Algorithms and Complexity

Introduction

Lecturer: Dr. Alaa Ahmed Abbood
Lecture 1.
Class 2nd .
Time: 8:30-10:30
Department: Businesses Information Technology (BIT)

Outline

- Introduction
- Algorithm Properties
- Algorithm uses in real world
- The concept of an algorithm
- GCD Problem

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Introduction

- When one writes a computer program, one is generally implementing a method of solving a problem which has been previously devised.
- This method is often independent of the particular computer to be used: it's likely to be equally appropriate for many computers. In any case, it is the method, not the computer program itself, which must be studied to learn how the problem is being solved.

Introduction Cont.

- The term algorithm is universally used in computer science to describe problem-solving methods suitable for implementation as computer programs.
- Most algorithms of interest involve complicated methods of organizing the data involved in the computation. Objects created in this way are called data structures, and they are also central objects of study in computer science.

Introduction Cont.

- When a very large computer program is to be developed, a great deal of effort must go into understanding and defining the problem to be solved, managing its complexity, and decomposing it into smaller subtasks which can be easily implemented.
- Often several different algorithms (or implementations) are available to solve the same problem. The choice of the very best algorithm for a particular task can be a very complicated process, often involving sophisticated mathematical analysis.

Introduction Cont.

- The branch of computer science where such questions studied is called analysis of algorithms.
- Many of the algorithms that we will study have been shown to have very good performance through analysis, while others are simply known to work well through experience.
- **An *algorithm* is a sequence of unambiguous instructions for solving a problem, i.e., for obtaining a required output for any legitimate input in a finite amount of time.**

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Algorithm Properties

An algorithm must satisfy the following properties:

- - It must be correct.
- - It must be composed of a series of concrete steps.
- - There can be no ambiguity as to which step will be performed next.
- - It must be composed of a finite number of steps.
- - It must terminate.

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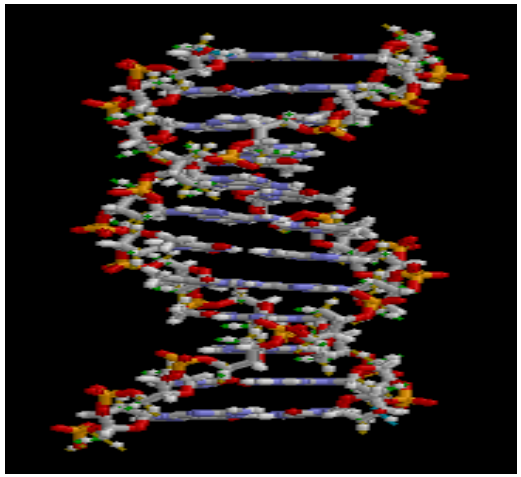
What kinds of problems are solved by algorithms?

- Practical applications of algorithms are found and include the following examples:

- The Human Genome Project has the goals of identifying all the 100,000 genes in human DNA, determining the sequences of the 3 billion chemical base pairs that make up human DNA, storing this information in databases, and developing tools for data analysis. Each of these steps requires sophisticated algorithms.



What kinds of problems are solved by algorithms? Cont.

- The Internet enables people all around the world to quickly access and retrieve large amounts of information. In order to do so, clever algorithms are employed to manage and manipulate this large volume of data.
- Examples of problems which must be solved include finding good routes on which the data will travel, and using a search engine to quickly find pages on which particular information resides.

What kinds of problems are solved by algorithms? Cont.

- Electronic commerce enables goods and services to be negotiated and exchanged electronically.
- The ability to keep information such as credit card numbers, passwords, and bank statements private is essential if electronic commerce is to be used widely.
- Public-key cryptography and digital signatures are among the core technologies used and are based on numerical algorithms and number theory.

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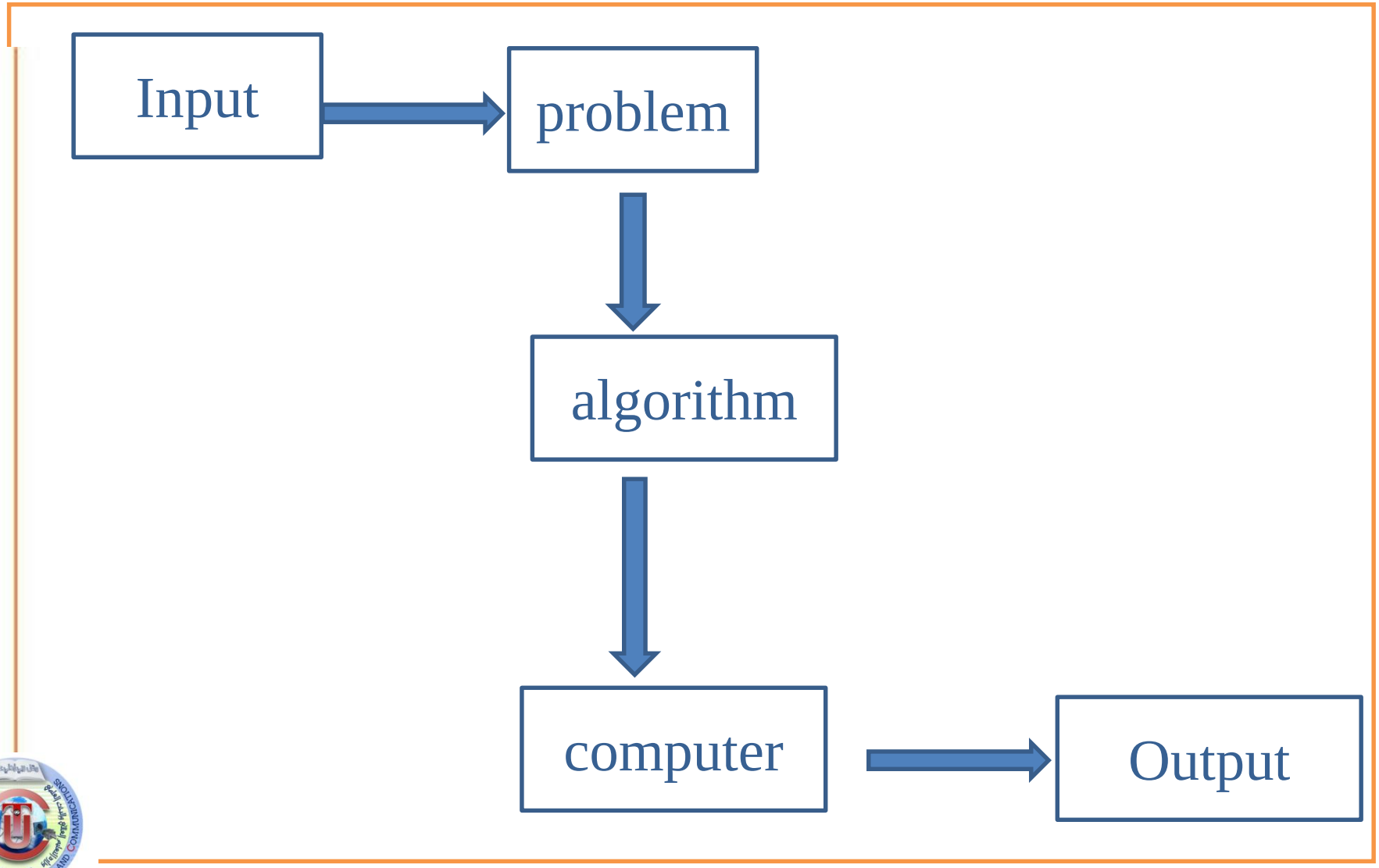
The concept of an algorithm

- In manufacturing and other commercial settings, it is often important to allocate scarce resources in the most beneficial way. An oil company may wish to know where to place its wells in order to maximize its expected profit.
- An Internet service provider may wish to determine where to place additional resources in order to serve its customers more effectively

The concept of an algorithm



The concept of an algorithm Cont.

- ❖ computing the greatest common divisor of two integers. These examples will help us to illustrate several important points:
- The non ambiguity requirement for each step of an algorithm is necessary.
- The range of inputs for which an algorithm works has to be specified carefully.
- The same algorithm can be represented in several different ways.
- There may exist several algorithms for solving the same problem

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Greatest Common Divisor (GCD)

GCD problem

- Recall that the ***Greatest Common Divisor*** of two nonnegative, not-both-zero integers *m* and *n*, denoted gcd*(m, n)*, is defined as the largest integer that divides both *m* and *n* evenly, i.e., with a remainder of zero.
- Euclid of Alexandria (third century b.c.) outlined an algorithm for solving this problem.
- *Euclid's algorithm* is based on applying repeatedly the equality gcd*(m, n)* = gcd*(n, m* mod *n),*

Greatest Common Divisor (GCD)

Example of GCD problem

Find the GCD of (m, n), where m=400, n =124

Dividend	m	400	124	28	12	4
Divisor	n	124	28	12	4	0
Reminder	r	28	12	4	0	

Euclid's algorithm for computing gcd(*m*, *n*)

- Step 1 If $n = 0$, return the value of m as the answer and stop; otherwise, proceed to Step 2.
- Step 2 Divide m by n and assign the value of the remainder to r.
- Step 3 Assign the value of n to m and the value of r to n. Go to Step 1.

Greatest Common Divisor (GCD)

Alternatively, we can express the same algorithm in pseudocode:

- ALGORITHM *Euclid(m, n)*

Computes gcd*(m, n)* by Euclid's algorithm

- Input: Two nonnegative, not-both-zero integers *m* and *n*
  Output: Greatest common divisor of *m* and *n*
  while $n \neq 0$ do
- $r \leftarrow m \bmod n$
  $m \leftarrow n$
- $n \leftarrow r$ return *m*


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