ALGO++

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Lecture – 01

Recursion & Backtracking

- Recursion & Backtracking
- Problems

Prateek Narang

Problem Solving Techniques

- Brute Force/ Complete Search
- Greedy Methods
- Divide and Conquer
- Dynamic Programming

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Brute Force Search

- Linear Search
- Finding the largest/smallest number in an array
- Finding a pair in an array with sum as K

- Substrings of an array
- Subsequences of an array
- N-Queen using recursion
- Sudoku Solver using Recursion
- Rat in a Maze using Recursion

Divide and Conquer

Problems have **don't have overlapping subproblems** property.

- Divide the original problem into subproblems.
- Solve these subproblems.
- If needed, combine the sub-solutions to get complete solution.

Examples-

- Binary Search
- Merge Sort
- Quick Sort
- Inversion Count
- Fast Power
- Square Root of Number

Greedy Strategy

- Greedy Algorithms make the choice that **looks best at the moment**.

- You hope that by choosing a **local optimum** at each step, you will end at a **global optimum.**

Examples -

- Counting Money – Greedy (Indian Currency)
- Ith Largest Element in sorted array
- Activity Selection Problems
- Fractional Knapsack
- Load Balancing
- Some Graph Algorithms

Dynamic Programming

Problems having an **optimal substructure** and **overlapping subproblems**.

- Fibonacci Problem
- Ladders Problem
- Knapsack Problem
- And much more…

Let's start

Pre-requisities

- Variables
- Data types
- Loops & Conditional Statements
- Functions
- Pointers
- Call by value & reference
- Basic algorithms – searching, sorting, merging etc.

Reference Variables

Call by reference !

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Static vs Dynamic Memory

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Never Return Address of Local Variable !

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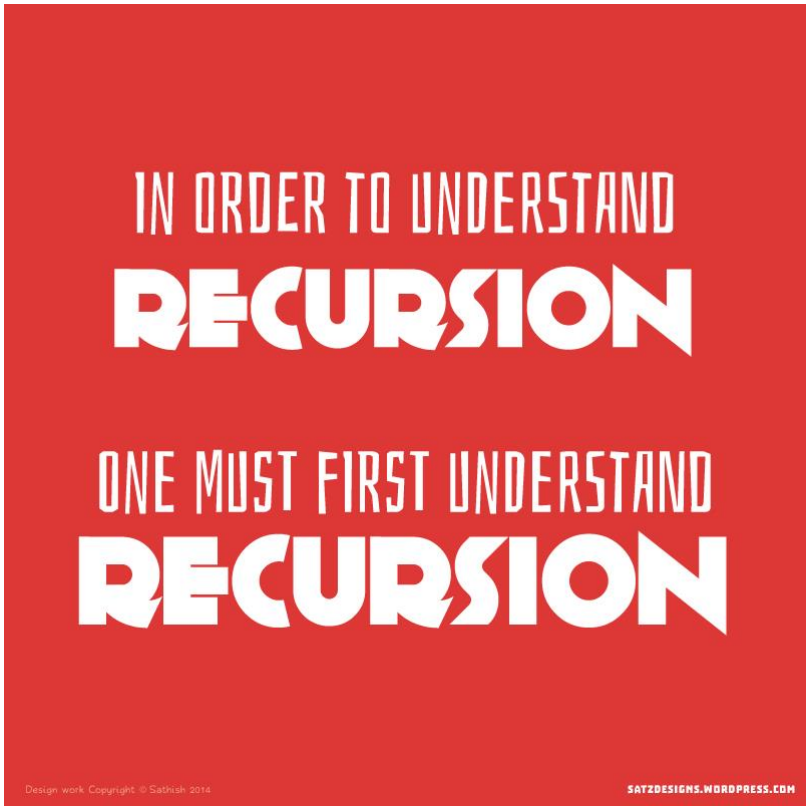
Call Stack!

How to understand Recursion ?



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Time to talk about Recursion!

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What is Recursion?

Recursion in computer science is a method where the solution to a problem depends on solutions to smaller instances of the same Problem.

Parts of Recursive Algorithm

- Base Case (i.e., when to stop)
- Work toward Base Case
- Recursive Call (i.e., call ourselves)

The "work toward base case" is where we make the problem simpler. The recursive call, is where we use the same algorithm to solve a simpler version of the problem. The base case is the solution to the "simplest" possible problem

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Problems

- Fibonacci Number
- Power Function in LogN
- Print Numbers from 1 to N
  - Increasing Order
  - Decreasing Order

Problems

- Replace PI
- Tower of Hanoi
- Merge Sort

Problems

- Subsequences of a String

Find all subsequence of a string

"abc" – "", "a", "b", "c", "ab", "ac", "bc", "abc"

Before we think about recursive solution lets look at few things:

- We need this function to return an array of strings.
- But in C++ we know we cannot return array as this would be address of local variable.
- Instead we can pass it as argument and expect it to fill this array with the strings.
- We also need to know how many strings in this array were filled by the function so that we can iterate over it and print it.

Lets find recursion in it.

- S(“”) – [“”]
- S(“c”) – [“”, “c”]
- S(“bc”) – [“”, “c”, “b”, “bc”]
- S(“abc”) – [“”, “c”, “b”, “bc”, “a”, “ac”, “ab”, “abc”]

Figured out?

S(“abc”) = S(“bc”) + copy of all S(“bc”) with ‘a’ prefixed.

STL

- Vectors
- String Class
- Sorting & Comparators

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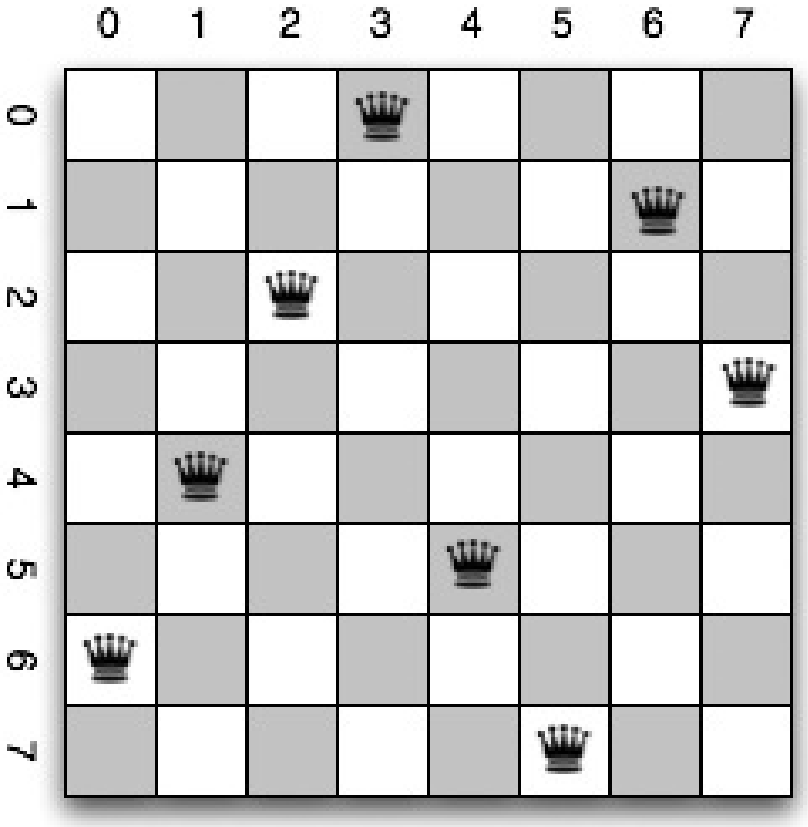
N-Queen Problem



Permutations of a String

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Sudoku Solver

Create a Sudoku Solver and Checker

7	8		4			1	2	
6				7	5			9
			6		1		7	8
		7		4		2	6	
		1		5		9	3	
9		4		6				5
	7		3				1	2
1	2				7	4		
	4	9	2		6			7

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Sample Input

```
int mat[9][9] =
        {{5,3,0,0,7,0,0,0,0},
        {6,0,0,1,9,5,0,0,0},
        {0,9,8,0,0,0,0,6,0},
        {8,0,0,0,6,0,0,0,3},
        {4,0,0,8,0,3,0,0,1},
        {7,0,0,0,2,0,0,0,6},
        {0,6,0,0,0,0,2,8,0},
        {0,0,0,4,1,9,0,0,5},
        {0,0,0,0,8,0,0,7,9}};
```

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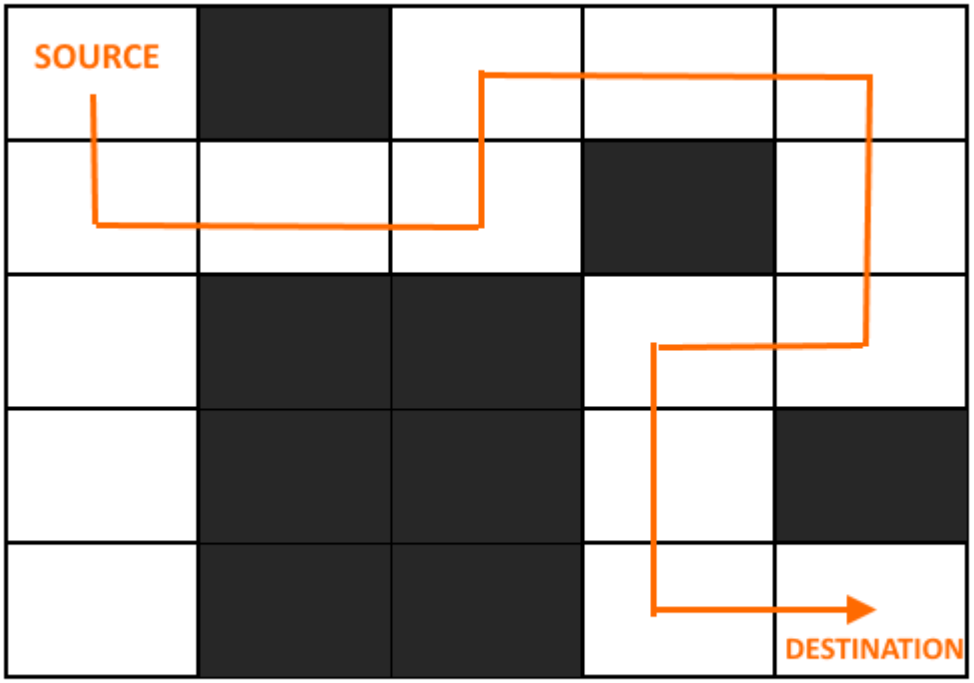
Rat in a Maze



Phone Keypad

HomeWork

Read and Implement **QuickSort**

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Thank you

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