Laboratory for Parallel Programming
Prof. Dr. Felix Wolf

TECHNISCHE UNIVERSITÄT DARMSTADT

Mock exam

Large-Scale Parallel Computing

February 8, 2016

Name _____

Surname _____

Student number _____

Study _____

Intended degree _____

- Please write your **name**, **surname**, and **student number** on every sheet.
- Please give your answers in readable and understandable form, and explain them properly.
- Please answer the tasks on the **task sheets** (also use back sides). Ask for additional task sheets if needed.
- Please **strike through** answers you don't want to be considered.
- Please use a **document proof pen** in black or blue color (No pencil!).
- If you are observed trying to deceive, the exam is graded as **0 points**.
- Please hand in **all sheets together with the task sheets** in the end.

Task	Pt.	OK
1.1	18	
1.2	26	
1.3	16	
1	60	

Task	Pt.	OK
2.1	25	
2.2	20	
2.3	15	
2	60	

	Task 1	Task 2	Sum
Points	60	60	120
OK			

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Task 1 (60 points)

Task 1.1 (6 + 3 + 3 + 3 + 3 = 18)

a) Give three costs and three benefits of parallelization (3 + 3 = 6)

b) What is hybrid parallel programming? (3)

c) What is peak performance? (3)

d) What is spatial locality? (3)

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e) What is weak scaling? (3)

Task 1.2 (8 + 10 + 8 = 26)

a) Draw the architecture of a typical supercomputer (8)

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b) What are the two types of shared memory systems? What are their pros and cons. Draw a figure of each. (10)

c) Describe Flynn's classification of computer architectures. (8)

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Task 1.3 (6 + 6 + 4 = 16)

a) Name and describe three metrics for network evaluation (6)

b) What is Amdahl's law? Based on Amdahl's law, how is the speedup calculated for single and multiple processor configurations. (6)

c) What should be the size of the sequential region to achieve a speedup of 50 on 80 processors? (4)

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Task 2 (60 points)

Task 2.1 (5 + 5 + 15 = 25)

a) What is the difference between the size and extent of an MPI data type? (5)

b) Create an MPI data type that covers the diagonal of a square matrix of type double. Assume the length of each side of the matrix to be `DIM_LEN = 4*N`. However, instead of `4*N`, the datatype should only cover `N` consecutive elements on the diagonal. Note: Provide your solution in the C language. Only code for the creation of the MPI data type is necessary. (5)

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c) Now assume that a `4*N` $\times$ `4*N` matrix is stored on process 0. Use the data type described above to distribute the diagonal of this matrix equally among processes of the MPI program. The total number of processes is 4. (15)

Task 2.2 (5 + 5 + 10 = 20)

a) What are the necessary conditions to write a custom reduction function? Is the order of invocation affected by any property? (5)

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b) Write a reduction operator that calculates the LCM (least common multiple). Assume there is a function
`int mat_lcm(int val1, int val2)`
already defined that calculates the LCM of `val1` and `val2`. (5)

c) Assume that in an MPI program, each process has `5` values stored in an integer array `val_array`. Using the above function, write a program such that each process finds the LCM of all the values in the program. At the end, there should be only 1 value which is the LCM of all the values and this value should be known to each process. (10)

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Task 2.3 (5 + 10 = 15)

a) Write the necessary MPI code to create a ring topology of processes. Assume there are in total `N` processes. (5)

b) Write the necessary MPI code, such that in the ring topology created above, each process prints its rank in `MPI_COMM_WORLD`. The algorithm should be such that, rank 0 (in `MPI_COMM_WORLD`) passes around a token message in the ring topology. When a process receives this token, it prints its `MPI_COMM_WORLD` rank and forwards the token to its neighbor in the ring. Process 0 starts with printing its rank as it already has the token. (10)