UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 8 Examination in Engineering: December 2018

Module Number: EE8203   Module Name: High Performance Computing

[Three Hours]
[Answer all questions, each question carries 10 marks]

Q1 a) What is the main purpose of the Peterson's algorithm?

[1 Mark]

  b) Write the Peterson's algorithm for two process using C or C# language.

[3 Marks]

  c) Explain how the philosophers ended up with deadlock state in the dining philosophers problem.

[2 Marks]

  d) Explain how the deadlock is avoided by "Resource hierarchy solution" proposed by Edsger Wybe Dijkstra to the dining philosophers problem.

[2 Marks]

  e) Explain how the solution for dining philosophers problem proposed by "K. Mani Chandy" and "J. Misra" solves the starvation.

[2 Marks]

Q2 a) What are the two underlying architecture types supported by OpenMp?

[1 Mark]

  b) List two directives used for Work-Sharing in OpenMP.

[1 Mark]

  c) Assume the following program written using OpenMp is executed using four threads in the parallel section. The program might have an erroneous result as the output.

```
#include <omp.h>
main(int argc, char *argv[]) {
   int x=0;
   #pragma omp parallel shared(x)
   {
     x=x+1;
   }
   printf("%",x);
}
```

  i) What would be the reason for it to give an erroneous result?

  ii) Do the correction to get the accurate results.

[2 Marks]

d) Use the following program to answer the questions below.

```
#include <omp.h>
#define N 1000
main(int argc, char *argv[]) {
int i;
float a[N], b[N], c[N], d[N];
for (i=0; i < N; i++) {
  a[i] = i * 1.5;
  b[i] = i + 22.35;
}
#pragma omp parallel shared(a,b,c,d) private(i)
{
   #pragma omp sections nowait
   {
     #pragma omp section
     for (i=0; i < N; i++)
       c[i] = a[i] + b[i];

     #pragma omp section
     for (i=0; i < N; i++)
       d[i] = a[i] * b[i];
   }
 }
}
```

i) Describe how this program executes in parallel.

ii) How would it affect the execution when the nowait key word is removed?

[2 Marks]

e) Write a parallel program using OpenMp to initialize a 2D integer array A[100][100] of size 100x100 according to the following expression.

```
A[i][j] = ixj; //i,j varies from 0-99
```

[2 Marks]

f) What is the purpose of using **pthread-join()** function in POSIX threads?

[2 Marks]

Q3 a) What is the difference between foreground and background threads used in C#?

[2 Marks]

b) Write the output of the following program.

```
public static void ThreadMethod(object o){
  for (int i = 0; i < (int)o; i++){
    Console.WriteLine("The value of i is:{0}", i);
    Thread.Sleep(0);
  }
}
public static void Main(){
  Thread t = new Thread(new ParameterizedThreadStart
  (ThreadMethod));
  t.Start(6);
  t.Join();
}
```

[2 Marks]

c) Assume you are given a 2D integer array A[100][100].
Write a multithreaded program in C# to get the sum of each row.
Note: You should create one thread for every row.

[2 Marks]

d) How the creation of large number of threads affect the performance of the program in Q3 c)?

[2 Marks]

e) List two advantages of using a "Task" with C# Threading.

[2 Marks]

Q4 a) How does the scalable programming model works in CUDA-enabled GPUs?

[2 Marks]

b) Assume you are using a CUDA three-dimensional thread block to compute elements in a volume. Total number of elements are NxNxN.

Number of blocks are defined as follows.

```
dim3 threadsPerBlock(8,8,8);
dim3 numBlocks(N/threadsPerBlock.x,N/threadsPerBlock.y,
N/threadsPerBlock.z);
```

If one thread is assigned for each element having coordinates (i, j, k).

Write an expression to get values of i, j and k in the kernel function to access the threads.

[3 Marks]

c) Describe how the Shared Memory is faster than global memory considering the memory hierarchy of the CUDA programming model.

[2 Marks]

d) What is the purpose of cudaMalloc() function in CUDA programming model?

[1 Mark]

e) Assume a text file containing "The University of Ruhuna is one of the leading universities in Sri Lanka. The University of Ruhuna was established on 1st September 1978" is given as an input to the following map function in a MapReduce program.
List the output key-value pairs of the map function.

```
private final static IntWritable one = new IntWritable(1);
private Text word = new Text();

public void map(Object key, Text value, Context context
) throws IOException, InterruptedException {
    StringTokenizer itr = new StringTokenizer
    (value.toString());
    while (itr.hasMoreTokens()) {
      word.set(itr.nextToken());
      context.write(word, one);
    }
}
```
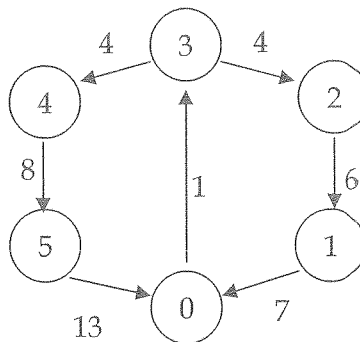
[2 Marks]

Q5 a) What is the purpose of MPI_Comm_rank() function in MPI?

[1 Mark]

  b) What is the difference between MPI_Send() and MPI_Isend() methods in MPI?

[1 Mark]

  c) Describe the output of the following MPI program using a diagram when world_size=3.
  Note: Mention the values of no1 and no2 for each of the ranks.

```
#include "mpi.h"
#include <stdio.h>
main(int argc, char *argv[])  {
    int numtasks, rank, dest=0, source;
    int no1=-5, no2=-3, tag=1;
    MPI_Status Stat;
    MPI_Init(&argc,&argv);
    MPI_Comm_rank(MPI_COMM_WORLD, &rank);
    if (rank == 0) {
      MPI_Recv(&no1, 1, MPI_INT, 1, tag, MPI_COMM_WORLD, &Stat);
      MPI_Recv(&no2, 1, MPI_INT, 2, tag, MPI_COMM_WORLD, &Stat);
    }
    else if (rank == 1) {
      no1=1;
      MPI_Send(&no1, 1, MPI_INT, dest, tag, MPI_COMM_WORLD);
    } else if (rank == 2) {
      no2=2;
      MPI_Send(&no2, 1, MPI_INT, dest, tag, MPI_COMM_WORLD);
    }
    printf("The rank is:%d\n",rank);
    printf("The value of no1 is:%d\n",no1);
    printf("The value of no2 is:%d\n",no2);
    MPI_Finalize();
}
```

[3 Marks]

  d) Write a MPI program using C programming language which does the following.
    i) Message passing starts at process 0 by sending number 1 to process 3 and ends when process 0 receive 13 and 7 from process 5 and process 1.
    ii) Arrows shows the number sent with the message.

[3 Marks]

  e) Describe how MPI_Reduce() function works in MPI.

[2 Marks]