BITS, PILANI – K. K. BIRLA GOA CAMPUS

Design & Analysis of Algorithms

(CS F364)

Lecture No. 2

Algorithms

- Seen many algorithms

Sorting

- **Insertion Sort**
- **Bubble Sort**
- **Merge Sort**
- **Quick Sort**
- **Heap Sort**
- **Radix Sort**
- **Counting Sort**

Graph Algorithms

- **Shortest Path**
- **Minimum Spanning Tree**

Graph Searching

- **Breadth First Search**
- **Depth First Search**
- **Tree Traversal**

Searching

- **Linear Search**
- **Binary Search**

And Many More

Key Questions

Given a problem:

1st Question

Does Solution/Algorithm exist?

Do we know any such problem?

2nd Question

If solution exists, is there alternate better solution?

3rd Question

What is the least time required to solve the problem?

- lower bound results

4th Question

Does there exist algorithm solving the problem taking the least time?

Key Questions

5th Question

Is the known solution polynomial time?

What about fractional knapsack?

What about 0-1 knapsack?

6th Question

If the known solution is not polynomial time, does/will there exist a polynomial time solution?

7th Question

Can we prove that no polynomial time solution will ever exist?

8th Question

If we don't know a polynomial time solution and answer to 7th Question is no, then what?

Course Objective 1:

Algorithm Design Techniques

We already know one popular strategy

Divide & Conquer

Consider the **Coin Change Problem** with coins of denomination 1, 5, 10 & 25

Solution is Easy

What is the guarantee that solution works!

Introduce two more popular & widely applicable problem solving strategies:

- **Dynamic Programming**
- **Greedy Algorithms**

Key Questions

Course Objective 2:

One of the objectives of this course is to look at Question 5 to Question 8 in detail for a class of problems

Understand famous **P vs NP** problem

We strongly believe that certain important class of problems will not have polynomial time solution.

Course Objective - 3

- How to deal with the class of problems for which we strongly believe that no polynomial time algorithm will exist?
- This class consists of important practical problems

Example: Traveling Salesman Problem, 0-1 Knapsack Problem, Bin Packing Problem

And Many more

Course Objective - 3

1st Alternative

Try to get polynomial time solution for an important particular instance of the problem

2nd Alternative

Backtracking Algorithms

With good heuristics this works well for some important particular instance of the problem

3rd Alternative

Approximation Algorithms

As name indicates, these algorithms will give approximate solutions but will be polynomial in time.

Many Other Alternatives

Course Objective - 3

Course Objective – 3

For a certain class of problems to study, develop and analyze ‘good’ approximation algorithms.

Binary Search Tree

- **Binary Search Tree**

Well known, important data structure for efficient search

If T is Binary tree with n nodes, then

min height of the tree is

logn

max height of the tree is

n-1

Disadvantage

Tree can be skewed making search inefficient

Binary Search Tree

- How to fix the **skewness**

Balanced trees

- **AVL Trees**
- **Red-Black Trees**
- **Multi-way Search Trees, (2, 4) Trees**
- **Few More**

Technique used for balancing

- **Rotations**

Left Rotation or **Right Rotation**

Binary Search Tree

- **Disadvantage** with Balanced Trees

Number of rotations needed to maintain balanced structure is

O(logn)

Question

Are there type of binary search trees for which **number of rotations needed for balancing is constant**

(independent of n)

Course Objective - 4

Course Objective – 4

Study type of binary search trees called **Treap** for which **expected number of rotations needed for balancing is constant**

We will be proving that **expected number of rotations needed for balancing in Treap is 2**

(something really strong)

Treap is an Randomized Data Structure