seconds.