Advanced Architectures

Prof. A. Massini

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End-of-term test

Student's Name

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Matricola **number**

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

Exercise 1 (4 points) - GPU & CUDA

You need to write a kernel that operates on a matrix of size **1440x2340**. You would like to assign a thread to each element of the array and use the maximum possible number of threads per block on your device.

a) How would you select the dimensions of a **2D grid and 2D rectangular blocks** for your kernel, minimizing the number of idle threads? Consider a device having compute capability 1.3.

a) How would you select the dimensions of a **2D grid** and **3D blocks** with the three sides all equal for your kernel, minimizing the number of idle threads? Consider a device having compute capability 3.7.

Technical specifications	Compute capability (version)									
	1.0	**1.1**	**1.2**	**1.3**	**2.x**	**3.0**	**3.5**	**3.7**	**5.0**	**5.2**
Maximum dimensionality of grid of thread blocks	2				3					
Maximum x-dimension of a grid of thread blocks	65535					2^{31}-1				
Maximum y-, or z-dimension of a grid of thread blocks	65535									
Maximum dimensionality of thread block	3									
Maximum x- or y-dimension of a block	512				1024					
Maximum z-dimension of a block	64									
Maximum number of threads per block	512				1024					
Warp size	32									
Maximum number of resident blocks per multiprocessor	8					16			32	
Maximum number of resident warps per multiprocessor	24		32		48	64				
Maximum number of resident threads per multiprocessor	768		1024		1536	2048				
Technical specifications	**1.0**	**1.1**	**1.2**	**1.3**	**2.x**	**3.0**	**3.5**	**3.7**	**5.0**	**5.2**
	Compute capability (version)									

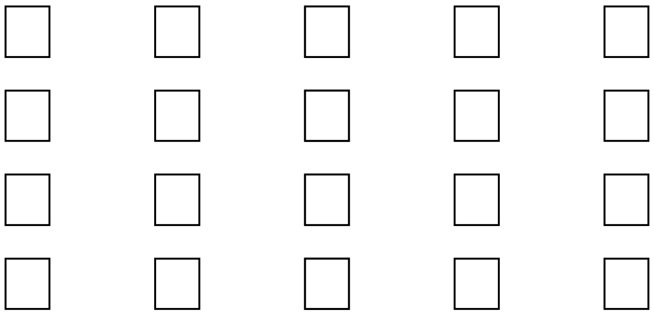
Exercise 2 (4 points) – Interconnection Networks – CLOS

Design a Clos network of size 510 x 510, using in the first stage modules having 20 inputs. Consider both cases, strictly non-blocking and rearrangeable network.

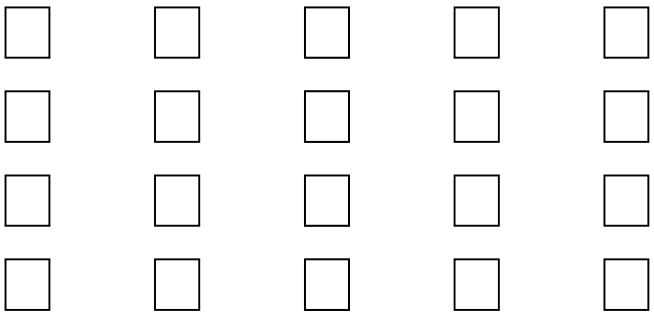
Compare the cost of the crossbar 510 x 510 and the Clos network, strictly non-blocking and rearrangeable non-blocking, designed in the previous point.

Exercise 3 (4 points) – Interconnection networks – (2 log N - 1) MIN

Draw a Shuffle-Shuffle network of size N=8 using the switches below. Is it possible to realize the permutation $P = \begin{pmatrix} 01 & 23 & 45 & 67 \\ 46 & 10 & 32 & 75 \end{pmatrix}$ setting all the switches in the central stage on the straight state?



Which multistage network with 2logN -1 stages would you use to route the permutation P above, that guarantees to find a solution? Draw the network and show the connections, making clear how you obtain the final configuration.



Question 1 (4 points)

Briefly explain what entanglement between two qubits is, how it can be explained in mathematical terms and show the expressions of the Bell states.

Question 2 (4 points)

Explain what CUDA threads are and how they are organized in terms of blocks and grids. Describe how to obtain a unique ID for each thread by using the block ID and thread ID, in the case of a 2D grid and 2D blocks and in the case of 1D grid and 3D blocks.

Exercises 4 (4 points) – Interconnection networks

Illustrate the design of an XGFT(3; 4, 2, 2; 1, 4, 2), specifying how many nodes there are on each level, how many parents and children they have, and then showing the drawing of the network.

Exercises 5 (4 points) – Quantum qubit systems

a) Verify which of the following systems consisting of two qubits is valid:

$$\psi_1 = \frac{1}{2\sqrt{3}}\,|00\rangle + \frac{3}{2\sqrt{15}}i|01\rangle + \frac{1}{3}i|01\rangle - \frac{\sqrt{3}}{\sqrt{15}}\,|11\rangle$$

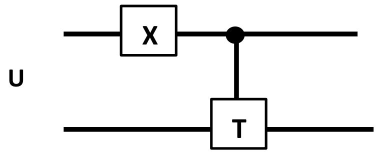
$$\psi_2 = \frac{\sqrt{6}}{6}\,|00\rangle + \frac{\sqrt{6}}{2\sqrt{3}}i|01\rangle + \frac{1}{2\sqrt{3}}i|01\rangle - \frac{1}{2}\,|11\rangle$$

b) Compute the probability of measuring $|01\rangle$ for the valid system

c) Compute the two component qubits for the valid system and the probability of measuring $|0\rangle$ for each of them.

Exercise 6 (4 points) – Quantum circuits

Consider the two-qubit transformations U based on gates $X = \begin{bmatrix} 0 & 1 \\ 1 & 0 \end{bmatrix}$ and $T = \begin{bmatrix} 1 & 0 \\ 0 & e^{i\frac{\pi}{4}} \end{bmatrix}$ shown below



- Show what transformations U represents, writing the associated 4x4 matrices.
- Show how U acts on the state represented by the statevector $[\frac{1}{2};\ \frac{i}{2\sqrt{3}};\ -\frac{i}{\sqrt{2}};\ \frac{\sqrt{2}}{2\sqrt{3}}i\ ]$.