Assignment 2

ECSE 420 – Parallel Computing – Fall 2015

Released: Wednesday, September 30, 2015
Due: Wednesday, October 7, 2015 at 11:59 pm

Assignment 2 is to be completed individually. This assignment is due on Wednesday, October 7, at 11:59 pm. You should submit a single PDF containing all the required solutions and textual answers.

Q1. **Amdahl's law** (25%)
Amdahls law says that the maximum speedup theoretically possible for a parallelizable program obtained by using n processors, S(n), is:

$$S(n) = \frac{T_1}{T_n} = \frac{T_1}{T_1(1-P) + T_1(\frac{P}{n})} = \frac{1}{(1-P) + \frac{P}{n}} \quad (1)$$

where T_1 is the runtime of the original program, and P is the fraction of T_1 which is spent doing work which can be parallelized.

Assume that a parallel program requires OV(n) seconds of overhead (time required for thread/process creation, communication, synchronization, etc.).

a. Write a more restrictive version of Equation 1 which takes the overhead OV(n) into account.

b. Assume that OV(n) = n. Plot the maximum possible speedup for P = 0.5, 0.95, 0.99, N = 2,4,8,16,32, and T_1 = 100 seconds.

Q2. **Communication performance**
(20%) Consider a simple 2D matrix of $30 * 40$ elements where at each step every point in the matrix is substituted by its symmetric point as in equation below:

$$A_{[i,j]} => A_{[j,i]}$$

how much data must be communicated per step? For a machine with the message start-up time T0 of 500 ns , what is the required asymptotic peak bandwidth for reaching the half of the peak bandwidth(in Byte) ?

Q3. (20%) For a machine with the communication overhead and network delay (message start-up time) of 200 ns, the biggest assist occupancy and the asymptotic peak bandwidth of 5 GB/s, calculate the communication time.

Considering a program that run 100 times an operation, assuming that 10% of operation communication time is during other usefull work of processor, calculate the the communication cost.

Q4. **MPI - Function Parallelism** (35%)

Suppose we have a machine with 4 processors. The operation shown below should be executed :

```
...
 D = A*B + B/(C+A) + (A-1)*(A-2) ;
...
```

One specific task is performed per processor (function parallelism). More specifically:

- P0 computes D - Variables A and D are located only in P0's local memory.
- P1 performs multiplication - Variable B is located only in P1's local memory
- P2 performs addition and division - Variable C is located only in P2's local memory
- P3 performs the second multiplication ,

Develop the proper MPI program that implements the aforementioned parallelization scheme. The goal of the current question is to orchestrate the communication scheme, by using MPI Send-Receive pairs and Broadcast properly. Do not simplify the equation. Thus, you do not have to submit an individual code file or to compile and execute your code. Directly attach your solution to the submitted PDF file. Hint: to use broadcast command, you need to rewrite the same command line in all processes which you need the value broad-casted. As an example

```
MPI_Bcast (&A, size , MPI_INT, root , MPI_COMM_WORLD);
```

send "A" to all other processes. To get that value in a process, you need to rewrite exactly this code, it acts like MPI_Recv.