HW#5 Solution

Q1. Fetch Phase:

T1 PCout, MARin, Read, Clear Y, Cin=1, Add, Zin

T2 Zout, PCin, WMFC

T3 MDRout, IRin ; 1st part of the instruction

T4 PCout, MARin, Read, Clear Y, Cin=1, Add, Zin

T5 Zout, PCin, WMFC

T6 MDRout, IRin ; 2nd part of the instruction

(a) ADD R1, 10

T7 R1out, Yin

T8 IRout, ADD, Zin

T9 Zout, R1in, END

(b) ADD R1, var1

T7 IRout, MARin, Read

T8 R1out, Yin, WMFC

T9 MDRout, Add, Zin

T10 Zout, R1in, END

(c) Add [var1], R1

T7 IRout, MARin, Read, WMFC
T8 Rlout, Yin
T9 MDRout, MARin, Read, WMFC
T10 MDR out, Add, Zin
T11 Zout, MDRin, write, WMFC
T12 End

(d) JNZ label1

T7 PCout, Yin, if ZF=1 END
T8 IRout, Add, Zin
T9 Zout, PCin, End

Q2 Memory access is synchronous

(c) Add [var1], R1

T7 IRout, MARin, Read
T8 Rlout, Yin
T9
T10 MDRout, MARin, Read
T11
T12
T13 MDRout, Add, Zin
T14 Zout, MDRin, write
T15
T16
T17 END

Q3 ADD R1, 10

- Two-bus organization:

Fetch
- T1 PCout, ALU (C=B), MARin, Read
- T2 PCout, ALU (C=B+1), PCin, WMFC
- T3 MDRout, ALU (C=B), IRin ; 1st part
- T4 PCout, ALU (C=B), MARin, Read
- T5 PCout, ALU (C=B+1), PCin, WMFC
- T6 MDRout, ALU (C=B), IRin ; 2nd part

T7 R1out, ALU (C=B), Ain

T8 IRout, ALU (C=A+B), R1in, END

$$\% \text{ Speedup} = \frac{T_{1\text{-bus}} - T_{2\text{-bus}}}{T_{2\text{-bus}}} \times 100$$

$$= \frac{9\tau_1 - 8\tau_2}{8\tau_2} \times 100$$

$$\tau_1 = \tau_{tristate} + \tau_{bus} + \tau_{ALU} + \tau_{FF}$$
$$= 5ns + 5ns + 14ns + 6ns = 30ns$$

$$\tau_2 = \tau_{tristate} + \tau_{bus} + \tau_{ALU} + \tau_{bus} + \tau_{FF}$$
$$= 5ns + 5ns + 14ns + 5ns + 6ns = 35ns$$

$$\Rightarrow \%\text{Speedup} = \frac{9 \times 30ns - 8 \times 35ns}{8 \times 35ns} \times 100 = -3.6\%$$

This means that for this instruction and propagation delay values given, the single-bus organization is faster.

- Three-bus organization:

Fetch
- $T_1$ PCout, MARin, B, Read, ALU(C=B+1), PCin, WMFC
- $T_2$ MDRout, ALU(C=B), IRin; 1st part
- $T_3$ PCout, MARin, B, Read, ALU (C=B+1), PCin, WMFC
- $T_4$ MDRout, ALU (C=B), IRin ; 2nd part

$T_5$ Rlout, B, IRout, ALU (C= A+B), Rlin, END

$$\% \text{ speedup} = \frac{T_{1\text{-bus}} - T_{3\text{-bus}}}{T_{3\text{-bus}}} \times 100$$

$$= \frac{9\tau_1 - 5\tau_3}{5\tau_3} \times 100$$

$\tau_1 = 30\,ns$

$\tau_3 = \tau_{tristate} + \tau_{bus} + \tau_{ALU} + \tau_{bus} + \tau_{FF} = 35\,ns$

$$\Rightarrow \% \text{ speedup} = \frac{9 \times 30ns - 5 \times 35ns}{5 \times 35\,ns} \times 100 = 54.3\%$$

Q4 (a)

$$Add = T_1 + T_4 + Inst1 \cdot T_8 + Inst2 \cdot T_9 + Inst3 \cdot T_{10} + Inst4 \cdot T_8$$

$$END = Inst1 \cdot T_9 + Inst2 \cdot T_{10} + Inst3 \cdot T_{12} + Inst4\,(T_9 + T_7 \cdot ZF)$$

(b) Horizontal Control word:

PCin, PCout, MARin, MDRout, IRin, IRout, Yin, Zin, Zout, Rlin, Rlout, Cin, Clear Y, Add, Read, Write, WMFC, END, MDRin