Review Problem 18

- A RISC machine is shown to increase the instructions in a program by a factor of 2. When is this a good tradeoff?

- At least halve CPI * clock period
- Power efficiency
- Code compression (i.e. shorter instr)
- Bloat in irrelevant parts of the program
- Cheaper
RTL & Processor Design

Convert instructions to Register Transfer Level (RTL) specification

\[ \text{RegA} = \text{RegB} + \text{RegC}; \]

RTL specifies required interconnection of units, control

Math unit example:

- (add): \( A = A + B; I++; \)
- (mul): \( A = A \times B; I++; \)
- (hold): \( A = A; I++; \)
- (init): \( A = \text{Din}; I++; \)
Instruction Fetch

\[ \text{Instruction} = \text{MEM}[\text{PC}] \]
\[ \text{PC} = \text{PC} + 4 \]
Add/Subtract RTL

Add instruction: ADD Rd, Rn, Rm

\[
\text{Instr} = \text{Mem}[\text{PC}];
\]

\[
\text{Reg}[\text{Rd}] = \text{Reg}[\text{Rn}] + \text{Reg}[\text{Rm}]
\]

\[
\text{PC} = \text{PC} + 4;
\]

Subtract instruction: SUB Rd, Rn, Rm

\[
\text{Instr} = \text{Mem}[\text{PC}];
\]

\[
\text{Reg}[\text{Rd}] = \text{Reg}[\text{Rn}] - \text{Reg}[\text{Rm}]
\]

\[
\text{PC} = \text{PC} + 4
\]
Add/Subtract Datapath

\[
Rd = \text{inst}[4:0] \\
Rm = \text{inst}[20:16] \\
Rn = \text{inst}[9:5]
\]

\[
\text{Reg}[Rd] = \text{Reg}[Rm] \text{ or } \text{Reg}[Rn]
\]

PC

Add

4

Address Memory

Instruction

Adder

Aw Ab Aa Da Dw

RegFile Db

ALU Op
Load RTL

Load Instruction: LDUR Rd, [Rn, DAddr9]

\[\text{Instr} = \text{MEM}[\text{PC}]\]
\[\text{Addr} = \text{Reg}[\text{Rn}] + \text{Signed} \text{Extended}(\text{DAddr9})\]
\[\text{Reg}[\text{Rd}] = \text{MEM}[	ext{Addr}]\]
\[\text{PC} = \text{PC} + 4\]
Datapath + Load

\[ \text{Addr} = R_{g} \times R + SE(\text{Daddr9}) \]

\[ R_{g}[Rd] = \text{mem}[\text{Addr}] \]
Store Instruction: STUR Rd, [Rn, DAddr9]

\[
\text{Instr} = \text{MEM}[\text{pc}]; \\
\text{Addr} = \text{Reg}[\text{Rn}] + \text{SE}(\text{DAddr9}); \\
\text{Mem}[\text{Addr}] = \text{Reg}[\text{Rd}]; \\
\text{pc} = \text{pc} + 4;
\]
Datapath + Store

\[ \text{Addr} = \text{Reg}[Rn] + 5 \times \text{SE}(\text{DAddr9}) \]
\[ \text{Mem}[\text{Addr}] = \text{Reg}[Rd] \]