Advanced information, computation, communication I
EPFL - Fall semester 2020-2021

Week 6

October 20, 2020

Exercise 1.

```
function f1() {
  x=0
  i=1
  while (i ≤ n) {
    x=x+1
    i=x+x
  }
  a=x
}
```

```
function f2() {
  y=0
  j=1
  while (j ≤ n) {
    y=y+1
    j=y*y
  }
  b=y
}
```

After execution of the two program fragments `f1` and `f2`, it is the case that

- ◯ $a \approx \frac{n}{2}$, $b \approx \sqrt{n}$.
- ◯ $a \approx n$, $b \approx \log_2(n)$.
- ◯ $a \approx \frac{n}{2}$, $b \approx \log_2(n)$.
- ◯ $a \approx n$, $b \approx \sqrt{n}$.

Exercise 2. The following three algorithms sort the input sequence $a_0, a_1, \ldots, a_n$ of real numbers in ascending order.

Algorithm 1 Bubble Sort

```
repeat
  swapped ← FALSE
  for i = 1 to n − 1 do
    if a_{i−1} > a_i then
      swap a_{i−1} and a_i
      swapped ← TRUE
    end if
  end for
until swapped = FALSE
```

Algorithm 2 Selection Sort

```
for i = 0 to n − 1 do
  min ← i + 1
  for j = i + 1 to n do
    if a_min > a_j then
      min ← j
    end if
  end for
  if a_i > a_min then
    swap a_i and a_min
  end if
end for
```

Algorithm 3 Insertion Sort

```
for j = 1 to n do
  i ← 0
  while a_j > a_i do
    i ← i + 1
  end while
  m ← a_j
  for k = 0 to j − i − 1 do
    a_{j−k} ← a_{j−k−1}
  end for
  a_i ← m
end for
```

1. Use Bubble Sort, Selection Sort and Insertion Sort to sort the following sequence:

   `9, 12,-43, 20, -2, 3, 7, 28, 19.`

2. How many comparisons are done in each of the algorithms?
3. How many swaps are done in each of the algorithms?
4. What is the approximate overall cost of the two algorithms for an input sequence of length $n + 1$?

Exercise 3. Recall the definition of Quicksort given in the lecture notes.

1. Using Quicksort with the first element as divider, sort the following sequence:

   `-7, 19, 11, -5, -4, 0, 18, -8, 16, 3, -3, 5, 1, 20, 6.`

2. How many comparisons are done in total?
3. How many swaps are done in total?

Exercise 4. Recall the definition of Mergesort given in the lecture notes.

1. Using Mergesort, sort the following sequence:

   `-5, 11, -7, 15, -1, 7, 10, 9, 8, -4, 18, 17, -8,-10, 19, 2.`

2. How many comparisons are done in total?
3. How many swaps are done in total?

Exercise 5.

(*français*) La raison d'avoir une mémoire cache est

(*English*) The reason to have a cache is

- ○ de rendre possible de servir rapidement des futures demandes de données de mémoire.
  so that it may be possible to serve future requests for data from memory in a fast manner.
- ○ de laisser les programmeurs décider eux-mêmes comment organiser au mieux l'accès à la mémoire.
  to let programmers decide for themselves how to best organize memory access.
- ○ d'exploiter la localité temporelle avec des lignes de cache courtes et simultanément
  la localité spatiale avec de longues lignes de cache.
  to exploit temporal locality with short cache lines and simultaneously spatial locality with long cache lines.
- ○ pour aider les programmeurs à transposer des matrices.
  to help programmers transpose matrices.

Exercise 6. A palindrome is a string that reads the same forward and backward. Describe an algorithm for determining whether a string of n characters is a palindrome.

Exercise 7. Describe an algorithm that determines whether a function from a finite set to another finite set is one-to-one.

Exercise 8. Adapt the bubble sort algorithm so that it stops when no interchanges are required. Express this more efficient version of the algorithm in pseudocode.

Exercise 9. Two strings are anagrams if each can be formed from the other string by rearranging its characters. Devise an algorithm to determine whether two strings are anagrams