

Algorithms & Data Structures

Exercise Sheets

Weeks 1-2: Lists, ADTs and complexity

Exercises

- (1) Number of integers in a vector
- (a) (Week 1) Write a program that generates random M integers and puts them in an vector. Then it generates another N random integers and counts how many of them are in the array using an iterator.
 - (b) (Week 2) Estimate the worst-case complexity of your program.
- (2) (Old exam question, week 2) What is the time complexity (Big-O) of myMethod? Argue for your answer:

```
int myMethod(int N)
{
    int x = 0;
    int y = 0;
    for (int i = 0; i < N; i++)
    {
        for (int j = 0; j < N; j++)
        {
            for (int k = 0; k < N * sqrt(N); k++)
            {
                x++;
            }
        }
        for (int i = 0; i < N * N; i++)
        {
            y++;
        }
    }
    return x + y;
}
```

- (3) (Week 2) For each of the following four program fragments:
- (a) Give an analysis of the running time in Big-Oh notation.
 - (b) Implement the code inside a C function, and give the running time for several values of N .
 - (c) Compare your analysis with the actual running times.
 - (d) Does compiling/running programs with the `-O` optimization flag change anything in your analysis?

```

(1) sum = 0;
    for (i = 0; i < n; ++i) {
        ++sum;
    }

(2) sum = 0;
    for (i = 0; i < n; ++i) {
        for (j = 0; j < n; ++j) {
            ++sum;
        }
    }

(3) sum = 0;
    for (i = 0; i < n; ++i) {
        for (j = 0; j < n * n; ++j) {
            ++sum;
        }
    }

(4) sum = 0;
    for (i = 0; i < n; ++i) {
        for (j = 0; j < i; ++j) {
            ++sum;
        }
    }

```

- (4) (a) (Old exam question, week 1) Write an implementation of the ADT MaxHeap described below. The implementation **must** be done by using the standard class vector from C++. If you need to iterate through the vector, you **must** use an iterator and its methods and operators begin(), end(), ++ and *

```

class MaxHeap
{
public:
    // is the heap empty?
    virtual bool isEmpty() const = 0;

    // number of elements in the heap
    virtual int size() = 0;

    // add an element to the heap
    virtual void insert(const int x) = 0;

    // find the maximum element in the heap
    virtual const int findMax() const = 0;

    // delete and return the maximum element of the heap
    virtual int deleteMax() = 0;
};

```

- (b) (Week 2) What is the time complexity of the five operations of MaxHeap? You must argue for your answers
- (c) (Week 2) make a new (other) implementation of the MaxHeap using a List (as described in the slides). Make sure to use the List interface where possible. You can find the code for the List on Brightspace.
- (5) (Week 2) One of the exam topics will be "Big-O and ADTs". In this exercise you must (in groups) prepare an agenda for how you would present this topic for the oral

exam. You will discuss in group the items you will present and the form. You must be able to argue for why you have chosen each item. The result will be an agenda consisting of 7 items with a clear justification for each. You must spent at most 20 min on this exercise. The agenda will be presented and discussed with peer groups in week 2 if time permits or else week 3.