

# Programming & Data Structures

## Tutorial 9

### Problem Solving Tutorial (well sort of)

Developing algorithms is about problem solving. There are four phases (or steps) of problem solving and from these we can tackle any problem. There are also several problem solving 'paradigms'. A paradigm is a general method for tackling a problem. There are many paradigms, inferencing, hill climbing, divide and conquer, working backwards etc. We will visit a number of these during the course.

#### Four Phases of Problem Solving

George Polya was a hungarian mathematician. He was born in 1887 in Budapest and died in 1985 in California. Worked in many areas of mathematics. His most famous book "How To Solve It", published early in his career and many times since, outlined 4 steps to solving any problem.

#### 1. Understand the Problem

- Step seems trivial but is extremely important.
- Must understand problem before it can be solved.
- How do you know when you have a solution or have reached goal? What is unknown? data? conditions?
- State problem in your own words.
- Helpful Hints: Write things down. Draw a figure.

#### 2. Devise a Plan

- How to get started?
- Similar problem, smaller version of problem, look at specific examples.
- Consider various strategies and techniques discussed below.

#### 3. Carrying Out the Plan

- Check each step of your plan for correctness?
- Test on several examples

#### 4. Looking Back

- Does solution solve problem or reach goal?
- Consider possible generalizations or simplifications of solution.

# Paradigms

## Inference

- About the Method

With the inference method one reasons from known facts and other available information to deduce the solution. The information may be implicit or explicit. Detective or mystery stories are good examples of inference. The main strategy is to use the information, operations and goals you are given to achieve a solution.

Example: A secretary types four letters to four people and addresses the four envelopes. If he inserts the letters at random, each into a different envelope, what is the possibility that *exactly* three letters will go into the right envelopes?

## Hill Climbing (Greedy)

- About the Method

With the hill climbing method, one makes a guess at part of the solution and then moves to a better solution closer to the goal (e.g. climb higher up the hill). In order to compare solutions, some type of reward function is needed with which the better solution yields the greater reward.

For example, in a game like checkers the reward function could be the number of opponents checkers captured. Using this reward function to compare two sequences of moves in a game, the "better" sequence would be the one with which you capture more checkers.

## Divide and Conquer

- About the Method

With the Divide and Conquer method, a problem is divided into smaller subproblems in such a way that the solution to the subproblems yields a solution to the original problem. It may be necessary to apply the same "divide and conquer" process to some or all of the subproblems; that is, break the subproblems into even smaller subsubproblems. This dividing process continues until we reach a problem small enough to be easily conquered.

In other words we have to go through three steps:

- Decompose, when we divide the problem into parts.
- Solve, when we solve (or conquer) the smaller subproblems.
- Combine, when we put all the subproblems back together to solve the larger original problem.

Divide and conquer is very common. You use it more often than you realize. Sorting algorithms, QuickSort and MergeSort are common and practical examples of divide and conquer.

### **Working Backward**

- About the Method

With the working backward method we begin with the goal and try to guess a preceding statement or statements that taken together would imply the goal statement. In other words, we start at the end point and try to determine preceding statements, which need not necessarily be the given statements but which when taken together will produce the goal. We hope to arrive at information that is sufficient to derive everything in between the givens and the goals.

The method of Working Backward is useful when the problem satisfies several criteria.

- There is a single, clearly and completely specified final result (goal) and the initial portion of the problem is obscure.
- A problem proceeds from being complex initially to being simple at the end.
- A direct approach involves a complicated equation.
- A problem involves a sequence of reversible actions. The operations in the problem are one-to-one so that it is possible to uniquely determine what

## Tutorial Questions (sort of)/Examples

### Inference

Roger, Laura, Brenda, and Mark work in the city as a singer, stockbroker, salesperson, and cook, but not necessarily in that order. The salesperson and the singer car pool with Laura. Mark plays tennis with the salesperson and the cook. The cook drives to work alone. Roger envies the salesperson. Which person has which career?

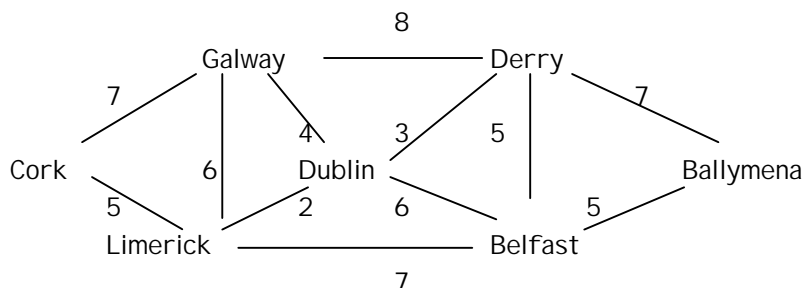
	Singer	Broker	Sales	Cook
Roger				
Laura				
Brenda				
Mark				

### Divide and Conquer

Quicksort algorithm involves sorting a large list of data. The steps required by the Divide and Conquer algorithm are

- Divide into a series of subproblems. Partition the list.
- Solve the subproblems. Quicksort each part.
- Combine the lists back to the original

### Hill Climbing



A Cable TV company wants to connect the seven urban centres listed above. They can only be connected along the links shown. The numbers shown against each link represent the cost of connection along that link (in thousands). The problem for the company is to find the set of links which minimises the cost.

### **Working Backwards**

John paid £2.00 for a box of chocolates. After giving his brother half of the chocolates, he ate nine pieces. His father then ate one more than half the remaining chocolates, leaving 3 pieces. How many chocolates were originally in the box?