Saarland University
Department 6.2 - Computer Science
Prof. Dr. W. J. Paul
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System Architecture (block course) - SS13

Exercise Sheet 3 (due: 19.08.13) - 18 points

Name, matr. nr., time spent: _____

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Exercise 1: (4)

Recall, for $a, k \in \mathbb{N}$, $(a,k)-$RAM is an addressable storage element with addresses in $\mathbb{B}^a$ that - for every address - stores a value in $\mathbb{B}^k$.

(a) (2 points) Give a specification for a 3 port RAM with one read/write port and two read ports.

(b) (2 points) Fully instantiate the 3 port RAM implementation given in the lecture for $a = 2$ and $k = 32$ at an appropriate level of detail (e.g., don't expand the decoders).

Exercise 2: (5)

Recall the predicates defined for MIPS configurations c.

(a) (1 point) Explain where the predicates for $rtype$, $jtype$, and $itype$ come from.

(b) (1 point) Define predicates $and(c)$ and $sysc(c)$, i.e., if $I(c)$ is the instruction with mnemonic "and" or the instruction with mnemonic "sysc", respectively.

(c) (1 point) Give similar predicates for $l(c)$ and $s(c)$, i.e., if $I(c)$ is a load instruction or a store instruction, respectively.

(d) (2 points) Explain the difference between instructions "add" - "addu " -"addi"-"addiu", "sub" - "subu", "slt"-"sltu" (don't forget the negation and the overflow signals!)

Exercise 3: (4)

Recall the MIPS ISA.

(a) (4 points) Implement in MIPS a subroutine for multiplying two binary numbers $a, b \in B_{32}$. Assume that your program starts executing from configuration c, where $c.gpr(\$29)[1:0] = 00$, $\langle c.gpr(\$29)\rangle \geq 16$, $c.m_4(c.gpr(\$29) -_{32} 4_{32}) = \text{bin}_{32}(a)$, $c.m_4(c.gpr(\$29) -_{32} 8_{32}) = \text{bin}_{32}(b)$, $c.m_4(c.gpr(\$29) -_{32} 12_{32}) = rdes$ for some aligned $rdes \in \mathbb{B}^{32}$, $c.m_4(c.gpr(\$29) -_{32} 16_{32}) = ra$ for some aligned $ra \in \mathbb{B}^{32}$ (this is a possible C0 program layout after you call the function performing software multiplication, if you store a stack pointer in register \$29). At the end of the subroutine store $a_{32} *_{32} b_{32}$ in the main memory at address $rdes$, jump to ra and decrement register \$29 by 16 (thus, executing return from the function). Comment your program in a way everyone can understand what it does. Hint: Section 8.4.2 from the script might be helpful.

(b) (bonus) Formulate and prove the correctness of your program.

Exercise 4: (2)

For $i \in \mathbb{N}$, MIPS configurations c and hardware configurations h such that $c^i \sim h^{2i}$, prove:

(a) (1 point) $h^{2i+1}.I = I(c^i)$

(b) (1 point) $c^i \sim h^{2i+1}$

You might want to look into the lecture notes for the precise definition of $\cdot \sim \cdot$.

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Exercise 5: **(3)**

Modify the construction of the MIPS machine given in the lecture in such a way, that it executes instructions in 1 cycle. Draw only those components of the construction which differ from the 2-cycle implementation given in the lecture.