

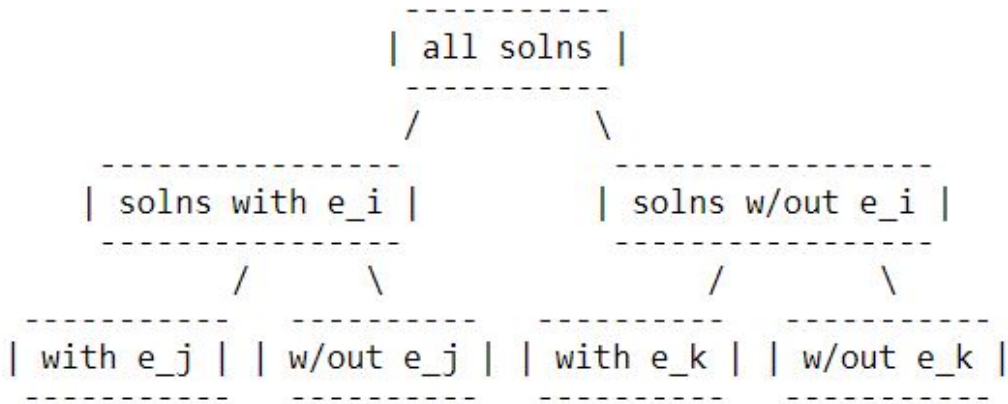
# Branch and Bound - Adding Removing Edges

Mohammad Poul Doust

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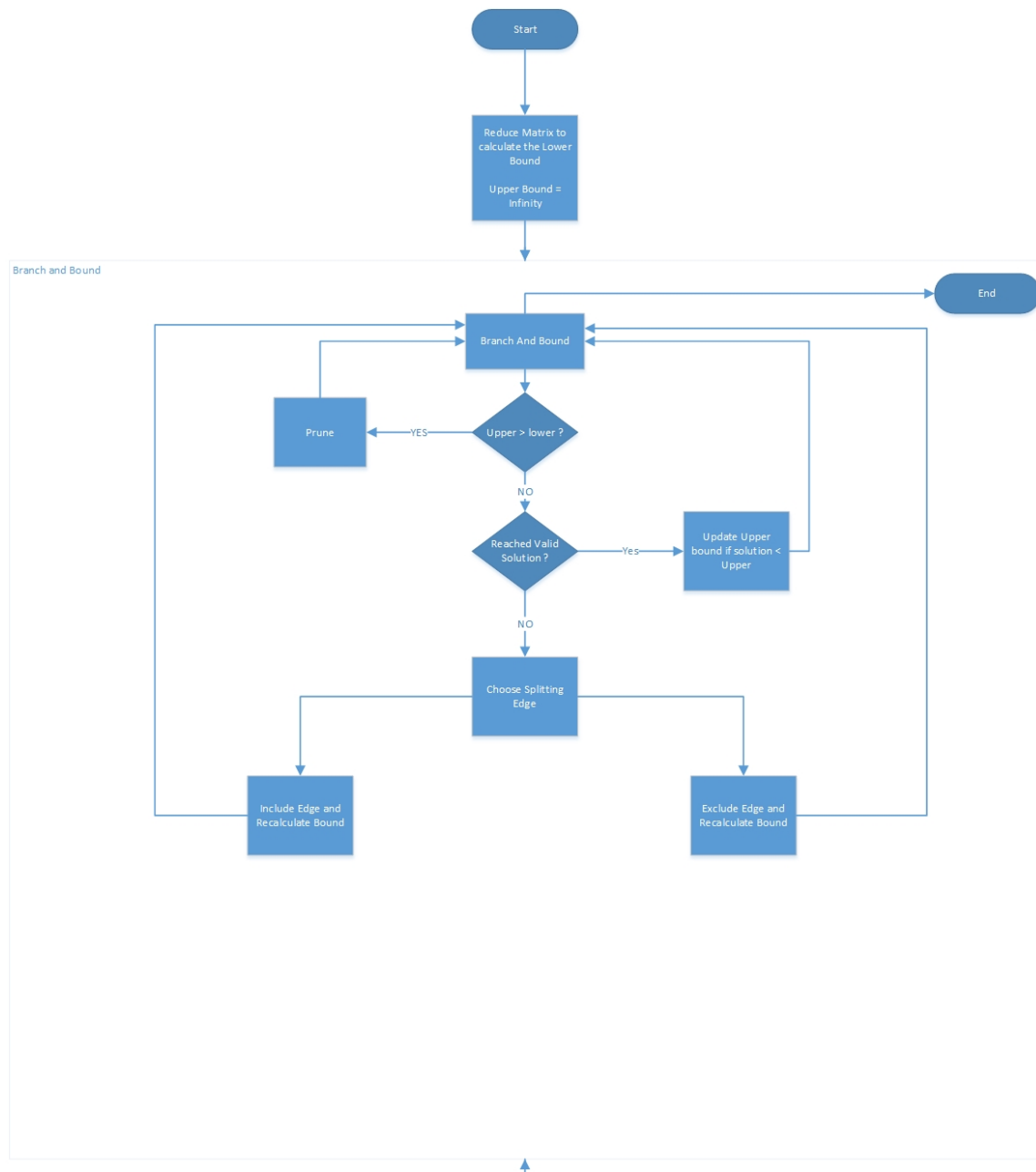
## 1 Introduction

One of the strategies used for searching the solution space is Branch and Bound keep dividing the space into branches. one for solutions containing a given edge and the other for those excluding the given edge. forming a binary tree as follows:



The main parts of these algorithm are:

1. Bounding Function
2. Choosing Splitting Edge
3. How to Include Edge
4. How to Exclude Edge



## 2 Bounding Function (Reduction)

The solution is bounded by normalizing the solution matrix. this is done by reducing the rows first and the columns after. by reducing the Rows/Columns we mean normalizing them. we subtract

the minimum element from each row from each element at that row. and the same for columns. at the end we will have a matrix with at least one zero in each column and each row. Our lower bound will be the sum of all minimum values with used to reduce the matrix.

### 3 Choosing Splitting Edge

We are looking to maximize the right part by trying to raising the lower bound of the right sub-tree. In order to do that, we choose to split on the edge that best maximize the lower bound. We look for the zero weight edges that maximize the increasing in the lower bound.

### 4 How to Include Edge

Including an edge (ie,  $I \rightarrow J$ ) is done by first, forbidding the going back from  $J \rightarrow I$  by setting the weight of edge  $J \rightarrow I$  to INFINITY ( we also forbid the going back to any sub-path in our partial solution). Moreover, since we have used this edge, we cannot go from node  $i$  to any other node, and similarly, we cannot reach node  $J$ . Consequently, we delete the  $I$  th row and the  $J$  th column from our solutions matrix. in the end, we reduce the new matrix after including the edge.

### 5 How to Exclude Edge

To exclude edge (ie,  $I \rightarrow J$ ), we start by setting the cost of the edge  $I \rightarrow J$  to INFINITY. and we reduce the new matrix afterwards.