

Intensive Computation

Prof. A. Massini

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Part B

- Student's Name -

- *Matricola* number -

Exercise 1 (7 points)	
Question 1 (4 points)	
Exercise 2 (3 points)	
Exercise 3 (6 points)	
Exercise 4 (7 points)	
Question 2 (4 points)	
Total (31 points)	

Exercise 1 (7 points) – Interconnection Networks

- a) Design a Clos network of size 920×920 , using modules having **18 inputs in the first and middle stages** (whereas the third stage is symmetrical to the first), specifying the size and the number of switches for each stage. Consider both cases, **strictly non-blocking** and **rearrangeable** network.
- b) Describe how a **Benes network** is built and define how big a Benes network should be to accommodate 920 inputs/outputs.
- c) Compare the cost of the Clos network designed in previous point a), in both cases strictly non-blocking and rearrangeable and the Benes network defined in point b).

Exercises 3 (6 points) Performance equation

Suppose we have made the following measurements, where we are considering the set of Arithmetic and logic instructions (A&L), the **subset** of Arithmetic Instruction (AR) and the **subset** of only integer Multiplications and Divisions (MD):

Frequency of A&L operations = 40%

Average CPI of A&L operations = 5

Frequency of MD = 10%

CPI of MD = 7

Frequency of AR = 20%

CPI of AR = 4

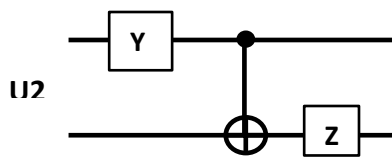
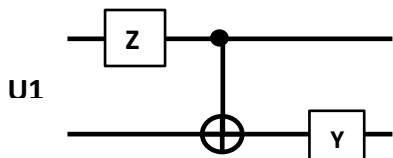
Average CPI of other (than A&L) instructions = 3.5

Assume that you have the following design alternatives: i) to decrease the CPI of A&L to 3.5; ii) to decrease the average CPI of MD operations to 4.4; iii) to decrease the average CPI of AR operations to 3.4.

- a) Compare these three design alternatives using the processor performance equation and give the speed-up in each case.
- b) What would the speedup be if both enhancements on MD and AR were applied?

Exercise 4 (7 points) – Quantum circuits

Consider the two-qubit transformations U1 and U2 shown below



where $Y = \begin{bmatrix} 0 & -i \\ i & 0 \end{bmatrix}$ and $Z = \begin{bmatrix} 1 & 0 \\ 0 & -1 \end{bmatrix}$

- Show what transformations U1 and U2 represent, writing the associated 4x4 matrices.
- Show how U1 and U2 act on the states $|01\rangle = |1\rangle \otimes |0\rangle$ and $|10\rangle = |1\rangle \otimes |0\rangle$.
- Compute the probability of measuring $|01\rangle$ and the probability of measuring $|10\rangle$.

