The Role of Algorithms in Computing

What will we study?

- Look at some classical algorithms on different kinds of problems
- How to design an algorithm
- How to show that an algorithm works correctly
- How to analyze the performance of an algorithm

1.1 Algorithms

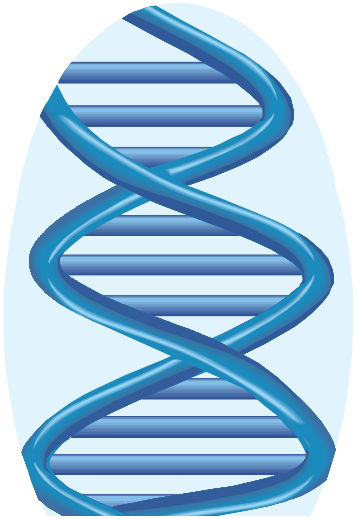
- Algorithm: Any well-defined computational procedure that takes some value, or set of values, as input and produces some value, or set of values, as output.
- *Or*; Algorithm: A method of solving a problem, using a sequence of well-defined steps
- Defined a Sorting problem
- Input: A sequence of *n* numbers $< a_1, a_2, ..., a_n >$
- Output: A permutation of the input sequence such that $a'_1 \leq a'_2 \leq ... \leq a'_n$

Instances of a problem

- An ***instance of a problem*** consists of the input (satisfying constraint imposed in the problem statement) needed to compute a solution to the problem
- An algorithm is said to be ***correct*** if for every input instance, it halts with the correct output
- A **correct** algorithm ***solves*** the given computational problem. An **incorrect** algorithm might not halt at all on some input instance, or it might halt with other than the desired answer

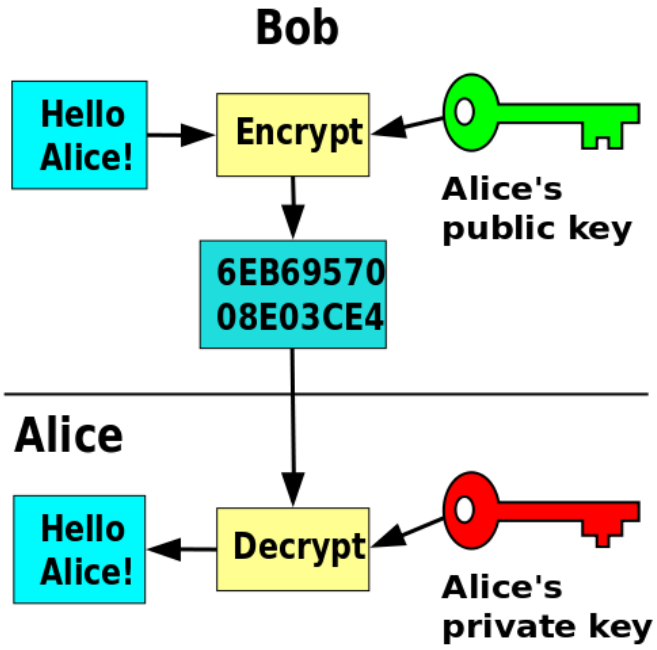
What kinds of problems are solved by algorithms? (1/2)

- The Human Genome Project
  - Determine the sequences of the 3 billion chemical base pairs of DNA
  - Identify all the 100,000 genes in human DNA
- The Internet applications
  - Quickly access and retrieve large amount of information such as Google
  - Big Data > 10^{15} Bytes/minute IP data transferred



What kinds of problems are solved by algorithms? (2/2)

- Electronic commerce with public-key cryptography and digital signatures
- Manufacturing and other commercial enterprises need to allocate scare resources in the most beneficial way.



1.2 Algorithms as a technology

- Efficiency:
  - Different algorithms solve the same problem often differ noticeably in their efficiency
  - These differences can be much more significant than difference due to hardware and software
- For example, in Chapter 2 we will see that *insertion sort* takes time roughly equal to $c_1 n^2$ (c_1 is constant) to sort n items. But, merge sort takes time roughly equal to $c_2 n \lg n$ (c_2 is constant)

1.2 Algorithms as a technology

- For example, assume a faster computer A (10^{10} instructions/sec) running insertion sort against a slower computer B (10^7 instructions/sec) running merge sort.
- Suppose that c_1=2, c_2=50 and $n = 10^7$.
  - the execution time of computer A is $2(10^7)^2 / 10^{10}$ instructions/sec = 20,000 seconds
  - the execution time of computer B is $50 \times 10^7 \times \lg 10^7 / 10^7$ instructions/sec = 1,163 seconds

Exercises

- Exercises: 1.2-2, 1.2-3 (Practice at home)
- Problem 1.1 (Practice at home)