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

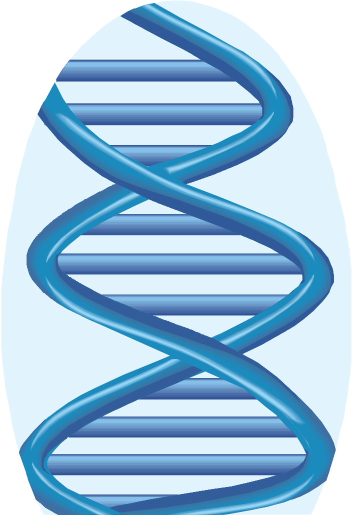
- Algorithm: Any well-defined computational procedure that takes some value, or set of values, as input and produces some value, or set of values, as output.
- *Or*; Algorithm: A method of solving a problem, using a sequence of well-defined steps
- Defined a Sorting problem
- Input: A sequence of *n*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

Instances of a problem

- An algorithm is said to be ***correct*** if for every input instance, it halts with the correct output
- An ***instance of a problem*** consists of the input (satisfying constraint imposed in the problem statement) needed to compute a solution to the problem
- 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

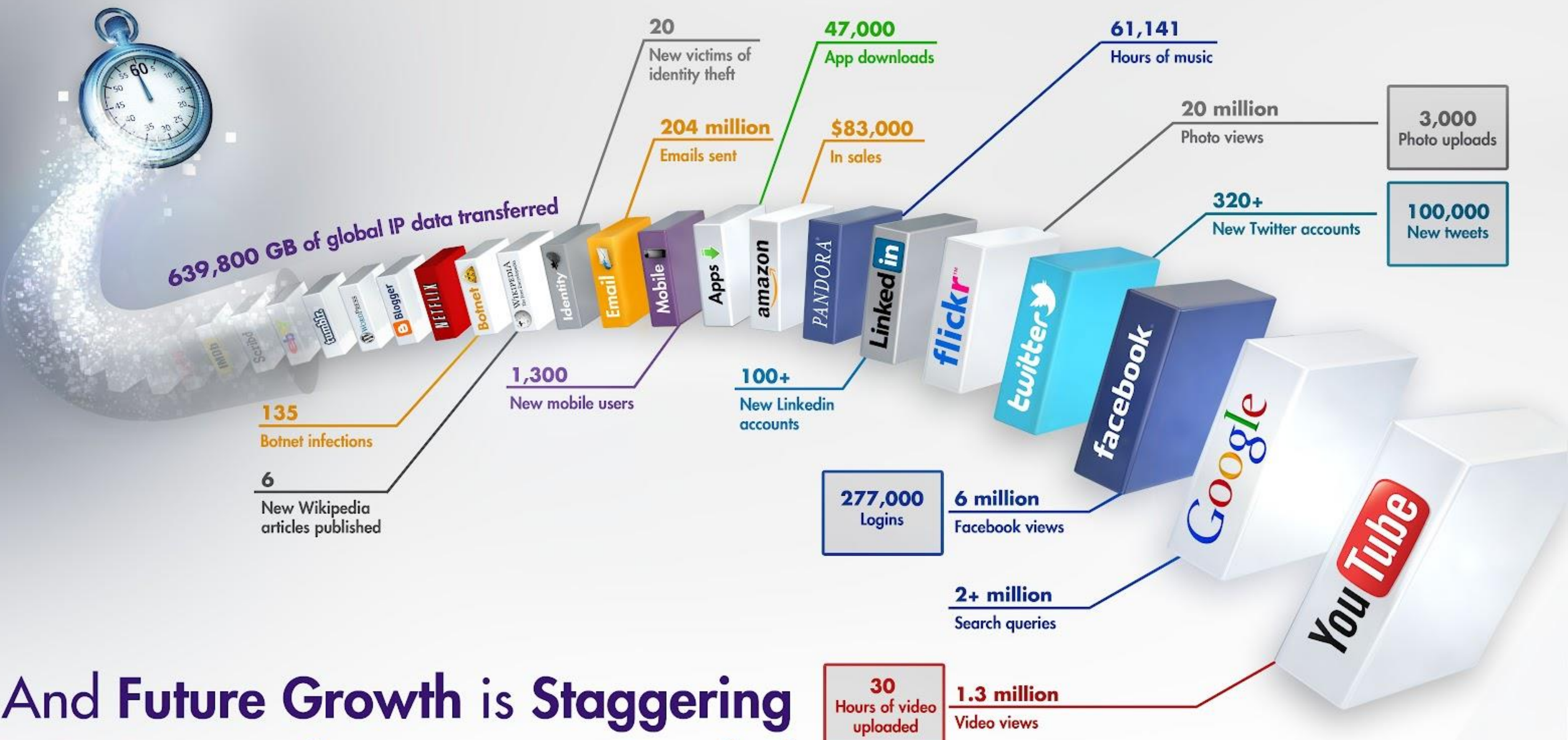
What kinds of problems are solved by algorithms? (1/2)

- 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 Happens in an Internet Minute?



639,800 GB of global IP data transferred

20
New victims of identity theft

204 million
Emails sent

47,000
App downloads

$83,000
In sales

61,141
Hours of music

20 million
Photo views

3,000
Photo uploads

320+
New Twitter accounts

100,000
New tweets

135
Botnet infections

6
New Wikipedia articles published

1,300
New mobile users

100+
New Linkedin accounts

277,000
Logins

6 million
Facebook views

2+ million
Search queries

30
Hours of video uploaded

1.3 million
Video views

And Future Growth is Staggering

Today, the number of networked devices = the global population

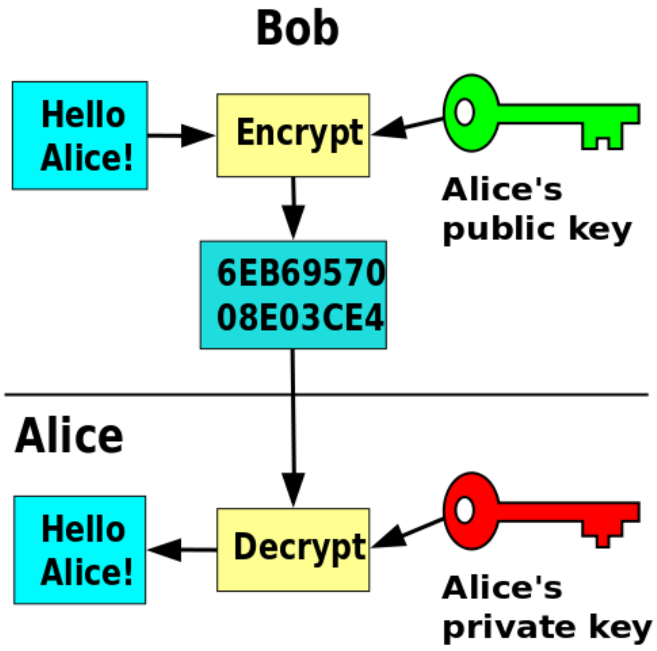
By **2015**, the number of networked devices = 2x the global population

In **2015**, it would take you **5 years** to view all video crossing IP networks each **second**

Source: Intel 2012 March

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_1n^2 (c_1 is constant) to sort n items. But, merge sort takes time roughly equal to $c_2n\lg n$ (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: 1.2-3 (Practice at home)
- Problem 1.1 (Practice at home)