Assignment description – Project 4

Objective

Build the Hack computer platform, culminating in the topmost Computer chip. With this step the hardware of our computer is complete!

Resources

The only tools that you need for completing this project are the hardware simulator supplied with the book (the same as the one used for projects 1-2) and the test scripts. The computer platform should be implemented in the HDL language specified in appendix A.

The templates of the Computer and the Memory are given the project directory. The template of the CPU (cpu-commented.hdl) is provided on the webpage (together with this description). The CPU template includes step-by-step suggestions for a possible way of constructing the chip.

Contract

The computer platform built in this project should be capable of executing programs written in the Hack machine language, specified in chapter 4. Demonstrate this capability by having your Computer chip run the test programs given in the project directory.

Component Testing

The project directory also contains test scripts and compare files for unit-testing the Memory and CPU chips in isolation. It is important to complete the testing of these chips before building and testing the overall Computer chip.

Test Programs

A natural way to test the overall Computer chip implementation is to have it execute some sample programs written in the Hack machine language. In order to run such a test, one can write a test script that loads the Computer chip into the hardware simulator, loads a program from an external text file into its ROM chip, and then runs the clock enough cycles to execute the program. We the project directory supplies all the files necessary to run three such tests. Before testing your Computer chip on any one of the above programs, read the test script associated with the program and be sure to understand the instructions given to the simulator. Appendix B may be a useful reference here.

1. Add.hack: Adds the two constants 2 and 3 and writes the result in RAM[0].
2. Max.hack: Computes the maximum of RAM[0] and RAM[1] and writes the result in RAM[2].
3. Rect.hack: Draws a rectangle of width 16 pixels and length RAM[0] at the top left of the screen.

Steps

Build the computer in the following order:

Memory: Composed from three chips: RAM16K, Screen, and Keyboard. The Screen and the Keyboard are available as built-in chips and there is no need to build them. Although the RAM16K chip was built in the project in chapter 3, we recommend using its built-in version, as it provides a debugging-friendly GUI.

CPU: Can be composed according to the proposed implementation given in figure 5.9, using the ALU and register chips built in chapters 2 and 3, respectively. We recommend using the built-in

versions of these chips, in particular ARegister and DRegister. These chips have exactly the same functionality of the Register chip specified in chapter 3, plus GUI side effects.

Computer: The topmost Computer chip can be composed from the chips mentioned earlier, using figure 5.10 as a blueprint. Use the built-in ROM32K chip for ROM.

Hints

The implementation of the Computer is straightforward.

To implement the Memory all you need is to solve the addressing.

The CPU implementation is complex. You need to remember the ALU functionality and the structure of the Hack machine language instructions and programs. Try to construct the blocks of the CPU one by one: the interpretation of the instruction, the handling of the A and D registers, the ALU and finally the PC.

Comment your programs, so that you can easily present your solution in class.

Submission

Your project must be mailed to your group leader by the deadline given on the course web. Make sure that the subject field states *EP1200-groupN*, if you are in seminar group N. All projects should be done individually.

One submission per student, in a zipped file named EP1200-seminarM-GroupN-firstname-familyname.zip including:

- The three HDL files for Memory, CPU, Computer.
- The list of the sub-projects you solved successfully and are able to present. Use the provided form. Add also your name!

Copying and other forms of plagiarism and cheating will be reported for disciplinary action!