Intensive Computation

Prof. A. Massini

9 June 2023

Part B

- **Student's Name** -

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- ***Matricola* number** -

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

Exercise 1 (6 points) – Interconnection Networks

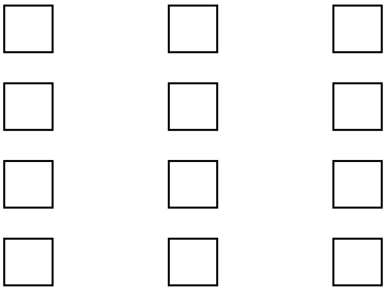
a) Design a Clos network of size 420 x 420, using modules having **24 inputs in the first and middle stages** (whereas the third stage is symmetrical to the first), specifying the size and the number of switches for each stage. Consider both cases, **strictly non-blocking** and **rearrangeable** network.

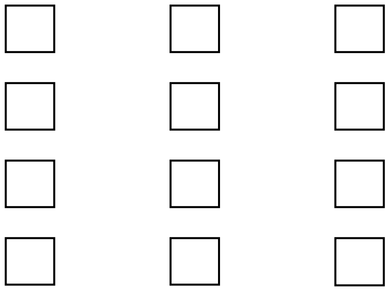
b) Compare the cost of the crossbar 420 x 420 and the Clos network, strictly non-blocking and rearrangeable, designed in the previous point.

c) Compare the cost of a baseline network large enough to accommodate 420 inputs/outputs and the designed Clos network, strictly non-blocking and rearrangeable.

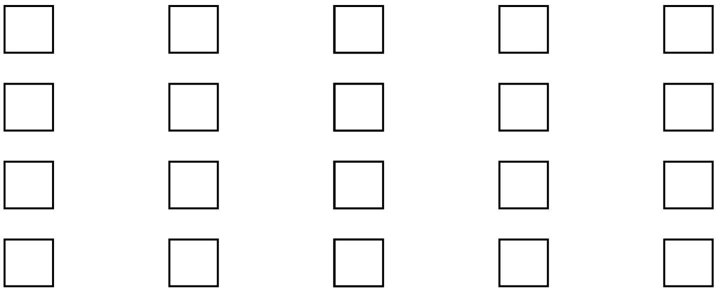
Exercise 2 (4 points) – Interconnection Networks

a) Complete the scheme of the Baseline and Butterfly networks of size N=8 and show if they can realize permutation $P = \begin{pmatrix} 01234567 \\ 40527316 \end{pmatrix}$, showing the switch setting obtained using the self-routing algorithm, and explaining how to do it.





b) Complete the scheme of the Butterfly-ReverseButterfly network of size N=8 and show how it realizes the permutation $P = \begin{pmatrix} 01234567 \\ 40527316 \end{pmatrix}$, using the Looping algorithm also explaining how to do it.



Exercise 3 (3 points) – Interconnection networks

Explain how an Extended Generalized Fat Tree (XGFT) is organized and show the representation of XGFT(3; 4, 2, 2; 1, 4, 1).

Exercises 4 (4 points) Amdhal Law

The following measurements are recorded with respect to the different instruction classes for the instruction set running a given set of benchmark programs:

Instruction Type	Instruction Count (millions)	Cycles per Instruction
Arithmetic and logic	8	7
Load and store	6	3
Branch	6	6
Others	10	5

Assume that "*Arithmetic and logic*" instructions can be modified so that they take 5 cycle per instruction. Compute the speedup obtained by introducing this enhancement using the **Amdhal law**.

Then assume that "*Branch*" instructions can be modified so that they take 5 cycle per instruction. Compute the speedup obtained by introducing this enhancement using the **Amdhal law**.

Then, compute the speedup obtained if both "*Arithmetic and logic*" and "*Branch*" instructions are modified (taking both 5 cycles per instruction).

Exercises 5 (5 points) Performance equation

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

Frequency of A&L operations = 45%
Average CPI of A&L operations = 3
Average CPI of other instructions = 2.2
Frequency of MD = 10%
CPI of MD = 7

a) Assume that the two design alternatives are to decrease the CPI of A&L to 2.5 or to decrease the average CPI of all MD operations to 3.4. Compare these two design alternatives using the processor performance equation and give the speed-up in each case.
b) What would the speedup be if both enhancements were applied?

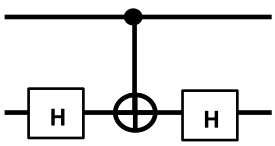
Exercise 6 (3 points) – Quantum circuits

a) Consider the two-qubit system state $|\psi_1\psi_2\rangle$, where $|\psi_1\rangle = \frac{\sqrt{6}}{3}|0\rangle - \frac{1}{\sqrt{3}}i|1\rangle$ and $|\psi_2\rangle = \frac{\sqrt{3}}{2}|0\rangle + \frac{1}{2}i|1\rangle$ and give the state vector representing it.

a) Compute the probability of measuring $|01\rangle$ and the probability of measuring $|10\rangle$.

Exercise 7 (4 points) – Quantum circuits

Consider the following circuit.



a) Calculate the matrix of the circuit and verify it is unitary.

b) Show the effect when the circuit is applied on states $|00\rangle$ and $|10\rangle$.

c) Show the effect when the circuit is applied on state $|\psi_1\psi_2\rangle$, where $|\psi_1\rangle = \frac{\sqrt{6}}{3}|0\rangle - \frac{1}{\sqrt{3}}i|1\rangle$ and $|\psi_2\rangle = \frac{\sqrt{3}}{2}|0\rangle + \frac{1}{2}i|1\rangle$ (it is the same computed in exercise

Question (3 points) – Quantum circuits

Show which quantum gates you need to obtain the Bell states.