Khoa Nguyen - Lab 8 Notes - 04/20/2022

1. Analysis on mmm-naive
   I ran the mmm-naive with the default arguments (1000 items per dimension) a couple times. On average, the running time to allocate memory for the matrices is 0 sec; the running time to initialize the values of the matrices is 0.025 sec; and the running time to calculate the matrix multiplication is 3.5 sec. As expected, the most expensive task in this code is the implementation of the matrix multiplication repeatedly. Thus, it will be efficient to parallelize only this part.

2. Design of parallel solution
   At first, every node will reallocate memory for the three matrices (mOne, mTwo, and mResult). Then, node 0 will populate values into the mOne and mTwo matrices, and broadcast the values into the rest of the nodes.

   For the matrix multiplication (very similar to my lab 6 design), because the resulting n by n matrix has $n*n=h$ items/sum calculations, I will split these calculations among the nodes. Imagine transform the n*n matrix into a list of h index, notice that $h=i*n+j$, where i is the row index and j is the column index. Therefore, instead of having two for loops with i and j (in the mmm-naive.c), I will derive i using h/n and derive j using $h \bmod n$. To split h items evenly, I divide h by the total nodes and the remainders will go to the last node. For example, if h = 100 and there are 3 nodes: node 0 handles from 0 to 32, node 1 handles from 33 to 65, and node 2 handles from 66 to 99.

   After the calculation, each subnode will send the results back to node 0. Depending on which subnode is sending the results, node 0 will precisely put the results into the correct location in its mResult matrix.

3. Analysis on parallelized version
   a) Mapping by nodes:
      Average total broadcasting time (from when node 0 sends to when all nodes receive) is 0.34 second. Matrix multiplication time varies from 0.38 to 0.44 second from node to node. Average total assemble time is 0.57. In total, the whole process takes 1.35 second on average.
   b) Mapping by slots:
      Average total broadcasting time (from when node 0 sends to when all nodes receive) is 0.54 second. Matrix multiplication time varies from 0.6 to 0.62 second from node to node. Average total assemble time is 0.2. In total, the whole process takes 1.36 second on average.