Building a Custom Instruction with the Nios Processor

Due: See course web-page

In this exercise, you will use your existing implementation of the round up circuit to create a custom instruction to perform hardware round up. The instruction will take a 32-bit unsigned integer and return the rounded-up value. To test your design, you will create two programs:

1. A program that performs round up in the software. Refer to Altera documentation on creating custom instruction and how to use the fine grain timer to measure execution time. The program is to randomly generate 500,000 unsigned integers. These integers will then be rounded up to the next 2^n if they are not exactly 2^n already. You will measure the execution time of the program and the time spent in EACH round up function call. You will report the percentage of execution time spent in the round up function and the basic statistics of the round up function: minimum execution time, maximum execution time, average execution time, and standard deviation. Present your data as a box plot.
2. Another version of the same program that replaces the software round up operation with the hardware extension instruction. Once again, generate 500,000 unsigned integers. These integers will then be rounded up to the next 2^n if they are not exactly 2^n already. You will measure the execution time of the program and the time spent in EACH round up function call (hardware). You will report the percentage of execution time spent in the round up function and the statistics of the round up function: minimum execution time, maximum execution time, average execution time, and standard deviation. Present your data as a box plot.

Write a short report that discusses the following issues:

- **Anticipated result.** Does the result meet your expectation? For example, you may have initially anticipated more performance speed-up than what you are able to achieve. Analyze why you did or did not get the expected result. My suggestion is to develop a hypothesis that describes what you expect to achieve, and what are the rationales for having such expectation. Then compare the obtained result and analyze whether the rationales used to develop your hypothesis are correct.
- **Noises in data collection.** Do you experience any factors that affect the accuracy of the data collection technique (e.g. timing function, data recording function)? Factors that cause inaccuracy are often referred to as noises. What are the sources of these noises? How would you further improve the accuracy of the data collection process?
- **The speed-up obtained through hardware**. Make sure that you evaluate the *Return On Investment* (*ROI*). Specifically, discuss whether the performance gain is worth the additional hardware investment. A suggestion is to compare the two box plots and analyze the sources of the difference in performance.
- **The amount of time spent on this assignment.** Evaluate the time spent in learning Quartus and NIOS. Also evaluate the time spent in creating instruction extension, data collection, and data analysis. Comment on the development environment (hardware design and software programming) and suggest at least three improvements.