

# CSCI 251: Concepts of Parallel and Distributed Systems

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## Test Answers

### Question 1

In this problem, we were given a  $4 \times 4$  matrix multiplication operation to parallelize across a  $2 \times 2$  grid. We can look at these as four individual processors to split the data among, or a  $2 \times 2$  grid on which we can implement Canon's algorithm. For this problem, the serial computation time  $T_s$  is  $O(n^3)$ , or 64 in this specific case. The parallel computation time is  $T_p$  is 16 units at minimum plus the communication costs. Depending on the implementation and initial assumptions, the communication costs can vary.

### Question 2

In this problem, we had a tree of  $P$  processor nodes, of which the  $k$  leaves must perform 1-to-all personalized communication. The generalized expression for the cost of this  $k$ -to-all communication is:

$$k \sum_{i=0}^{\log_2(P)} 2^i \times i$$

### Question 3

For this problem, we had to implement a parallelized bitonic sort, merge sort, odd-even sort, or quicksort. The only thing to note is that those who implemented bitonic sort needed to implement the correct `compare_split` and `compare_exchange`

operation as discussed in class. For bitonic sort in the case of  $N > P$ , the order complexity becomes:

$$\frac{N}{P} \log\left(\frac{N}{P}\right) + \frac{N}{P} \log^2(P)$$

## Project 2

Project 2 will involve implementing bitonic sort. Since it requires message passing, the use of MPI is suggested. Please review the `compare_split` operation. With MPI, the process with rank 0 can be treated as the master process. The data can then be scattered across the other processes for manipulation.

## Reminders

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