Problem 1

Letting \( a_{ij} \) and \( b_{ij} \) denote the elements of row \( i \) and column \( j \) of matrices \( A \) and \( B \), respectively, then the transpose of matrix \( A \) is the matrix \( B \) with \( b_{ij} = a_{ji} \). Give an algorithm to transpose a matrix represented by an MX quadtree.

Problem 2

How many interchange operations are needed to transpose an MX quadtree representation of a \( 2^n \times 2^n \) matrix so that it is not sparse (i.e., all blocks are of size 1)?

Problem 3

Compare the savings in space and time requirements when a matrix is represented as an MX quadtree and as an array. Use the time required to perform a transpose operation as the basis of the comparison. You should assume the worst case which occurs when there is no sparseness (i.e., all blocks are of size 1).