ITCS 4/5145 Parallel Computing  
Test 2 5:00 pm - 6:15 pm, Wednesday April 13th, 2016

Name: ............................................................

Answer questions in space provided below questions. Use additional paper if necessary but make sure your name is on additional sheets. Clearly show how you obtained your answers. (No points for simply writing a numeric answer without showing how you got the answer, even if correct.) This is a closed book test. Do not refer to any materials except those supplied for the test. Supplied: “Brief Summary of CUDA”

Total /40
6 pages

Qu. 1 Answer each of the following briefly:

(a) In Assignment 4 (Monte Carlo \( \pi \) calculation using MPI with a workpool), how do the slaves know when to terminate?

(b) What does the Suzaku routine \texttt{SZ\_Scatter(A,A1)} do? How is the size of data transfer determined?

(c) In the command mpicc, what does the \(-c\) option specify (as used in Assignment 5 on Suzaku)?
(d) In the Seeds framework, there is a variable called “segment” that is an input parameter in the DiffuseData method. What is the name of the corresponding variable in the Suzaku framework and what does it specify?

(e) What is the sequential time complexity of the “brute force” algorithm used for the gravitational $N$-body problem (as used in Assignment 5) given $N$ bodies and $t$ iterations? When parallelized using a master-slave pattern, what is the parallel time complexity (not given in the slides but can be inferred if each process handles one body at the same time)?

(f) Very briefly describe how to solve a general system of linear equations by iteration.
(g) In a pipeline executing more than one instance of a complete problem, the speedup is given by:

\[ S(m) = \frac{p \times m}{p + m - 1} \]

where there are \( m \) instances of the problem and \( p \) pipeline stages. Briefly explain how this equation is derived?

(h) What is the best possible sequential time complexity (lower bound) for a compare and exchange sorting algorithm that does not use any special properties of the numbers if there are \( N \) numbers? (Sufficient to state without proof.)

Hence what is best possible parallel time complexity (lower bound) for a compare and exchange sorting algorithm that does not use any special properties of the numbers if there are \( N \) numbers and \( N \) parallel processes?
(i) Show the steps to sort the following four numbers using odd-even transposition sort. It will take four steps for four numbers generally and show all four steps even if sorted before that.

7 4 8 3

(j) Is the following a Bitonic sequence? Explain your answer.

3 4 5 3 4 5

(k) In CUDA, what does threadId.y indicate?
Qu. 2  Write a CUDA program that copies the values from a 1-dimensional array of integers, A[N], into a second array B[N] but in reverse order, e.g. if the array A[N] has the values:

\[
\begin{array}{cccccc}
4 & 6 & 5 & \cdots & 3 & 1 & 9 \\
\end{array}
\]

afterwards the array B[N] has the values:

\[
\begin{array}{cccccc}
9 & 1 & 3 & \cdots & 5 & 6 & 4 \\
\end{array}
\]

Use one CUDA thread to copy one element in the array. Organize the kernel structure as a 1-D grid of 1-D blocks with 16 threads in each block and the minimum number of blocks necessary given N as a defined constant. For example if N = 30, you would need two blocks. Your code must take into account any value for N. You may assume that the program has code to store initial values in the array A[N]. Declare all variables and arrays needed. Provide comments in your code to help the grader! If I do not understand the code, I will assume it is incorrect.

Note: The C library function `double ceil(double x)` returns the smallest integer value greater than or equal to x. Use this to round a number up.
Intentionally blank to continue your answer for question 2 if needed.