Homework 9:  
SAM

Homework is due in class on the date indicated above. Late homeworks will be penalized by weighting errors on those problems that were completed past the due date by the number of days past the due date plus an extra 5% per day. Please indicate which problems, if any, took extra time.

For this homework, you are going to write a sequential description of a microprocessor and decompose this to a collection of communicating processes. You will be required to use the chpsim simulator to test the initial and final descriptions of the microprocessor.

1. Sequential CHP description of a SAM  
   Write a sequential description of a processor that implements the Simple Asynchronous Microprocessor(SAM) architecture. Use arrays, named imem and dmem to respectively implement the instruction and data memories. You may assume that the imem is externally initialized.

   It will be useful to write the sequential CHP in such a manner that it is possible to distinguish the part that computes the program counter, pc, from the part that executes the instructions. Name this process SAM. Simulate the SAM process in chpsim to verify that it is correct.

2. Isolating the memories and register file  
   Since the implementation of a memory differs from the implementation of other logic, it is useful to isolate memories to their own process. Decompose your description from the previous part into 3 process such that:

   \[ SAM \equiv SAM_2 \parallel IMEM \parallel DMEM \]

   where IMEM and DMEM are processes whose interfaces only permit reads and/or writes to the respective memories. Do not remove the original CHP body of the SAM process from your code, simply add a META body to the process.

   For similar reasons, it will be helpful to isolate the register file into a process that permits only reads and writes to one or more registers. Let this process, REGFILE be such that

   \[ SAM_2 \equiv SAM_3 \parallel REGFILE \]

3. Isolating the fetch  
   Often, the throughput of a microprocessor is limited by the rate at which instructions can be fetched from the instruction memory. Decompose the SAM_3 process into two process FETCH and EXEC. Let the FETCH process handle all accesses to the IMEM and any manipulations of the pc. The EXEC process implements all instructions that do not modify the pc.

   \[ SAM_3 \equiv FETCH \parallel EXEC \]

4. Completing the decomposition  
   Decompose the EXEC process so that

   • there is a process that handles all ALU instructions
   • there is a process that handles all DMEM instructions
   • there is a process that handles all SHIFT instructions

   Decompose the FETCH into 3 processes as follows:
Let the \textit{PCUNIT} process handle all manipulations of the \textit{pc}. Let the \textit{YMODE} process compute the \textit{y} operand of the instruction and forward it to any processes that need it. The \textit{DISPATCH} process will forward the various fields of an instruction to the appropriate processes.

Simulate each level of decomposition in \texttt{chpsim} to convince yourself that no errors have been introduced during the decomposition. Remember to always leave the original CHP description of any processes that you decompose.