DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING
AY 2025-26

HIGH PERFORMANCE COMPUTING (22CS71)

7th SEMESTER B SECTION

LA-2 PROGRAMMING ASSIGNMENT (10 Marks)

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Instructions:
- Write the C language code to provide the solution to the problem statement assigned to you.
- Late submissions will not be accepted.
- Students must demonstrate the functioning of the programs that have been assigned to them. On the fly changes to the problem during the demonstration will have to be made and executed accordingly.
- If the degree of similarity between programs of students who would have been assigned the same problem is found to be high, then both the students will be awarded zero marks.
- **If student is unable to give a demonstration on the specified schedule, He/She should exchange with the student who will present during his schedule,2 days prior intimation must be sent to the course faculty along with the proof.**

Problem Statements:

1. There exists an apple orchard in Kashmir where the apple trees are planted in very neat rows and columns. There are 100 rows and 100 columns of trees in this orchard. The orchard has a team of four Robots. Each Robot can count the number of Red apples and Green apples in a tree, and then move to the next tree in the row and continue counting. Once it completes the traversal of one row it will stride to a row which is 4 rows away from the current row. The orchard owner is interested in getting a running count of the red and green apples during the process of counting by the Robots. To accomplish this there is a central site in which the consolidated running counts of Red and Green apples are maintained. Each Robot sends its total count values after it traverses a row completely.

   Assume a shared memory model, where the consolidated counts are maintained in global memory. The functions carried out by each Robot should be modeled as a separate thread (P1..P4). Let the master thread be P0. This master thread should wait for a request from the console and based on this print the accumulated values of the count of the Red and Green apples which is resident in global memory. Use Open MP.

2. In the above problem consider the following additional requirement. All Robots asynchronously keep doing their work while counting the number of red and green apples in a row of trees. However, the movement from one row to the other will happen when all

the Robots complete the job of counting apples in their assigned rows. Modify the threads modelling the Robots to accommodate this new requirement using Open MP.

3. An Army platoon is conducting mock battle drills. The exercise comprises of two teams named the Red and the Blue, with eight members in each group. The Blue team must defend the territory allocated to it against an invasion by the Red team. In addition, there is a team in the HQ which keeps monitoring both the teams. Every team member is given a Radio set as a part of his combat gear. The Radio sets (R0 … R7) of the Red team operates in the500 MHz & 550 MHz bands, while that of the Blue team (B0 … B7) operates in the 500 MHz and 600 MHz bands. The HQ has both types of Radio sets labelled as HQR and HQB. Initially, all Radio sets work on the 500 MHz band using which the Platoon Commander briefs all the team members about the objectives of the exercise. Once the mock combat starts the teams switch to their respective individual frequencies until the end of the exercise. Model this using Open-MPI programming constructs. You can model the initial phase as a "Briefing" function, and subsequently the team members of each team can be modeled as performing "Red strategy" function and "Blue Strategy" function respectively. The focus of the problem is on the modeling of the "communication groups".

4. MTR runs a set of four restaurants in Bangalore geographically distributed (labelled M0 … M3).. In order to profitably run the chain, the manager located in M0 collects information on an hourly basis from all the locations. The following data set is collected on an hourly basis: (Number of Customers, Number of Rice Idlis sold, Number of Vadas sold, Number of Dosas sold, Number of Rava Idlis sold). At the end of the day the manager sends the accumulated count of each item to all the restaurants for their information. Assume that the restaurants work only for 3 hours. (Therefore, each restaurant sends 3 messages to the head office and receives one message from the head office.) Model this using OpenMPI.

5. A shopping Mall has three entrance gates and four exit gates (Note: the security guards ensure that entrance gates are strictly used only for entering the mall and the exit gates only for leaving the mall). We need to ensure that all the customers have left the mall before closing and locking up the mall. Design a multi-threaded program using shared memory paradigm to keep track of the number of persons entering the Mall, and the number of persons leaving the Mall. A thread should be spawned for handling the activity for each gate of the mall. Use Open MP.

6. Assume that there are two Matrices A & B of size 4x4. We need to determine the following
   i. $\sum A_{i,j} + \sum B_{i,j}$ for i = 0 to 3 and j = 0 to 3.
   ii. Min element of A + Min element of B
   iii. Max element of A - Max element of B

   Use OpenMP / pthreads with appropriate "reduction" operations for doing the job. Use 4 threads and distribute data using Chunks and Stride schemes.

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Use MPI with (Scatter & Gather) and Reduction operations for doing the job. Use 4 processes

8. Determine the area under the parabola $y2 = 40*x$ which lies in the first quadrant of the coordinate axis. Assume x coordinate range is (0, 20). Assume this is divided into 100 strips. Implement the program using four processes in MPI.

9. Use Cuda and GPU and solve Problem 1. Choose 4 blocks and 4 threads / block.

10. Use Cuda and GPU and solve Problem 6. Choose 1 block and 4 threads / block.

11. Determine the area under the parabola $y2 = 40*x$ which lies in the first quadrant of the coordinate axis. Assume x coordinate range is (0, 10). Assume this is divided into 100 strips. Implement the program using CUDA with 1 block containing 5 threads.

12. A long underground tunnel has been built cutting across a mountain. Due to the difficult terrain, the tunnel had to be pretty narrow and the width was just sufficient to accommodate one vehicle. Also, as some sections of the tunnel had bridges over very deep gorges, it was decided to let only one vehicle into the tunnel at any time. Each end of the tunnel has a controller which regulates entry into the tunnel and also tracks exit of the vehicles from the tunnel. Write a multi-threaded program to mimic this system. Assume, that at any time a random number of vehicles are present at the entrances. Use MPI programming.

13. There is a very large lake with boat rental facility. There are three renting stations. People can hire the boat from any of these stations and after using it can park it any of the four designated areas around the lake. Each rental agency has been allocated a unique colour: Red, Blue and Green respectively with which they paint the boats they own. A person is allocated to each of parking lots. He is supposed to keep track of the number of boats belonging to each of the rental agencies and also inform the rental agency as soon as one of their boats enter the parking bay. Based on these counts the rental agencies can keep track of the number of boats currently being used by customers and can also take decision on when the boats need to be retrieved from the parking lot. Design a multi-threaded program for handling this Lake boat management system. Use MPI programming.

14. An institution has five centres. They want to keep track of the energy utilization in each centre. They need information about the maximum demand and the average demand from each centre based on which they would compute the average and maximum for the institution. This is required for them to enter into a Service Level Agreement with a utility service provider. Write a multi-threaded program to achieve this. You can use a random number generator for each thread which will generate the power demand value every 10 units of time. We need to compute the institution wide figures over a period of 100 units of time. Use MPI programming.

15. Four Robots are deployed to perform the census activity in a district which has 3 villages. Each village has four streets and 15 houses in each street. One Robot is allocated for each street. The Robot allocated to street 0 is the leader. When the Robots visit a house, the head of the house punches in the number of members in the house, number of adult males, number of adult females, number of male children and female children. In addition, the head has also got to punch in the number of "girl" children above the age of 5 years who are attending school. Each robot keeps these counts locally. All the robots must synchronously move from one house to the next. Once data from

all the houses in a street have been collected the Robots allocated to streets 2, 3 and 4 transfer their data to Robot#1 which maintains the count for the whole village. Simulate this scenario using MPI communication paradigms for synchronization and data transfer. Assume, random number of inmates and distribution of males, females and children in each house.

16. A set of four robots are doing quality inspection on four separate assembly lines in a factory producing light bulbs. Each of them keeps a count of the number of failures of bulbs in its assembly line. After checking hundred bulbs they send the information to the Robot managing the first line which is the Master and which keeps track of the overall failure status. If the number of failures exceeds a threshold then an alarm is generated and the assembly line is shut down and all the robots are asked to stop checking. Simulate this quality inspection activity using a Message passing paradigm. Use CUDA programming.

17. A school has five sections for each grade and they have three grades (PreKG, LKG and UKG). They send a teacher to each section to get the information about the age of each child in the section. Assume that there are ten students in each section. Assuming each teacher is simulated as a thread use the MPI-Reduction function to determine the Minimum age, the Maximum age and the Average age for each section, each grade and for the whole school. Use random numbers for generating the age of the children.

18. There is a parking lot with 3 floors having space for 50 cars each. A display is maintained at the entrance which has information about the number of slots vacant in each floor and also the total number of vacant slots in the lot. An attendant is assigned to each floor. Every five minutes he sends a message to update the display with the current number of free slots in the floor. This should also update the number of free slots available in the parking lot. Assume that a random number of cars are parked in each floor at the beginning of the simulation. Simulate the system for a duration of fifteen minutes. Also, assume that every five minutes a random number of vehicles enter and exit the parking lot.Use CUDA programming.

19. A college has entered into a competition with its teams of boys and girls (2 each). The head coach needs to communicate with all the players in some instance while in other cases he wants to exclusively talk to the boys or the girls. Using the MPI group communication paradigms implement this requirement and write a sample program to demonstrate the same.

20. The management of a large store is interested in knowing exactly how many customers visit the store in a day. The store has five entrances. Write a multi-threaded program with one thread dedicated to each entrance to keep track of number of customers entering through it, and another thread to handle queries by the management. At any time, the management might want to know the number of customers who have entered the shop from the time the store was opened in the morning. At the end of the day the management asks all entrances to be closed, and they would want to know the total number of customers who entered the shop on that particular day. Design a multi-threaded program using shared memory paradigm to meet these requirements. Use CUDA programming.

21. A farmer has 3 acres of land in three different villages (one acre in each village). He adopts modern techniques in his farm and plants 64 Jackfruit trees in each acre of land. They are planted in 4 rows with each row containing 16 trees. Once every week he hires four robots which have the capability of inspecting the fruits and determining whether they are ripe or not. He deploys the robots for counting by assigning one row to each robot. The robots will send a message to the managerial process containing the running count of the number of fruits that are ripe & number that are not yet ripe for every set of four trees. After all robots finish their job, they are moved together to the next piece of land and this process of counting is repeated to cover all the 3 plots. Write a

program using Open MPI extensions to simulate the above process.

22.   A set of four robots are configured as a circular network (ring). Each robot has a link with its two immediate neighbours. While performing a task assigned to them, each one of them is supposed to receive a message containing one data item of type integer from the robot on its left and is supposed to double the value and send it to the robot on its right. The activity is completed after one round of message passing is completed (i.e. the first robot receives a message from the last robot in the chain). Write the programs for each of the robots using OpenMPI extensions. Ensure that the programs are safe.

23.   Tirupati Tirumala Devasthanam has a collection box for devotees to offer cash to the deity. The collection hours are 5 am to 5 pm. After 5 pm the collection box is moved to a strong room where the contents are counted manually. The contents are divided among five persons. The values reported by the counters are added up to generate a statement reflecting the total amount deposited in the collection box. Develop a shared memory parallel program to simulate the process outlined above using CUDA programming.