

Advanced and parallel architectures

Prof. A. Massini

June 13, 2017

Part A

Student's Name

Matricola number

Exercise 1 (5 points)	
Exercise 2 (4 points)	
Exercise 3 (4 points)	
Exercise 4 (5 points)	
Exercise 5 (7 points)	
Exercise 6 (3 points)	
Exercise 7 (4 points)	
Total (32 points)	

Exercise 1 (3 + 2 points) – Instruction pipeline

a) Consider the following loop expressed in a high level language:

```
for (i =0; i < N; i ++)  
{  
    vectA[i] = vectA[i] + 4;  
    vectB[i] = vectB[i] + 2;  
}
```

The program has been written in MIPS assembly code, assuming that registers \$t6 and \$t7 have been initialized with values 0 and 4N respectively. The symbols VECTA, VECTB and VECTC is a 16-bit constant.

Let us consider the loop executed by 5-stage pipelined MIPS processor WITHOUT any optimisation in the pipeline.

1. Identify the Hazard Type (Data Hazard or Control Hazard) in the last column
2. In the first column identify the number of stalls to be inserted before each instruction (or between stages IF and ID of each instruction) necessary to solve the hazards
3. For each hazard, add an ARROW to indicate the pipeline stages involved in the hazard

Num. Stalls	INSTRUCTION	C1	C2	C3	C4	C5	C7	C6	C8	C9	C10	C11	C12	C13	C14	Hazard Type
	FOR: beq \$t6,\$t7,END	IF	ID	EX	ME	WB										
	lw \$t2,VECTA(\$t6)		IF	ID	EX	ME	WB									
	addi \$t2,\$t2,4			IF	ID	EX	ME	WB								
	sw \$t2,VECTA(\$t6)				IF	ID	EX	ME	WB							
	lw \$t3,VECTB(\$t6)					IF	ID	EX	ME	WB						
	addi \$t3,\$t3,2						IF	ID	EX	ME	WB					
	sw \$t3,VECTB(\$t6)							IF	ID	EX	ME	WB				
	addi \$t6,\$t6,4								IF	ID	EX	ME	WB			
	blt \$t6,\$t7,FOR									IF	ID	EX	ME	WB		

b) Specify the number of stalls actually inserted taking into account that solving some hazards can help to solve those that follow

Exercise 2 (4 points) - Number representation

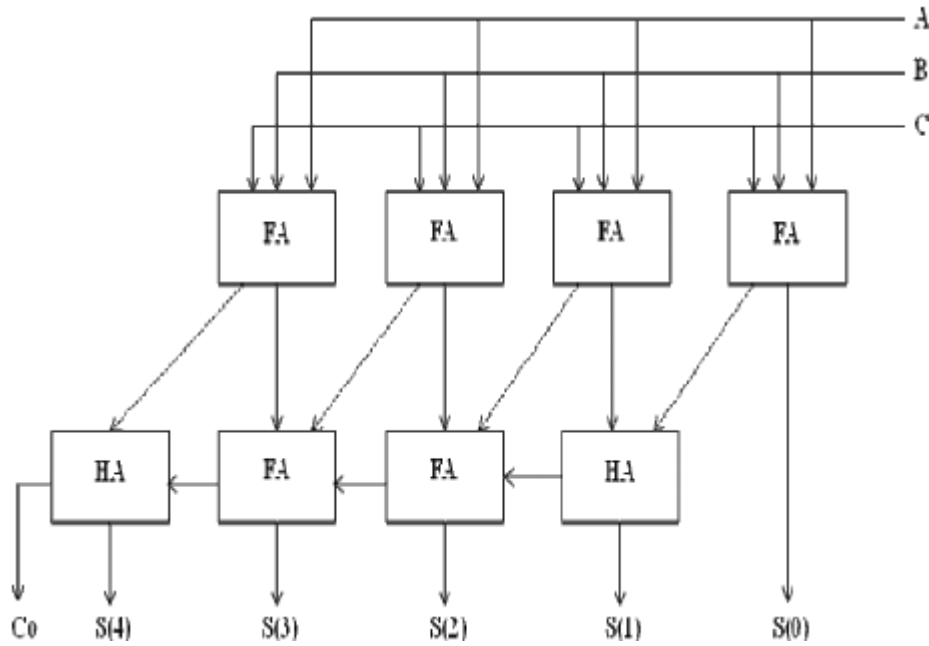
Represent the natural number range $[0; 359]$ using the **residue number system**, considering different choices of the moduli set (at least three different choices). Compare the different choices with respect to the number of bits necessary for the representation. Consider also the number of bits needed for representing the range $[0; 359]$ with the conventional binary system.

Represent $A=45$ and $B=67$ using the considered different choices of the moduli sets, and show how to compute the sum $A+B$.

Exercise 3 (4 points) - Circuit time and area

Compute the time (propagation delay) and area required by the 4-bits Carry-Save-Adder, that is an adder for three values A, B and C, shown here below.

Compute the speedup of 4-bits Carry-Save-Adder with respect to the standard binary ripple-carry adder.



Exercise 4 (5 points) Pipelined operations

Given the values $A=6$ and $B=5$, show the scheme and the execution of the pipelined multiplications $A \times B$. Verify the results.

Exercise 5 (4 + 3 points) – Number representation

a) Given the values $A = 00\ 00\ 00\ 11\ 10$ and $B = 01\ 00\ 10\ 11\ 01$ in the signed RB (Redundant Binary) representation, convert A and B in decimal. Show the execution of operation $A+B$.

b) Show the procedure to verify if the result is 0.

Exercise 6 (3 points) – Loop dependences

In the following loop, find all the true dependences, output dependences and antidependences.

Eliminate the output dependences and antidependences by renaming.

```
for (i=1; i<=n; i++) {  
    Y[i]= X[i]+2;    \*S1*\  
    W[i]= W[i]+X[i]; \*S2*\  
    X[i]= Y[i]-1;   \*S3*\  
    W[i]= Y[i]+3;   \*S4*\  
    Y[i]= X[i]*2;   \*S5*\  
}
```

Exercise 7 (4 points) – Arithmetic operations

Show the execution of the multiplication $A \times B$, where $A=10110001$ and $B=011101110$, in the standard way and using the Booth recoding. Explain what is the gain when Booth recoding is applied.