CST2550 Software Engineering

Management and Development

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**REPORT OF LIBRARY SOFTWARE PROJECT**

**INTRODUCTION**

**Brief description**

This project consists of designing and developing a software simulation intent on organising, searching, and modifying books data in a library. In the following report, the type of design conceived and implemented for the realisation of this project will be deepened by illustrating various details such as the choice criterion and analysis of the data structure and algorithms employed, going through the type of approach undertaken for testing furthermore summarised as a table, and finally, a summary conclusion followed by references in Harvard format.

**Report layout/index**

The report layout, as required, includes 5 sections which are: Introduction, Design, Testing, Conclusion and References, and they are displayed as per followed index.

Introduction – brief description of the project and report layout ……………………………....... Page 1

Design, justification of selected data structure(s) and algorithms ….………………….……..…..………. Page 2

Time complexity analysis ………………………………………………………………………………………….... Page 3 – 6

Testing and Approaches, and table of test cases ………………………………..……….………………… Page 7

Conclusion and References in Harvard format …………………………………………………….……….. Page 8

**DATA STRUCTURE & ALGORITHMS ANALYSIS**

**Selection of data structure and algorithms**

**Data structure Selection and Example:**

The data structure was designed to improve searching performances but to the detriment of its overall time and space complexity. Indeed, memory and time cost are weaknesses of such a data structure due to more complex "insert", "remove", and "access" methods, shown in the time-complexity table here followed.

As mentioned above, its advantage lies in the search. It provides different layers of sorted data to allow faster research of multiple books just by entering any title fraction of the target. Its time-complexity worst case is quadratic for ***insertion***, polynomial for ***removing*** and polynomial/linearithmic for the ***random access***. Its space complexity is O(n\*t) in the worst-case scenario and Ω(2n) in the best one.

|  |  |  |  |
| --- | --- | --- | --- |
|  |  | DDC | SDS |
| Insert | Front  Middle  End | O(1)  O(n)  O(1) | O()  O()  O() |
| Remove | Front  Middle  End | O(1)  O(n)  O(1) | O(n\*t)  O(n\*t)  O(n\*t) |
| Lookup | Front  Middle  End | O(1)  O(1)  O(1) | O(t log n)  O(t log n)  O(t log n) |

Default Data Container *(deque)*

DDC = { e2, c2, a3, d1, b2, a2, c1, e1, a1, b1, a4, e3 }

*(SDS size depends on the words amount of the longest book title in DDC)*

Sorted Data Structure *(structure made of deques)*

SDS = { { a1, a2, a3, a4, b1, b2, c1, c2, d1, e1, e2, e3 }

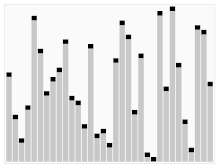
{ a2, a3, a4, b2, c2, e2, e3 }

{ a3, a4, e3 }

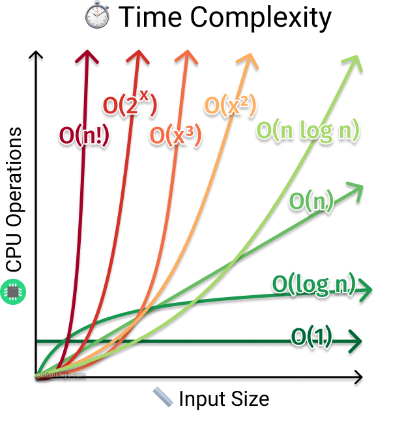
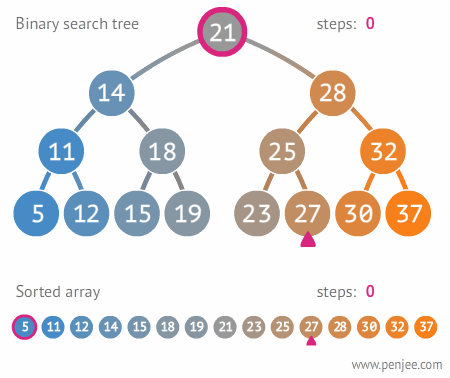
{ a4 }

}

**Sorting Algorithm Selection:**

Quick-Sort is the sorting algorithm chosen and implemented in this project since, in order to experience faster research, one of the most powerful algorithms happens to be the Binary-Search, which is a searching algorithm that requires an ordered list of elements in order to work. Hence, since the data in question is sortable by its alphabetical relation, binary search appears to be the most suitable solution, and therefore a subsequential needs for a sorting algorithm, perhaps based on *divide and conquer* as well.

Quick-sort *“middle pivot”* selection is due to its efficiency in terms of time-complexity since its best & average performance is linearithmic, Θ(n log n).

***Searching Algorithm Selection:***

As a searching algorithm, Binary-Search (divide and conquer) was my choice according to its performances in terms of time-complexity, which in the worst-case behaves logarithmically, O(log n). Its choice was suitable due to the planned implementation of a data structure containing sorted data alphabetically related to each other as a binary tree.

Eventually, such an algorithm was adapted to obtain multiple results. Hence the final time-complexity of the worst case is now O(n).

**Analysis of data structure and algorithms**

**Algorithm: QUICKSORT Pseudocode**

Code Cost Times

Recursion(left, right)

     i ← left C1 1

j ← right C2 1

     newTitle ← (left + right) / 2 C3 1

     pivot ← A[newTitle] C4 1

     while i <= j do C5 n+1

         while A[i] < pivot do C10 [0, n/2+1]n

i++ C11 [0, n/2]n

end while

         while A[j] > pivot do C12 [0, n/2+1]n

j-- C13 [0, n/2]n

end while

         if i <= j then C14 [1, n]

             tmp  ← A[i] C15 [0, n]

             A[i] ← A[j] C16 [0, n]

             A[j] ← tmp C17 [0, n]

             i++ C18 [0, n]

j-- C19 [0, n]

         end if

     end while

     if left < j then C19 1

Recursion(left, j) C20 T(n/2)

end if

     if i < right then C21 1

Recursion(i, right) C22 T(n/2)

end if

  end of recursion

Recursion(0, A.length-1)

end of Quicksort method .

*(Master method applied due to the recursion solution instead of an iterative one)*

***Worst case: O()***

T(n) = *aT(n/b) + f(n/d)* = 2T(n/2) + /2 ***(d = 2)***

= = = 1 ∴ d > 1 ∴ O()

***Best case:*** ***Ω(n log n)***

T(n) = *aT(n/b) + f(n/d)* = 2T(n/2) + O(n) ***(d = 1)***

= = = 1 ∴ d == 1 ∴ Ω( log n) = Ω(n log n)

**Algorithm: BINARYSEARCH Pseudocode**

Code Cost Times

l ← 0

r ← n-1

Recursion() T(n)

    mid = l + (r - l) / 2 C1 1

       if r >= l then C2 1

           iterTitle ← A[mid] C3 [0, 1]

            if iterTitle == search then C4 [0, 1]

                increaseMid ← mid C5 [0, 1]

decreaseMid ← mid C6 [0, 1]

                while right >= ++increaseMid do C7 [0, n/2+1]

if A[increaseMid] <> search then  C8 [0, n/2]

break C9 [0, 1]

end if

end while

                while left <= --decreaseMid do C10 [0, n/2+1]

if A[decreaseMid] <> search then C11 [0, n/2]

break C12 [0, 1]

end if

end while

                decreaseMid++ C13 [0, 1]

                for i in A[decreaseMid] is <> A[increaseMid] do C14 [0, n]

                    found[i.getId()] ← i C15 [0, n]

end for

                return true C16 [0, 1]

end if

            if iterTitle > search then C17 [0, 1]

                r ← mid -1 C18 [0, 1]

                return Recursion() C19 T(n/2)

end if

            l ← mid +1 C20 [0, 1]

            return Recursion() C21 T(n/2)

end if

return false C22 [0, 1]

end of recursion

Recursion()

end of BinarySearch method .

*(Master method applied due to the recursion solution instead of an iterative one)*

***Worst case: O(n)***

T(n) = *aT(n/b) + f(n/d)* = T(n/2) + n ***(d = 1)***

= = = 0 ∴ d > 0 ∴ O(n)

***Best case: Ω(1)***

T(n) = Ω(1)

**Data structure: ADDBOOK Pseudocode** *(insert method)*

Code Cost Times

addBook(book)

    DDC.push\_back(book) C1 1

    shuffle(DDC) C2 n

    quicksort(DDC) C3 n log n

    titleSize ← book.length C4 1

    for i in 0 to titleSize-1 do C5 t+1

        if i >= SDS.length then C6 [1, t]

            if i == 0 then C7 [0, t]

                SDS.push\_back(DDC) C8 [0, t]

            else do

                SDS.push\_back({}) C9 [0, t]

                for j in 0 to DDC.length-1 do C10 [0, n+1]t

                    iterTsize ← DDC[j].length C11 [0, n]t

                    if iterTsize > i then C12 [0, n]t

  SDS[i].push\_back(DDC[j]) C13 [0, n]t

end if

                end of for

                quicksort(SDS[i], 0, SDS[i].length-1, i) C14 [0, ]t

            end of if and else

        else do

            SDS[i].insert(bookSearch(SDS[i], book, i)[1], book) C15[0,log(n)+n]t

        end of if and else

    end of for

end of addBook (insertion method) .

*(Master method does not apply to the current solution since it is iterative instead of recursive)*

let C’ = ( C1 + C4 ) 1

let C’’ = ( ( ) ) [0, t]

let C’’’ = ( ( ) + C16 ) [0, n]t

***Worst case: O()***

T(n) = C’ + C”t + C’’’(n\*t) + C2n + C3(n log n) + C5(t+1) + C10(n+1) + C14\*t) + C15(n log n)

= C’ + C”t + C’’’(n\*t) + C2n + C3n log n + C5t + C5 + C10n + C10 + C14\*t + C15n log n

=(C` + C5 + C10) + (C`` + C5)t + C```nt +(C2 + C10)n + (C3 + C15) n log n + C14

= O()

***Best case: Ω(n log n)***

T(n) = C’ + C2(n) + C3(n log n) + C5(t+1) + C6t

= C’ + C2n + C3n log n + C5t + C5 + C6t

= ( C’ + C5 )1 + ( C6 + C5 )t + C2(n) + C3(n log n)

= Ω(n log n)

**Data structure: REMOVEBOOK Pseudocode** *(remove method)*

Code Cost Times

removeBook(indexes)

  removed ← true C1 1

    for i in 0 to indexes.length-1 do C2 t+1

      if indexes[i] <> -1 then C3 [1, t]

        if i == 0 then C4 [0, t]

          if indexes[i] < DDC.length && indexes[i] >= 0 then C5 [0, t]

            b ← DDC[indexes[i]] C6 [0, t]

            DDC.erase(indexes[i]) C7 [0, t]

          else do removed ← false C8 [0, t]

          end of if and else

        else

          if i-1 <= SDS.length then C9 [0, t]

            if indexes[i]<SDS[i-1].length&&indexes[i]>=0 then C10 [0, t]

              SDS[i-1].erase(SDS[indexes[i]) C11 [0, n]t

            else do removed ← false C12 [0, t]

            end of if and else

          else do removed ← false C13 [0, t]

          end of if and else

end of if and else

      else do removed ← false C14 [0, t]

      end of if and else

    end of for

    return removed C15 1

end of bookRemove (remove method) .

*(Master method does not apply to the current solution since it is iterative instead of recursive)*

let C’ = ( ( ) + ( ) ) [0, t]

let C’’ = ( C1 + C15 ) 1

***Worst case: O(n\*t)***

T(n) = C’t + C3t + C’’1 + C2( t+1 ) + C11(n\*t)

= C’t + C’’1 + C3t + C2t + C11n\*t

= C’’1 + (C’ + C3 + C2)t + C11n\*t

= O(n\*t)

***Best case: Ω(1)***

T(n) = C’0 + C’’1 = Ω(1)

**TESTING**

**Testing and approach (Unit testing and RAD)**

The approach undertaken is the *"functional test"* which consists of testing the application against the expected requirements. *Unit testing* is the first level of testing and is the method of my choice for developing test cases. It is the process of ensuring that the individual components of a piece of software programmatically are functional and perform as they were designed. Unit testing also simplified debugging, as finding problems earlier means smaller debugging time than if they were discovered later in the testing process.

The approach adopted for software development is *"RAD"* (Rapid Application Development). The reason why this is the approach of my choice lies in its characteristics indicated in the current context, that is, where the agreed deadline is immovable and therefore superfluous functionality are expendable.

In fact, one of the characteristics most similar to the type of context in question is the prioritization of the requirements only, therefore making use of the *"MoSCow"* concept, which consists in prioritizing the requirements by neglecting non-essential functionalities even if important, and then possibly implementing them if time permits.

**Table of test cases**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| CLASS | STATUS | MACRO | DESCRIPTION | | |
| **INPUT** | **EXPECTED OUT** | **OBTAINED OUT** |
| Global  *This section is where Global class methods get tested* | PASSED | CHECK( toLower() ); | “TeSt” | “test” | “test” |
| PASSED | CHECK\_FALSE( split() ); | “hello world” | vec.size() == 2 | vec.size() == 2 |
| PASSED | CHECK\_FALSE( vec[0] ); | “hello” == “” | false | false |
| PASSED | CHECK\_FALSE( vec[1] ); | “world” == “” | false | false |
| PASSED | CHECK\_FALSE( getCstate() ); | setColor(false); | false | false |
| PASSED | CHECK( colorReset() ); | setColor(false); | “” | “” |
| PASSED | CHECK( color() ); | “green” | “” | “” |
| PASSED | CHECK( getCstate() ); | setColor(true); | true | true |
| PASSED | CHECK( colorReset() ); | setColor(true); | != “” | != “” |
| PASSED | CHECK( color() ); | “green” | != “” | != “” |
| PASSED | CHECK( sToll() ); | “abc” | 0 | 0 |
| PASSED | CHECK( sToll() ); | “0” | 0 | 0 |
| PASSED | CHECK( sToll() ); | “123” | 123 | 123 |
| Operations  *class methods testing* | PASSED | REQUIRE(is\_class<Operations>); | ::value | true | true |
| PASSED | CHECK( reader() ); | “0” | 0 | 0 |
| PASSED | CHECK\_FALSE( reader() ); | “1” | != 0 | != 0 |
| Collection  *class methods testing* | PASSED | CHECK( getBook(0).getId() ); | book1 | "12345" | "12345" |
| PASSED | CHECK( getBook(1).getId() ); | Book2 | “54321” | “54321” |
| PASSED | CHECK( removeBook() ); | BI0 | true | true |
| PASSED | CHECK( removeBook() ); | BI1 | true | true |
| Books  *testing* | PASSED | REQUIRE( is\_class<Books> ); | ::value | true | true |
| PASSED | CHECK\_FALSE( emptyCheck() ); | b (a book obj) | false | false |
| 4 test cases |  | 22 assertions |  |  |  |

**CONCLUSION AND REFERENCES**

**Summary reflection**

* In conclusion, the completed project essentially consists of the development of mainly four sections. Each included in the same final report, which happens to be also one section itself.
* Another section is software programming, written in C++ language with the support of *Git Version Control* and relative repository on *Bitbucket*.
* The following section is *"unit testing"* (performed employing the *"Catch.hpp"* library for C++) included in the same software directory and both compiled by the same *“makefile”*.
* The last section consists of a report assertion of the choice justification about algorithms and data structures implemented in the software and their respective time complexity analysis.

The work performed was carried out by undertaking a *RAD* *(Rapid Application Development)* approach, with the main reason being the predetermined delivery deadline, which consequently limited the development flexibility in terms of time and, therefore, made the choice of this approach indicated to the case in question. Furthermore, were not for the context, a preferable approach could have also been the *“Agile”* one, as it is one of the most requested and used approaches in the professional environment.

Indeed, in a possible next project, the software development approach's choice is likely to fall into the *"Agile"* mode, to learn all the advantages and obtain the ability to approach programming in one of the most requested ways in the professional framework, and as a sorting algorithm, most probably the next chosen ones would be *Radix LSD* when values to be sorted are integers; otherwise, a variant of *Quicksort (dual pivot)*.

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