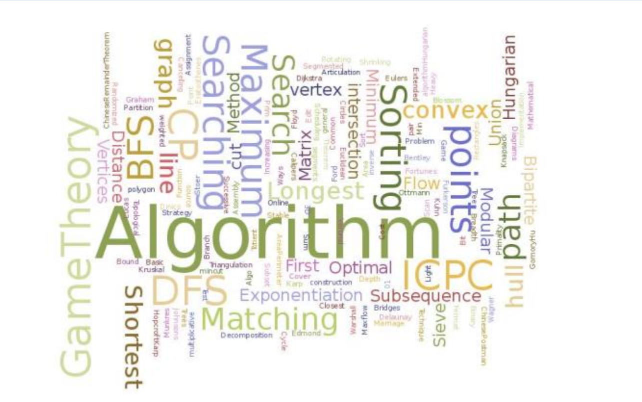
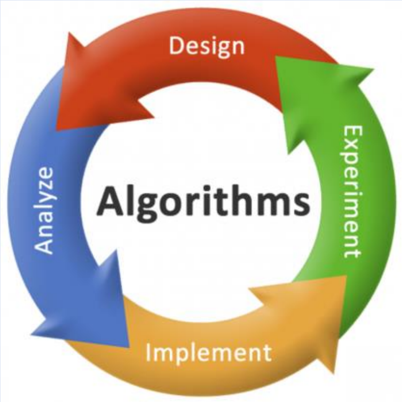
Backtracking

COP 3503
Fall 2021

Department of Computer Science
University of Central Florida
Dr. Steinberg

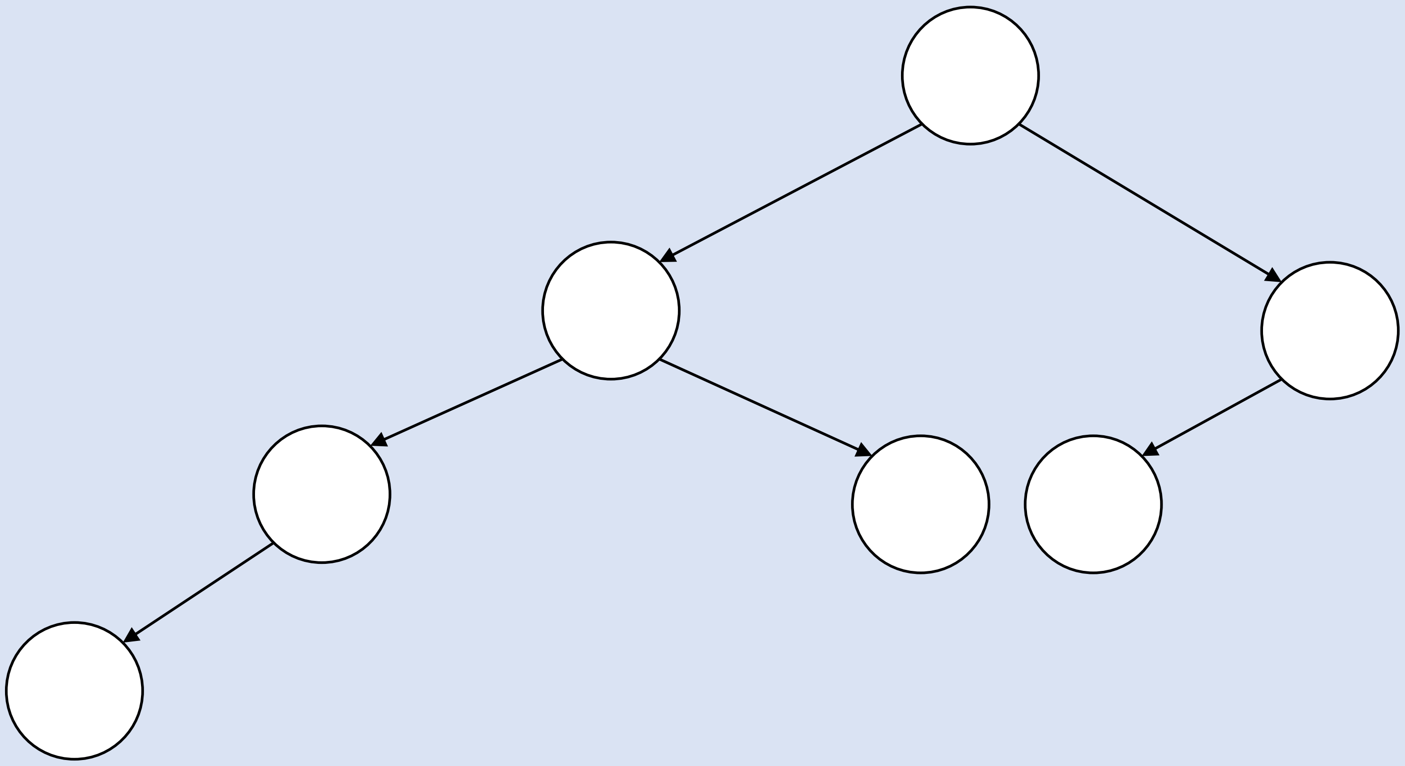




Introduction

- We just observed two common approaches to designing algorithms
  - Brute Force (BF)
  - Divide and Conquer (DC)
- BF and DC both yield correct results to problems. Both have their pros and cons that were discussed in previous lectures.
- There can be more than one correct result, however one may be better than the other.
- In this lecture we will discuss a technique called Backtracking

Quick Review of Tree Terminology



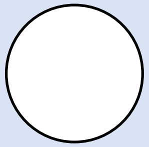
Backtracking

- Uses a Search Tree
- The Root is the starting state before the search for solutions
- Nodes on the first level, choices made for the first component of the solution
- Nodes on the second level, choices for second component of the solution
- The pattern continues…
- Each node on the tree is considered a potential solution, if it corresponds to a partially constructed solution that may still lead to a full solution.
- Leaves in the tree are dead ends or complete solution.

The Search Tree Construction

- If the current node is considered a potential solution, its child is generated by adding the first remaining legitimate option for the next component of a solution
  - The algorithm moves onto the child
- If the current node is NOT considered a potential solution, then the algorithm “backtracks” to the parent to consider the next potential solution.
  - If no option is possible, then the algorithm backtracks up on more level in the search tree.
- If the potential solution turns out to be the complete solution, then the algorithm stops (assuming we are searching for one solution).

The Big Picture of Backtracking



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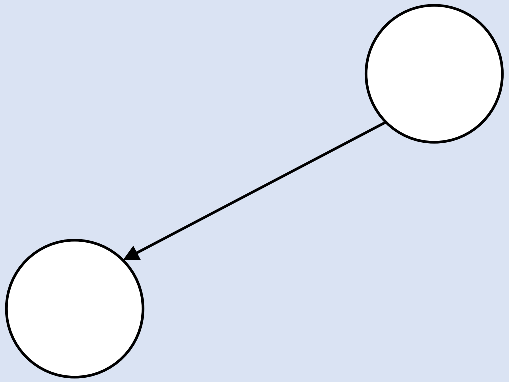

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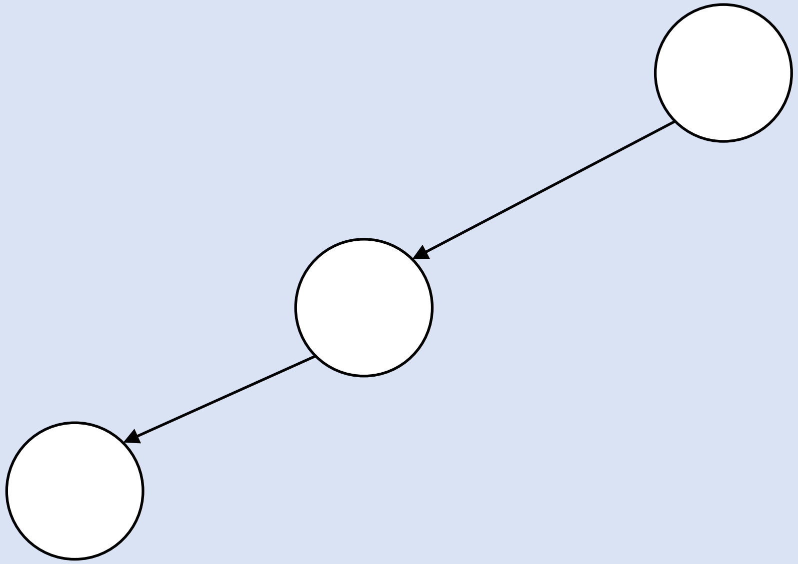

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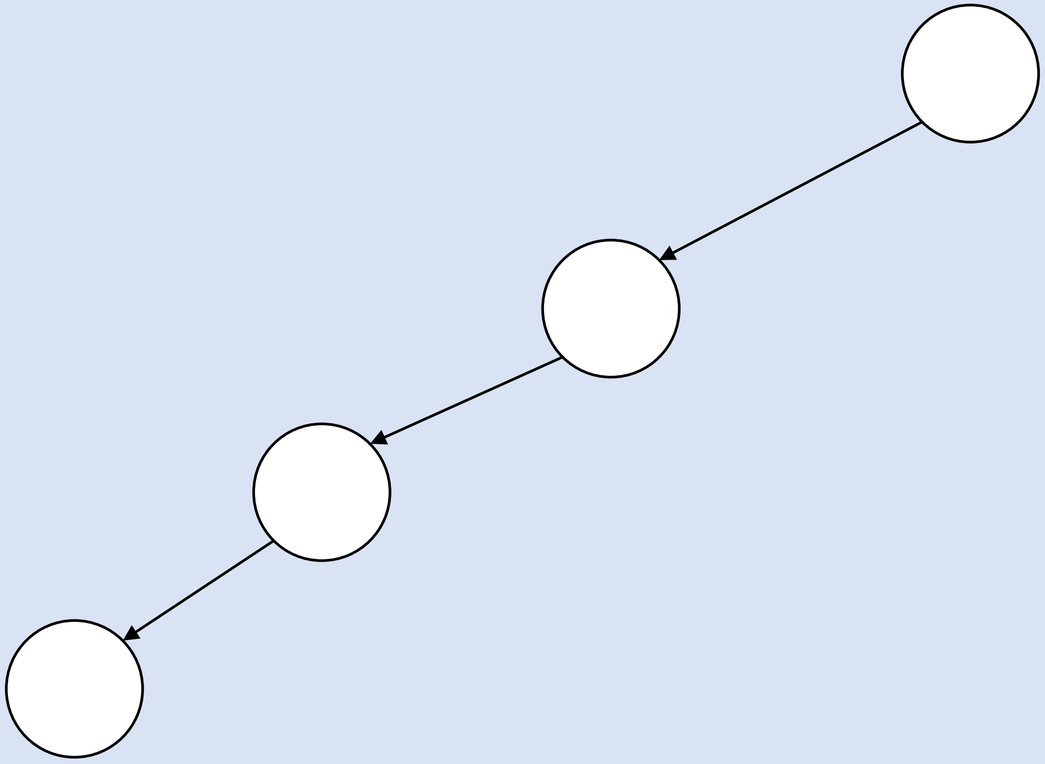

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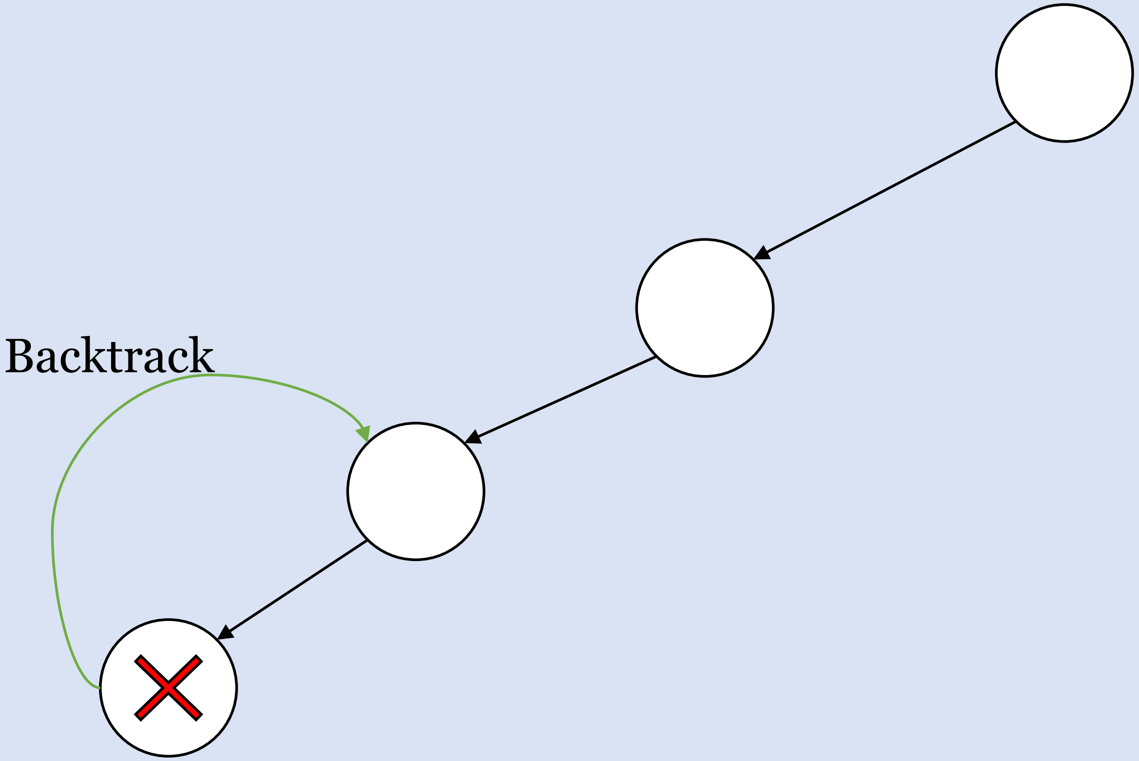

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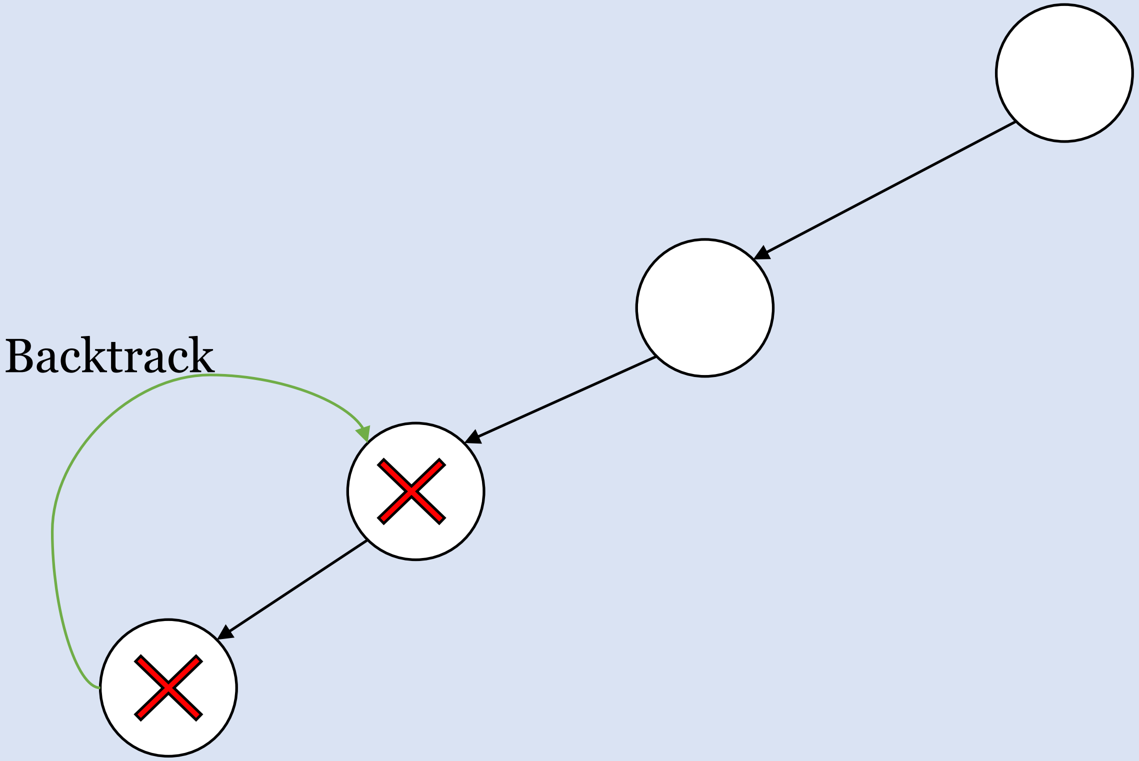

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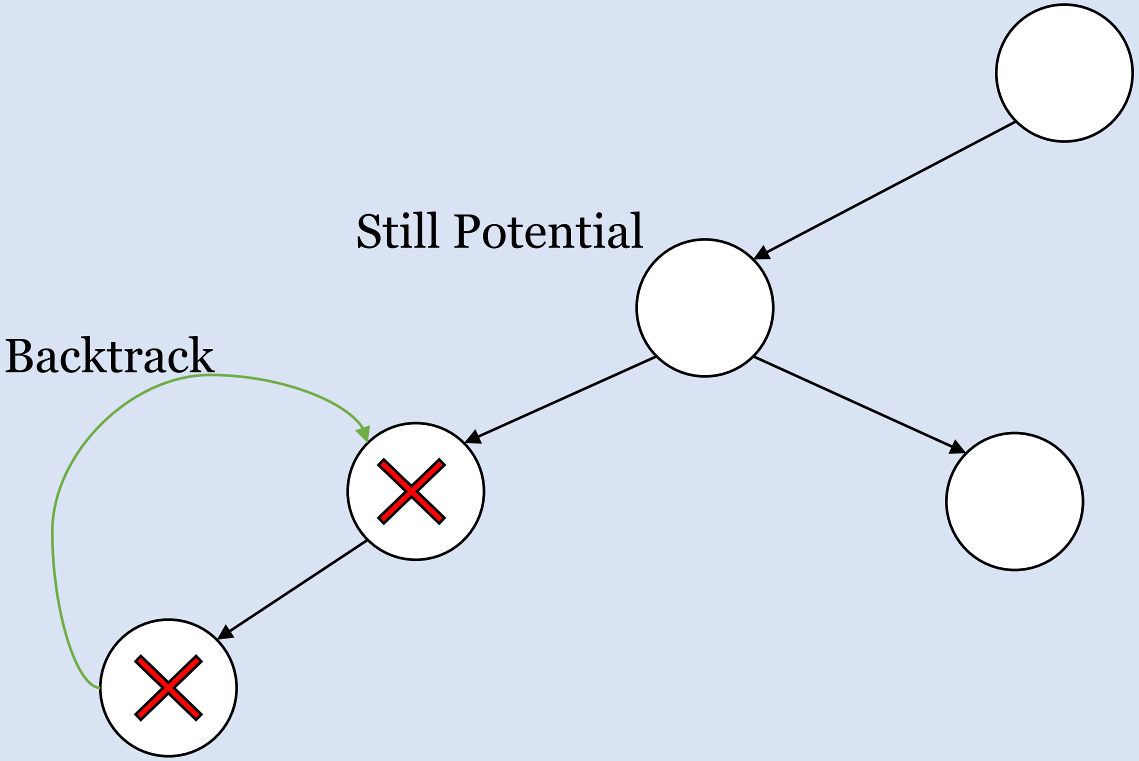

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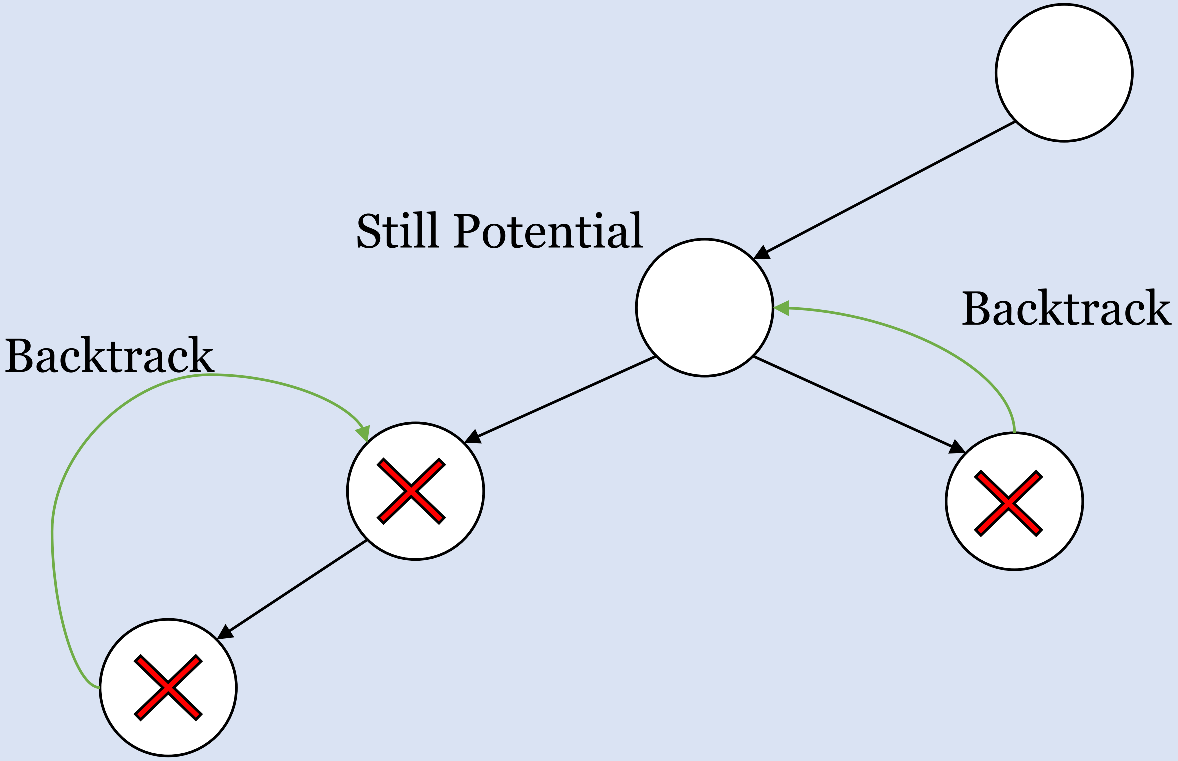

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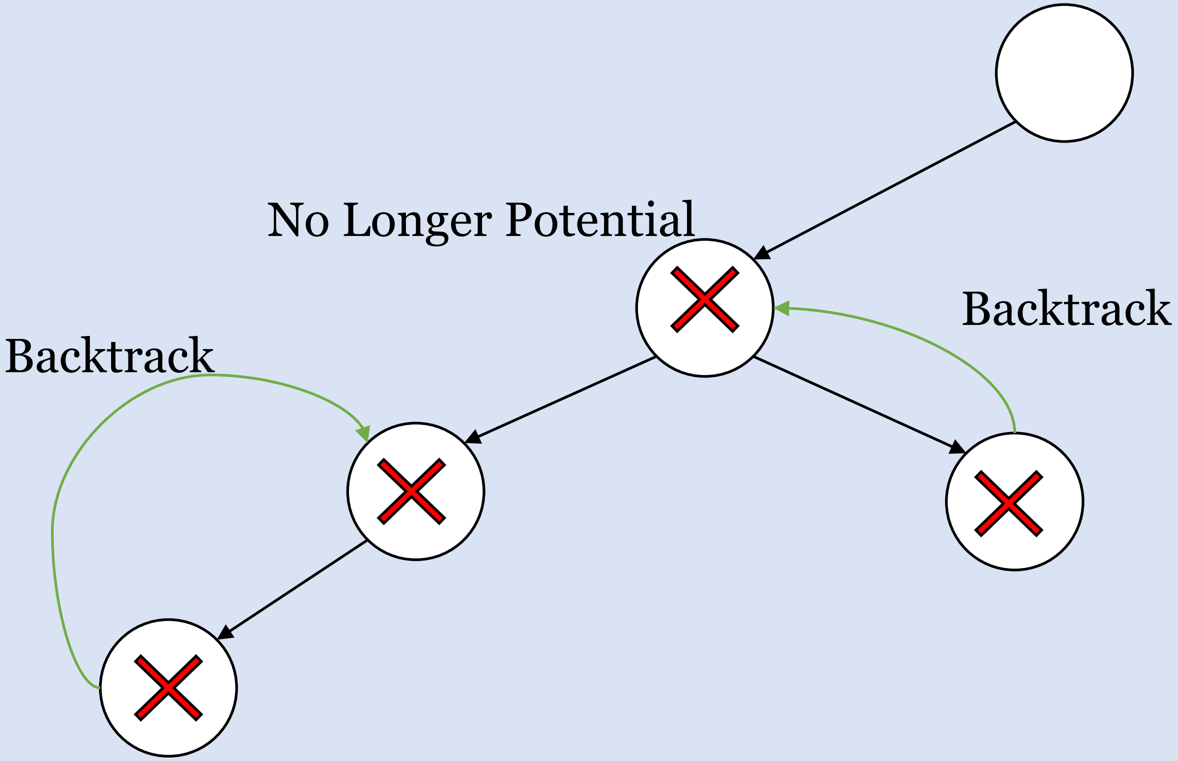

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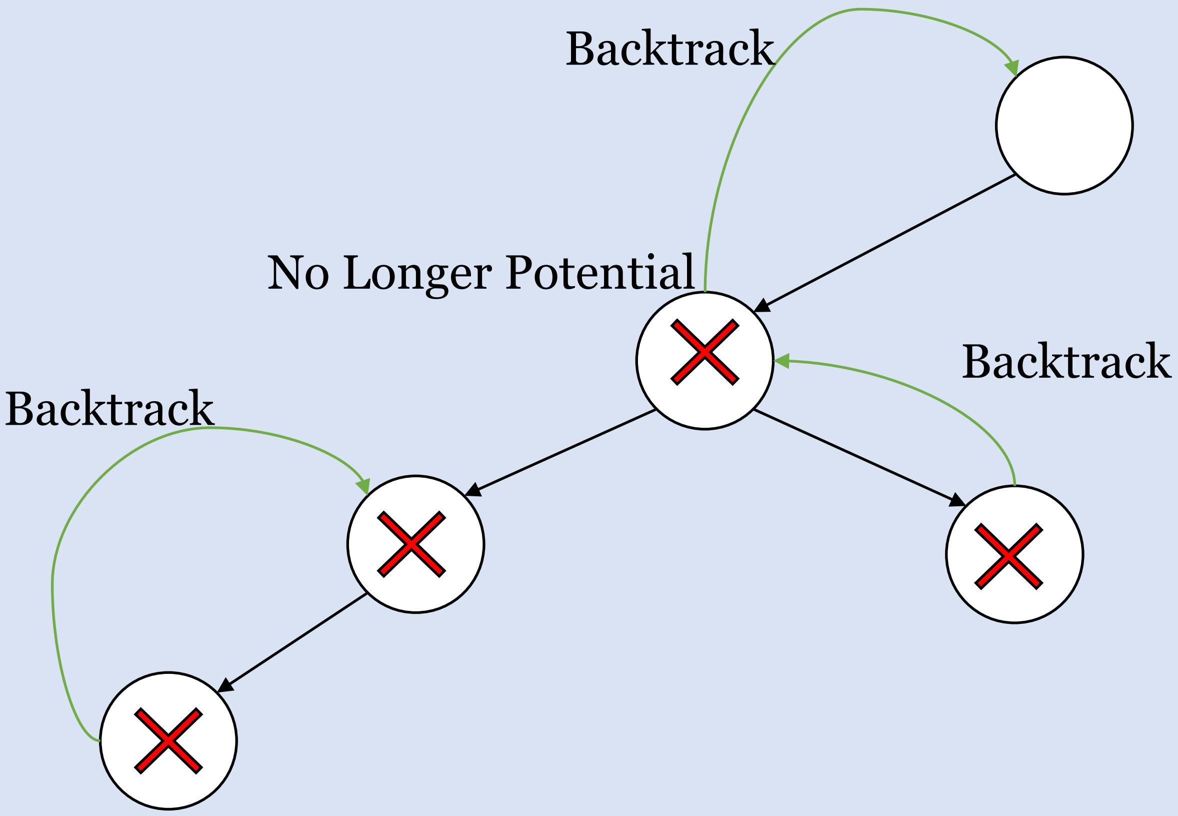

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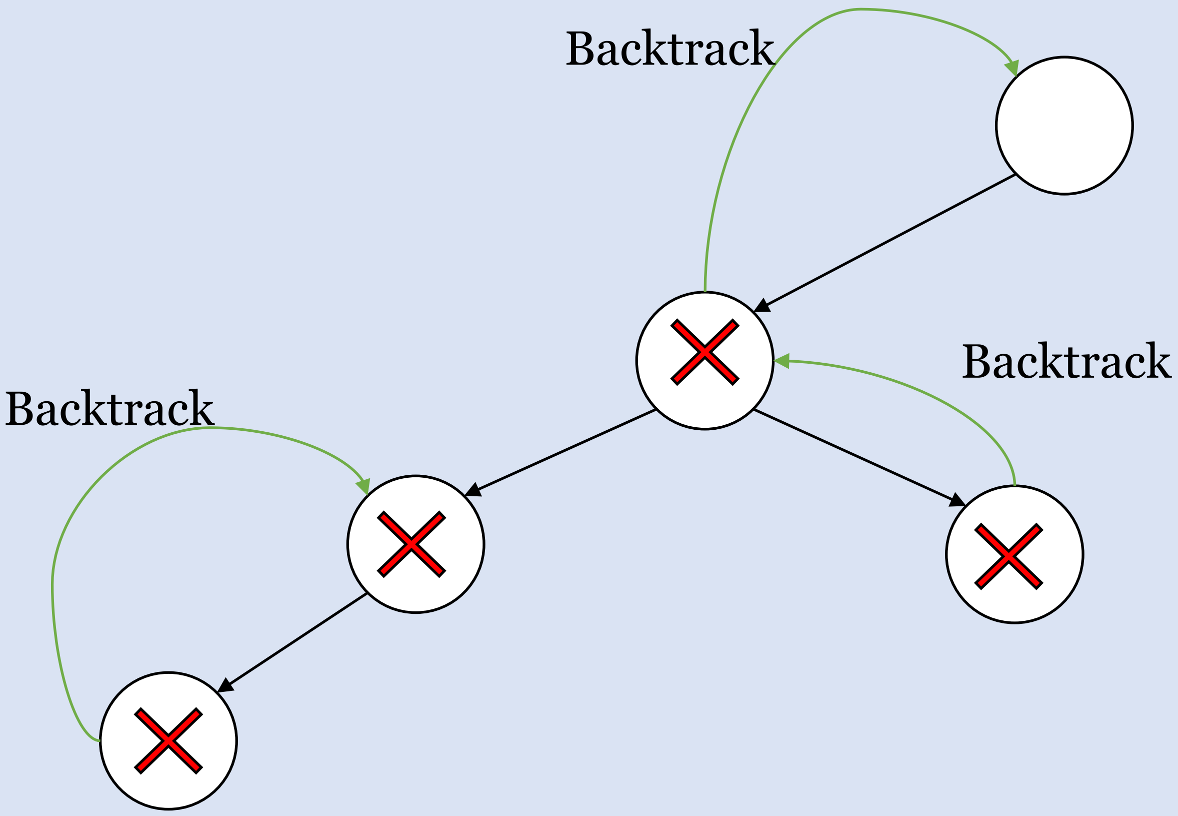

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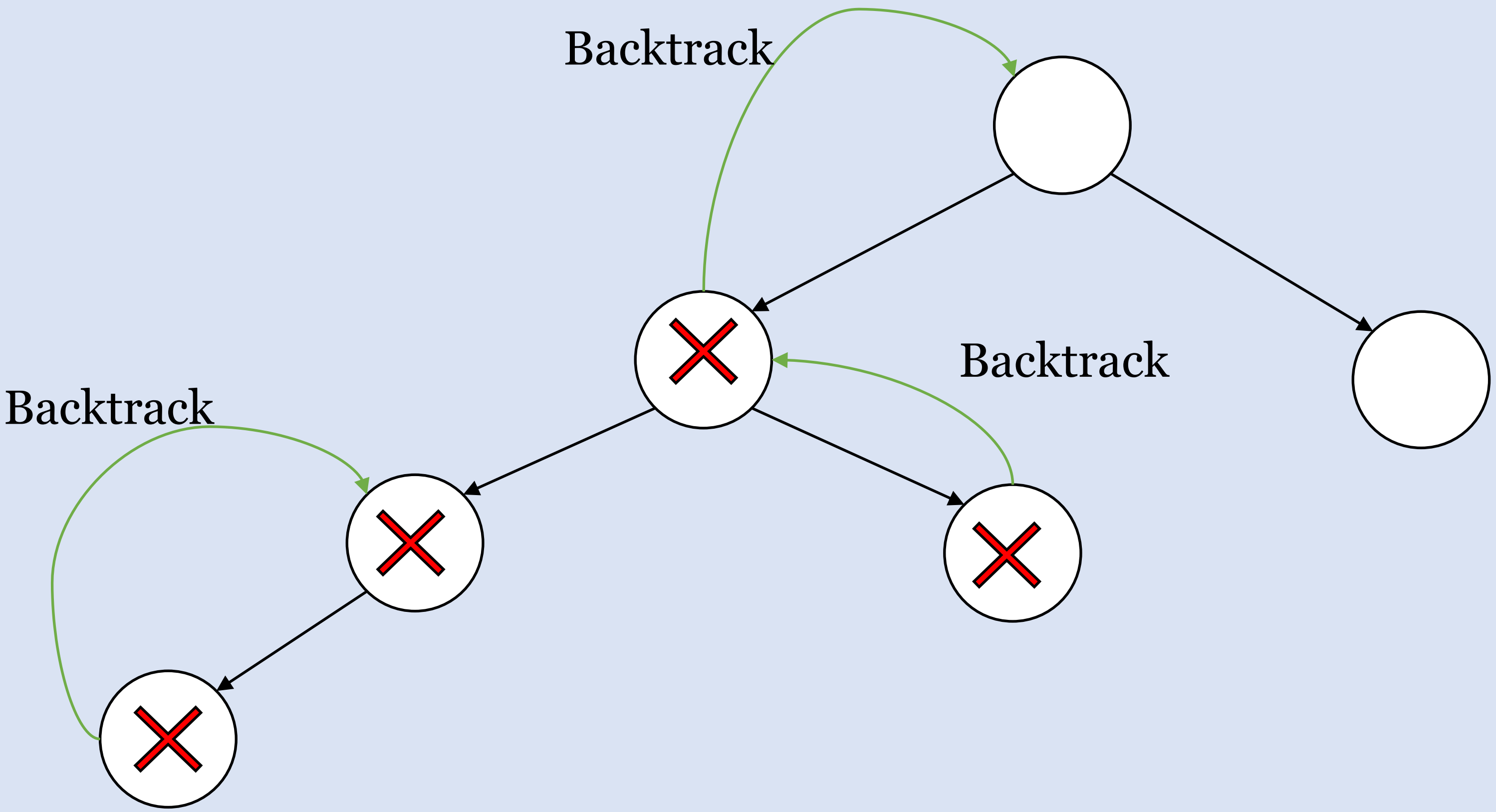

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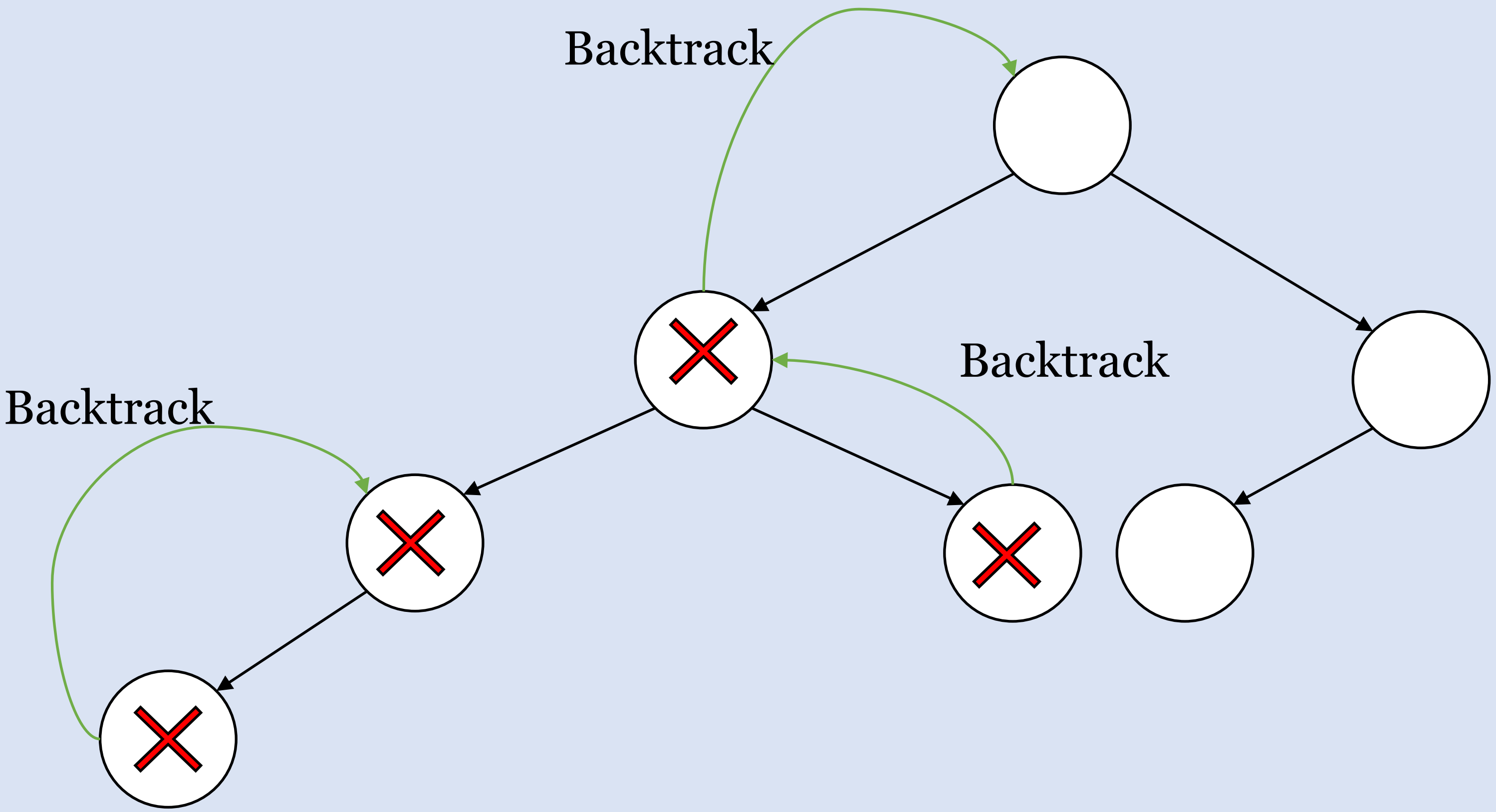

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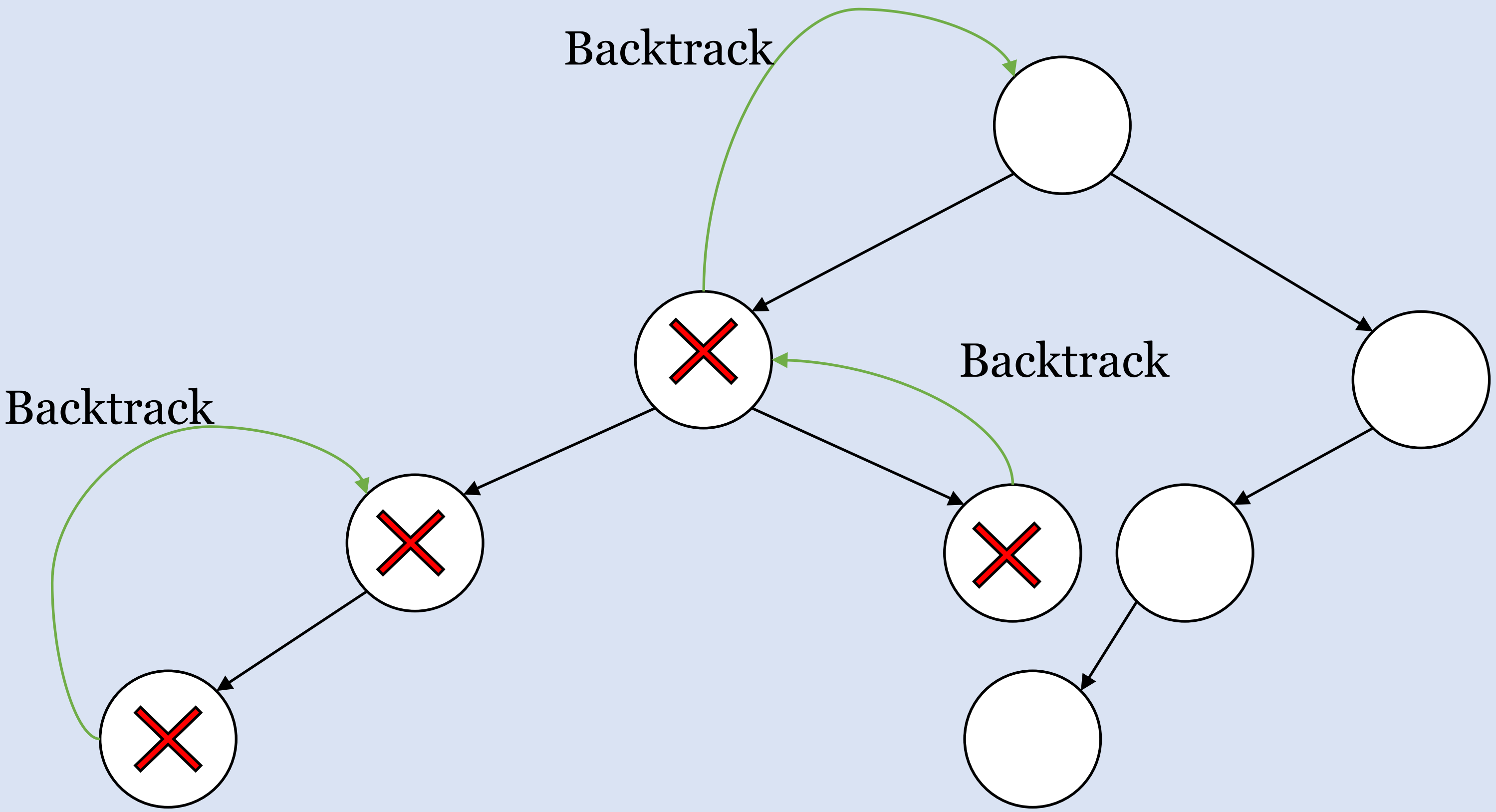

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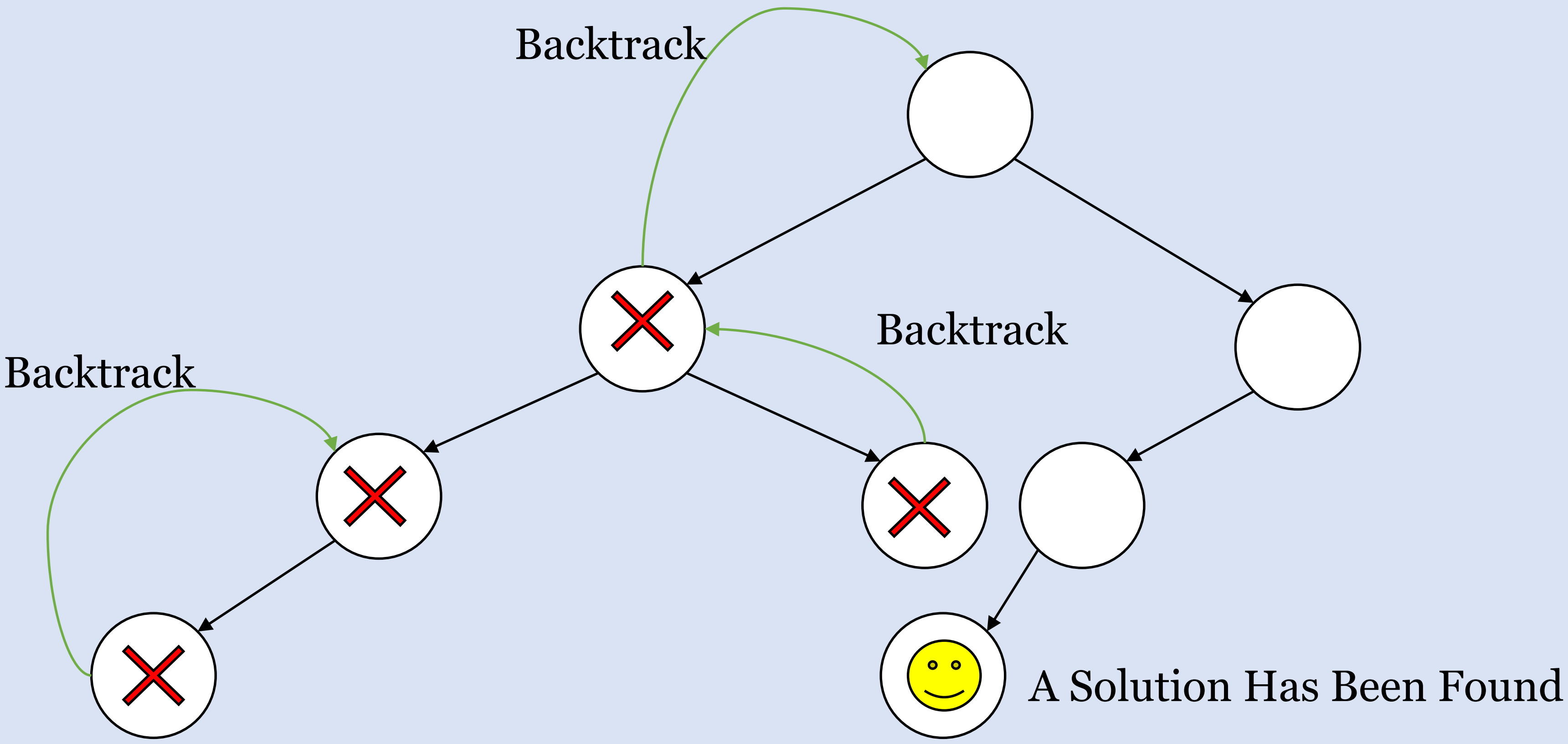


Based on observation of Backtracking what kind of problems can we apply this technique too? From the description, are there limitations?

Let’s Observe the Classic N-Queens Problem

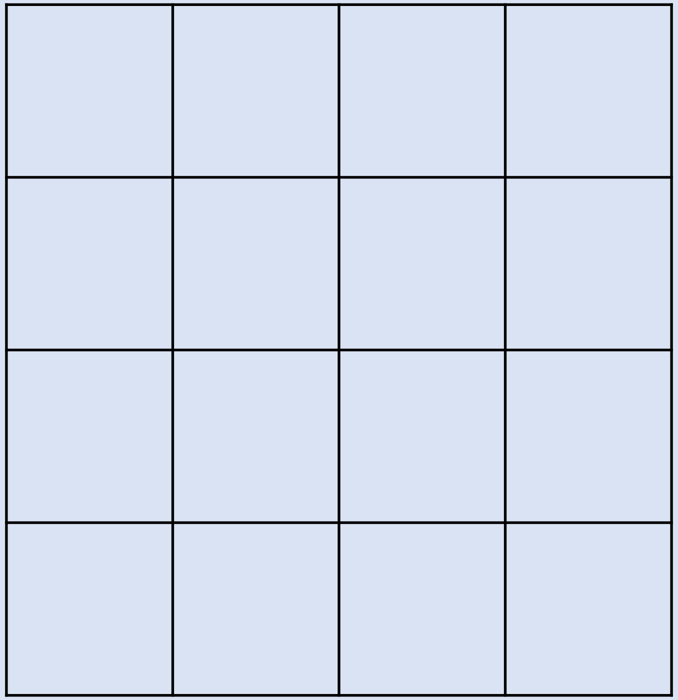
Problem Definition

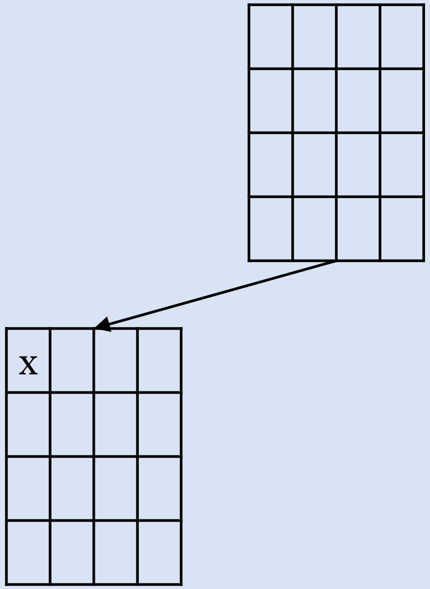
The n-queens problem is to place *n* queens on an *n x n* board so that no two queens are in the same row, column, or diagonal.

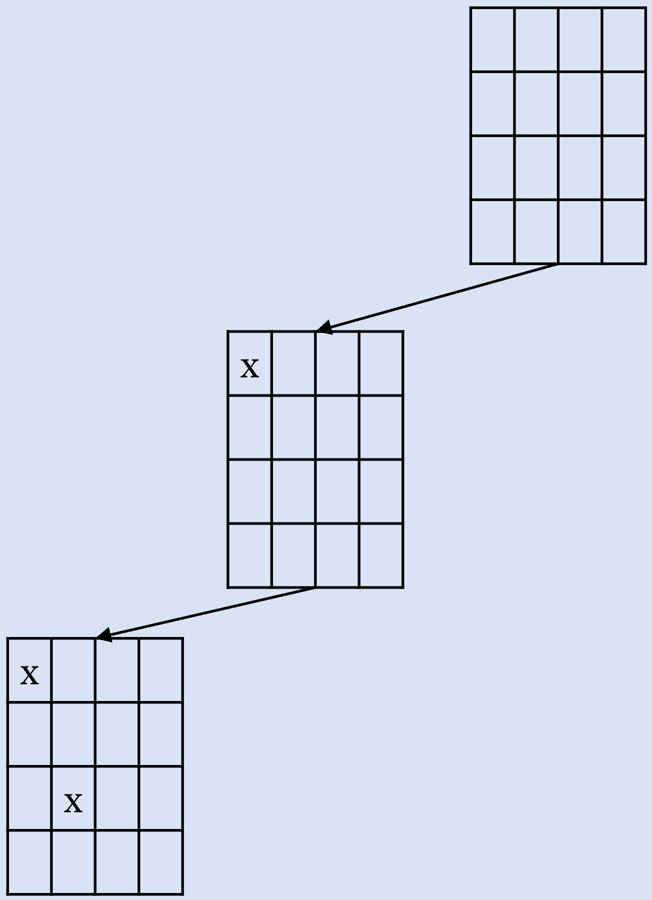
Sample
4 queens on 4 x 4

		X	
X			
			X
	X		

Search Tree Example of 4 queens on 4 x 4




x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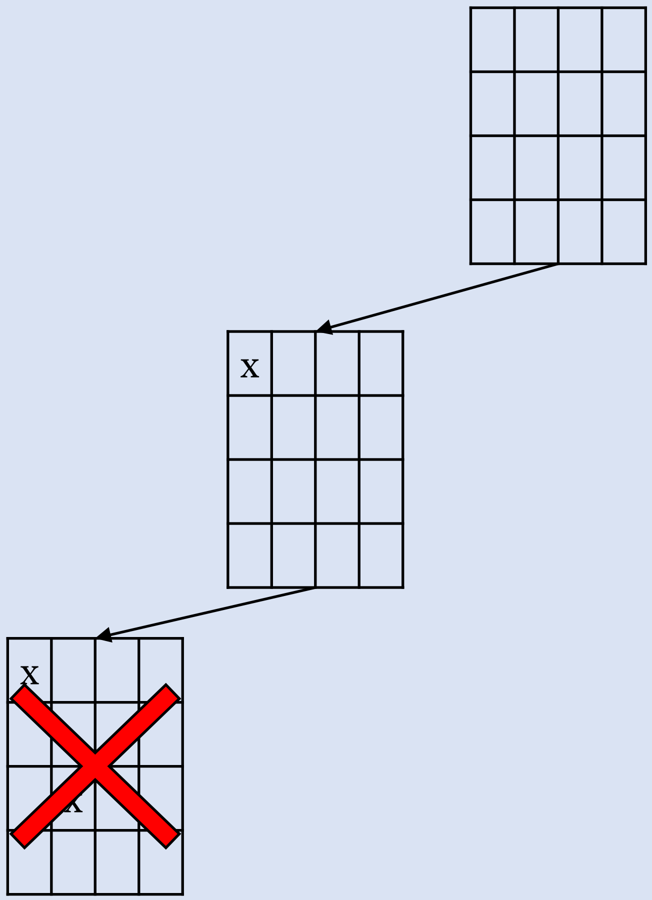
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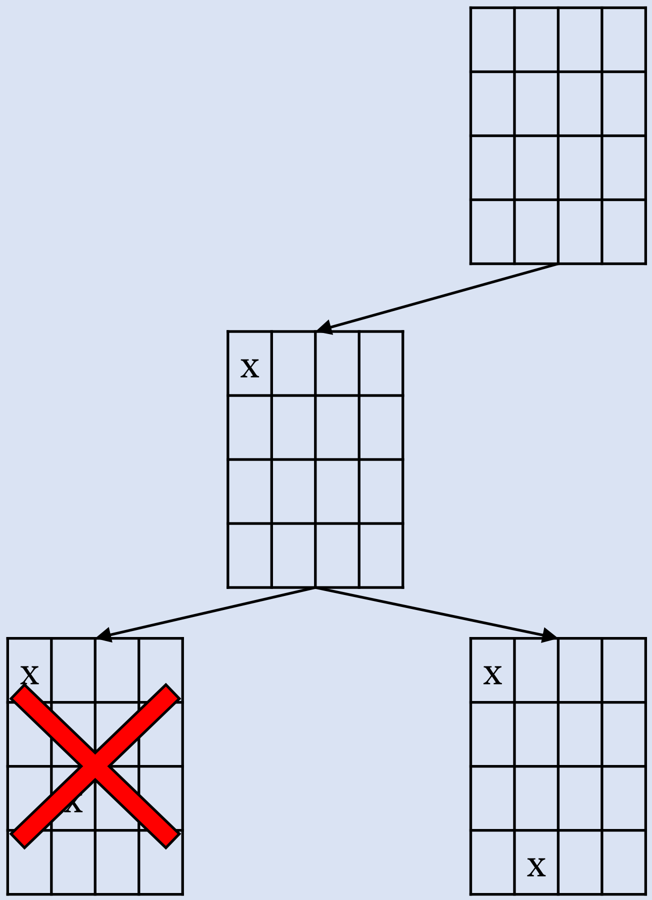
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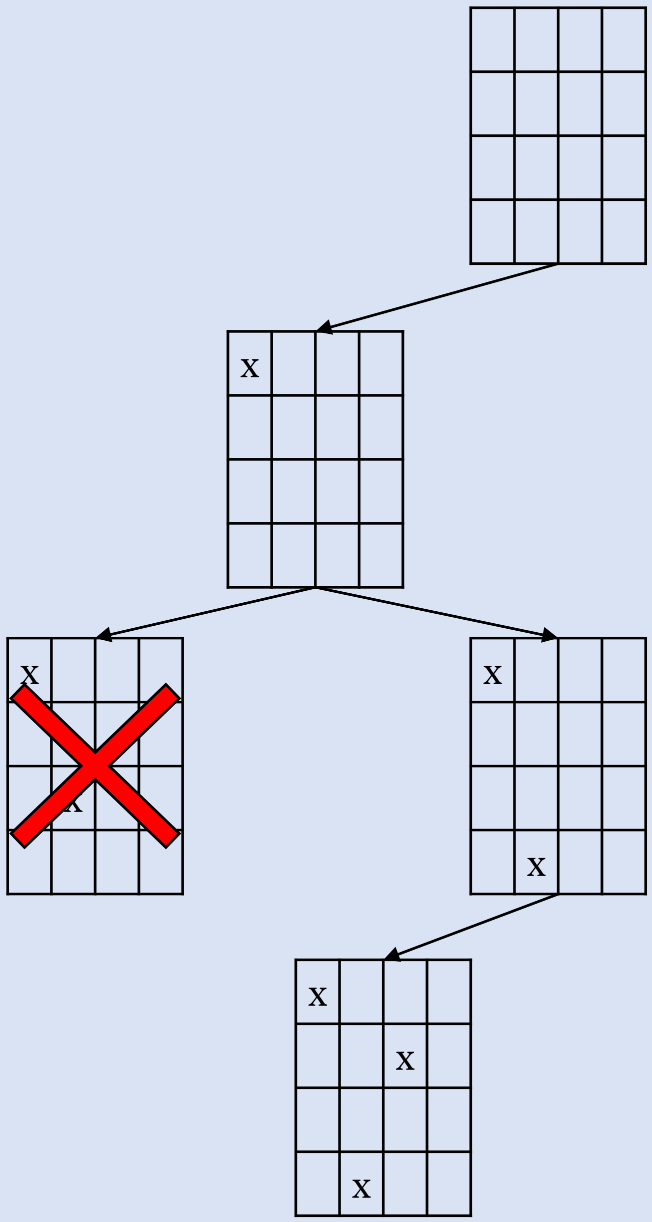
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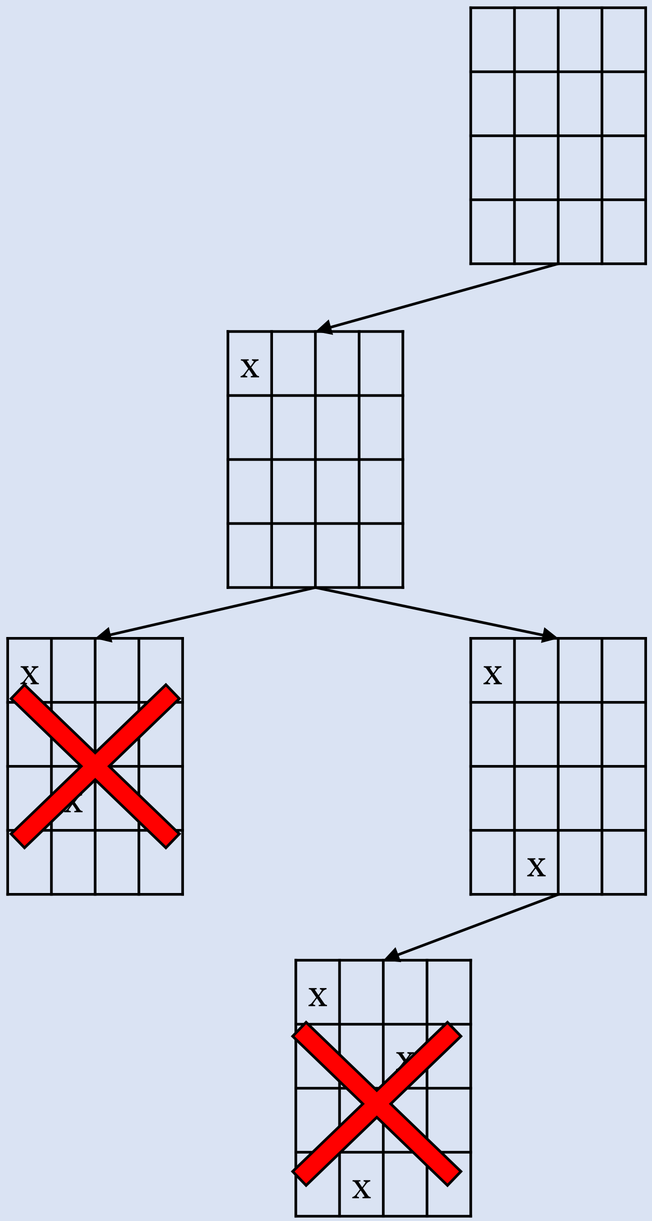

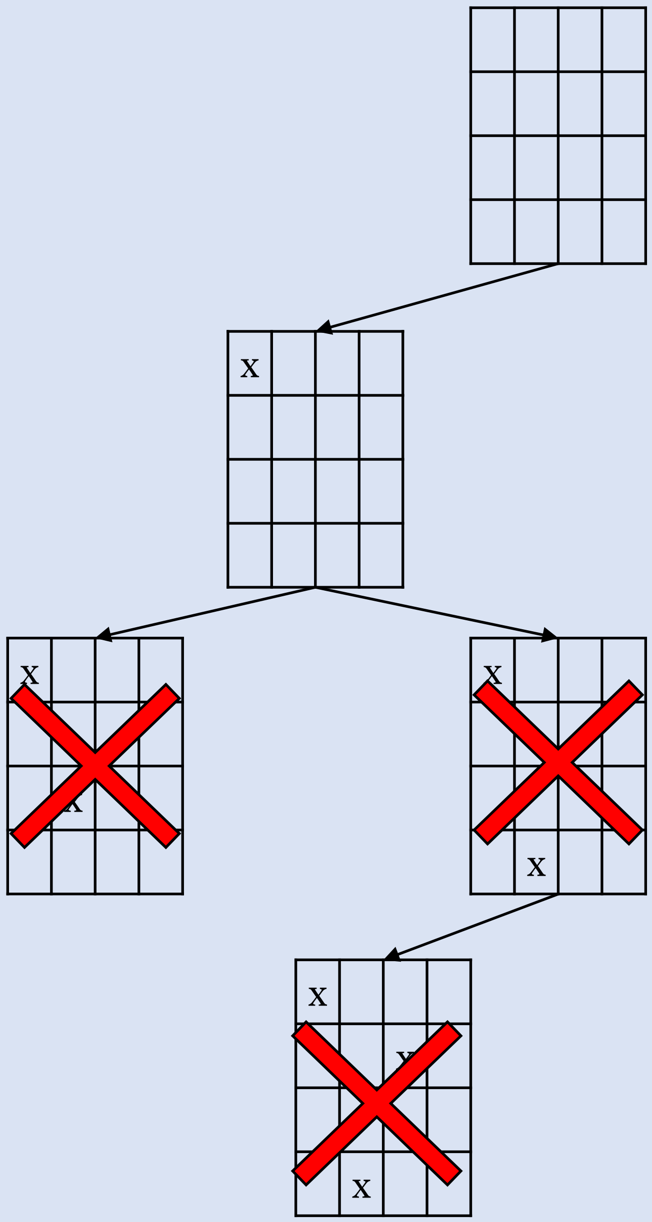

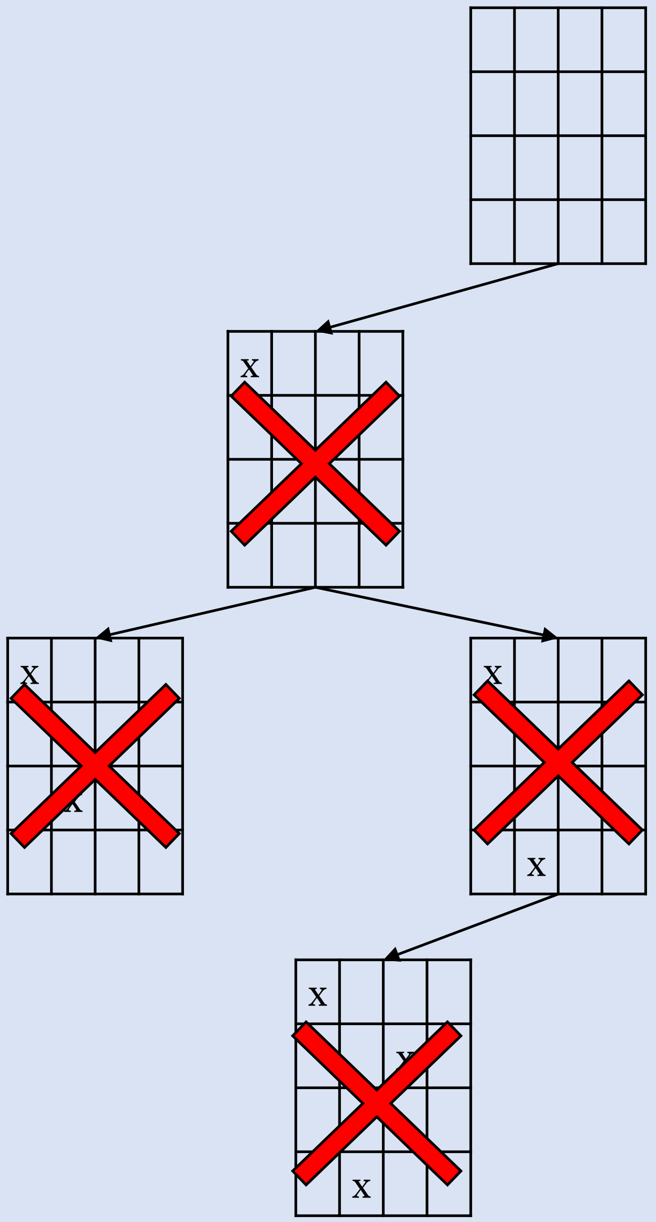
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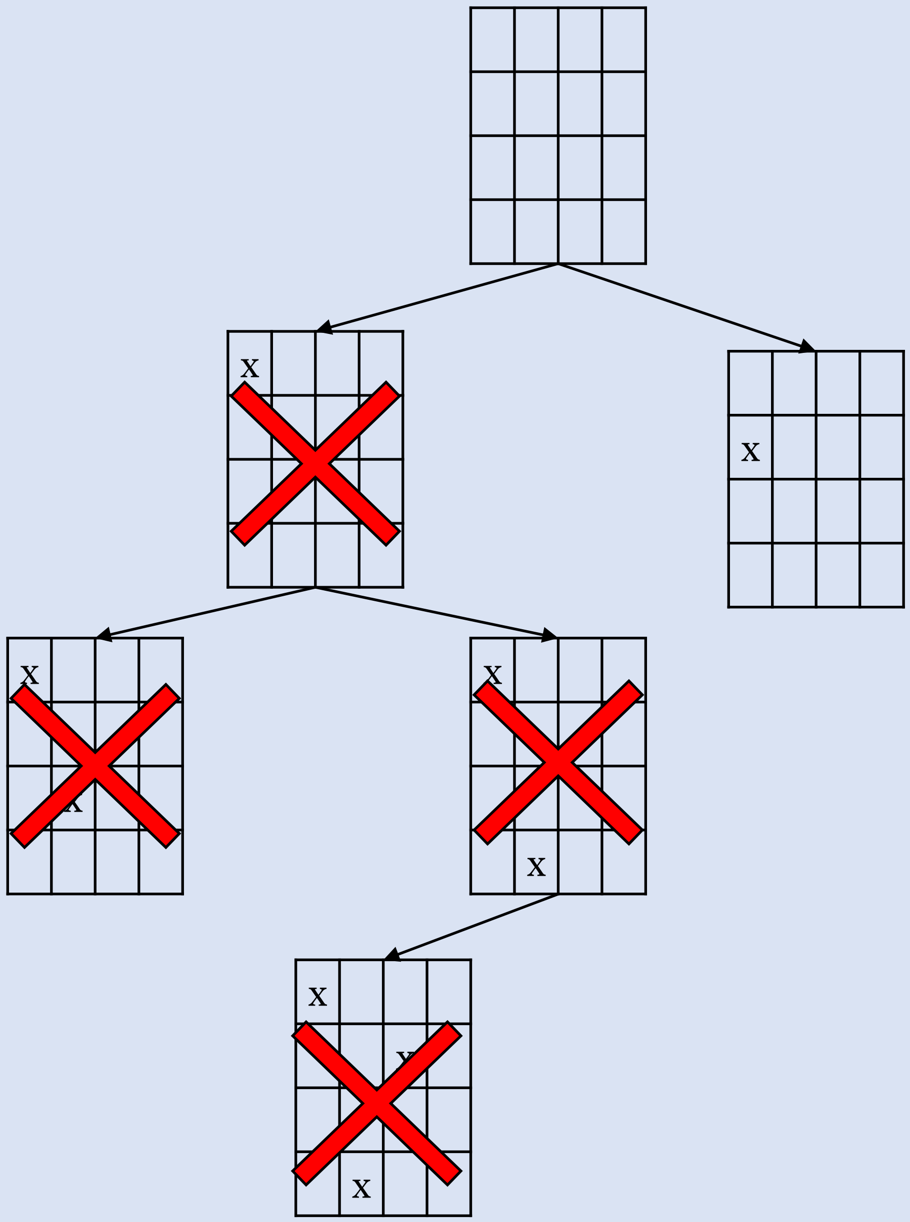

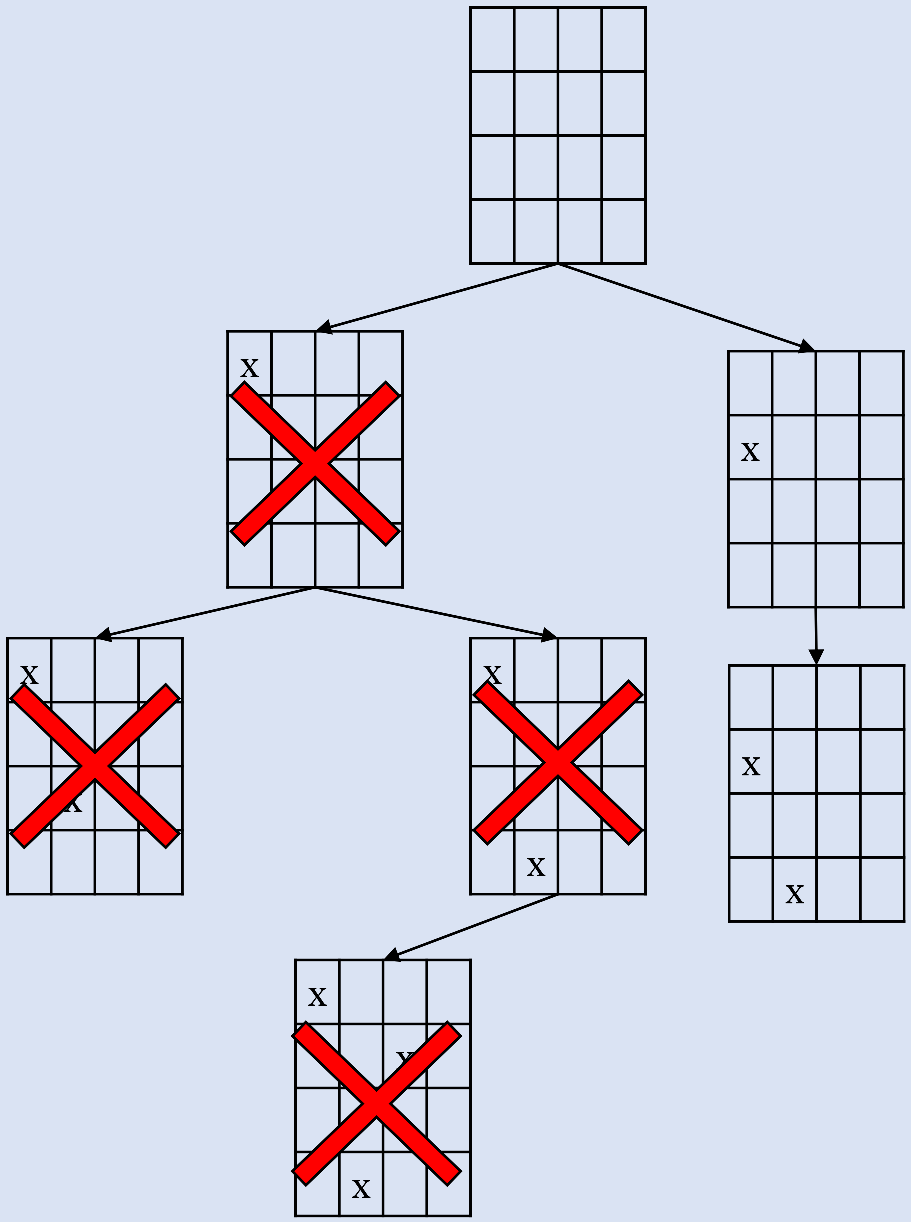

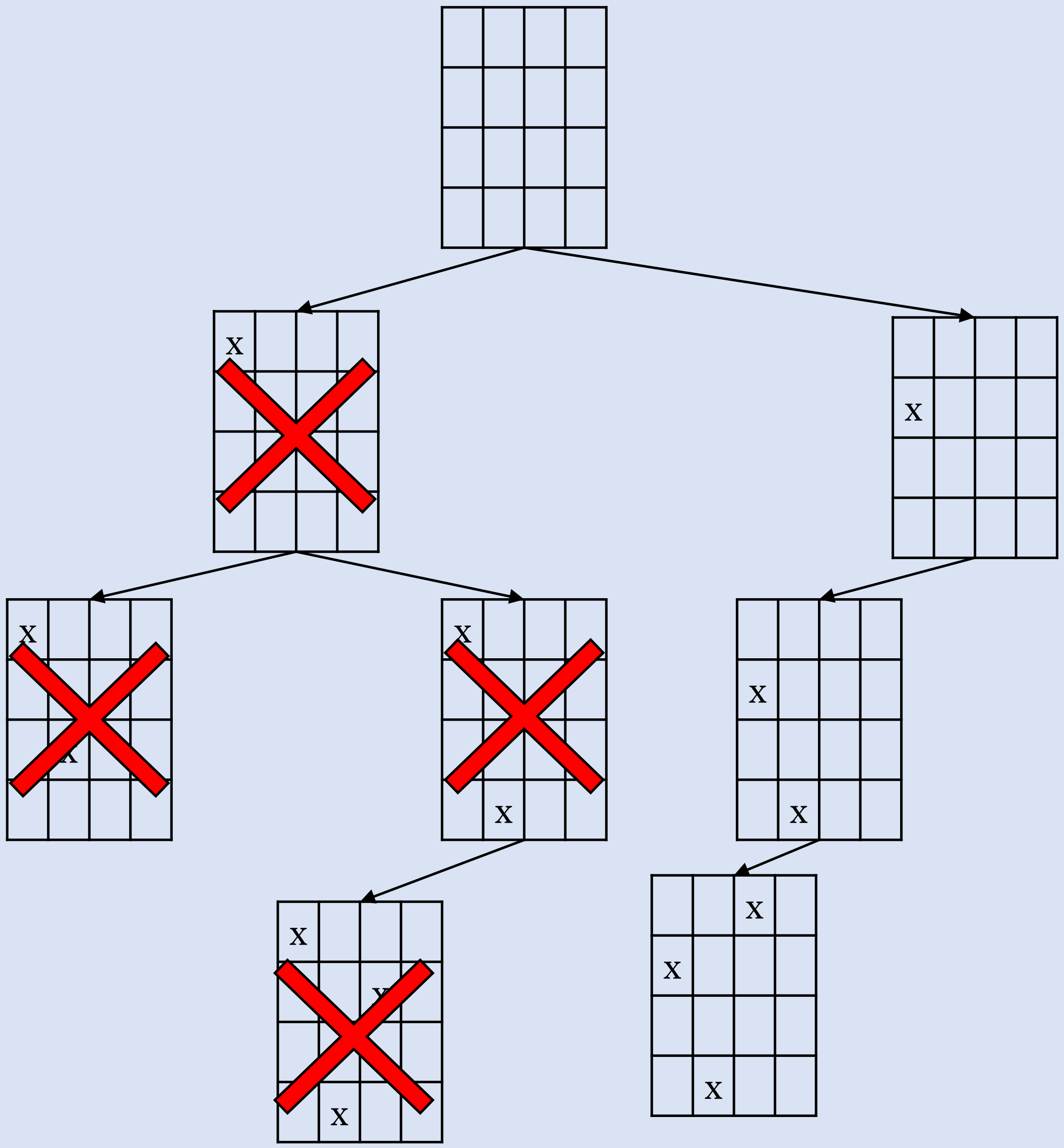

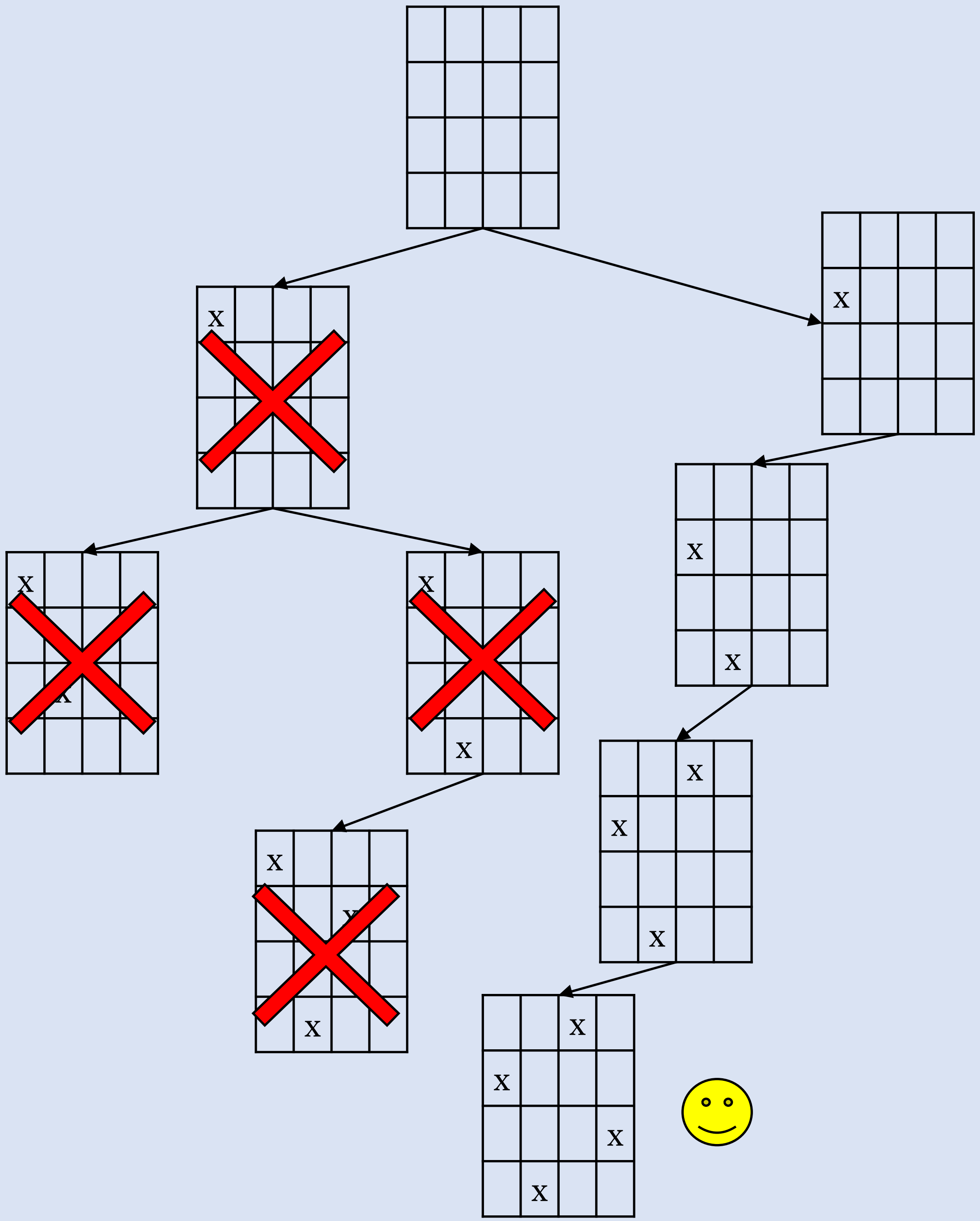

Now Lets Derive the Backtracking Algorithm for N-Queens

Now Lets Derive the Running Time Analysis

The Skeleton Backtracking Algorithm

- This is a skeleton backtracking algorithm you can utilize in design your backtracking solutions to various problems
- bound() tests for a partial solution

```
backtrack(n)
    rbacktrack(1,n)
```

```
rbacktrack(k, n)
    for each x[k] ∈ S
        if (bound(k))
            if (k == n)
                //output the solution
               for i = 1 to n
                   print(x[i] + " ")
                println()
            else
                rbacktrack(k+1,n)
```