**b.**) Consider multiplying two matrices of size n x m and m x p, and there are k number of

nodes/servers in the cluster. Calculate the total computation and communication cost for

the multiplication processes. The total computation and communication cost can be computed by adding the computation and communication cost separately for each map and reduce step. You have to provide two equations for two different costs, in terms of m, n, p and k.

**Ans**) Assume n = p:

– Sequential matrix-matrix multiplication time complexity is Θ(n3)

– For parallel algorithm, each process multiplies its portion of the matrix by the vector

– No process is responsible for more than n/p rows

– Complexity of multiplication portion is Θ(n3/k)

– In an efficient all-gather communication, each PE sends [log k] messages, total number of elements passed is n2\*(k − 1)/k when k is a power of 2

– Communication complexity: Θ(log k + n2)

– Overall complexity of parallel matrix-matrix multiplication algorithm Θ(n3 /k + n2 + log k)