

Design Specification  
JobSeeker  
Version 2

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## Revision Page

By virtue of submitting this document we electronically sign and date that the work being submitted by all the individuals in the group is their exclusive work as a group and we consent to make available the application developed through [CS] or [SE]-2XB3 project, the reports, presentations, and assignments (not including my name and student number) for future teaching purposes.

### ***First revision:***

Senni Tan — Edited the title page and created the contribution table.

Zihao Du — Added the attestation and consent in Revision.

### ***Second revision:***

Senni Tan — Edited the contribution table.

Zihao Du — Edited the contribution table.

Wang Wenzhi — Edit the contribution table.

Gengyun Wang — Edited the contribution table.

### ***Third revision:***

Senni Tan — Modules MIS; Description of implementation; View of uses relationship; Internal review.

Zihao Du — Modules MIS; Description of implementation; Description of Modules; Internal review.

Wang Wenzhi — Modules MIS; Description of implementation; implementation and two UML for two most interesting classes; Internal review.

Gengyun Wang — Modules MIS; Description of implementation and trace back to requirements; Internal review.

## Contribution Page

Name	Role(s)	Contribution	Comments
Zihao Du	Designer Researcher Designer  Tester	Proposal Abstract and motivation Database of jobs SRS Functional requirement Graphing algorithm implementation Client module Unit test for graphing algorithm Design Specifications(refer to document revisions)	
Senni Tan	Designer  Tester	Proposal I/O SRS Non-functional requirement Sorting Algorithm Implementation Unit test for sorting algorithm implementation Design Specifications(refer to document revisions)	
Gengyun Wang	Designer  Tester	Proposal Prior Work SRS Assumptions, Domain Searching Algorithm Implementation Unit test for searching algorithm implementation Design Specifications(refer to document revisions)	
Wenzhi Wang	Designer  Tester	Proposal Reference page SRS Maintenance and Development Data processing implementation Test and modify the client code implementation Design Specifications(refer to document revisions)	

## Executive Summary

JobSeeker is designed for potential immigrants, people new to Canada that are looking for a job and Canadian job seeker. It will provide the user positions of jobs they are interested in and show the relative information. The project is composed by five main modules; a Job module which constructs the Job ADT; a Data Process module which processes data from datasets, converts them to Job objects, stores the objects and return; a Sorting module which sorts the Job objects arrays, with the help from the Comparable module; a Searching module which does the searching on Job objects with some given conditions; and a DFS module which finds the relative jobs for a given job source in the graph constructed by the Graph ADT. The prototype of this design will be presented in the Demo module. This document gives the detail of the project design in the sections below.

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# 1 Description of Modules

The design is made up with nine modules including the client module. These modules can be divided into four categories: Data Processing, Sorting, Searching and Graphing.

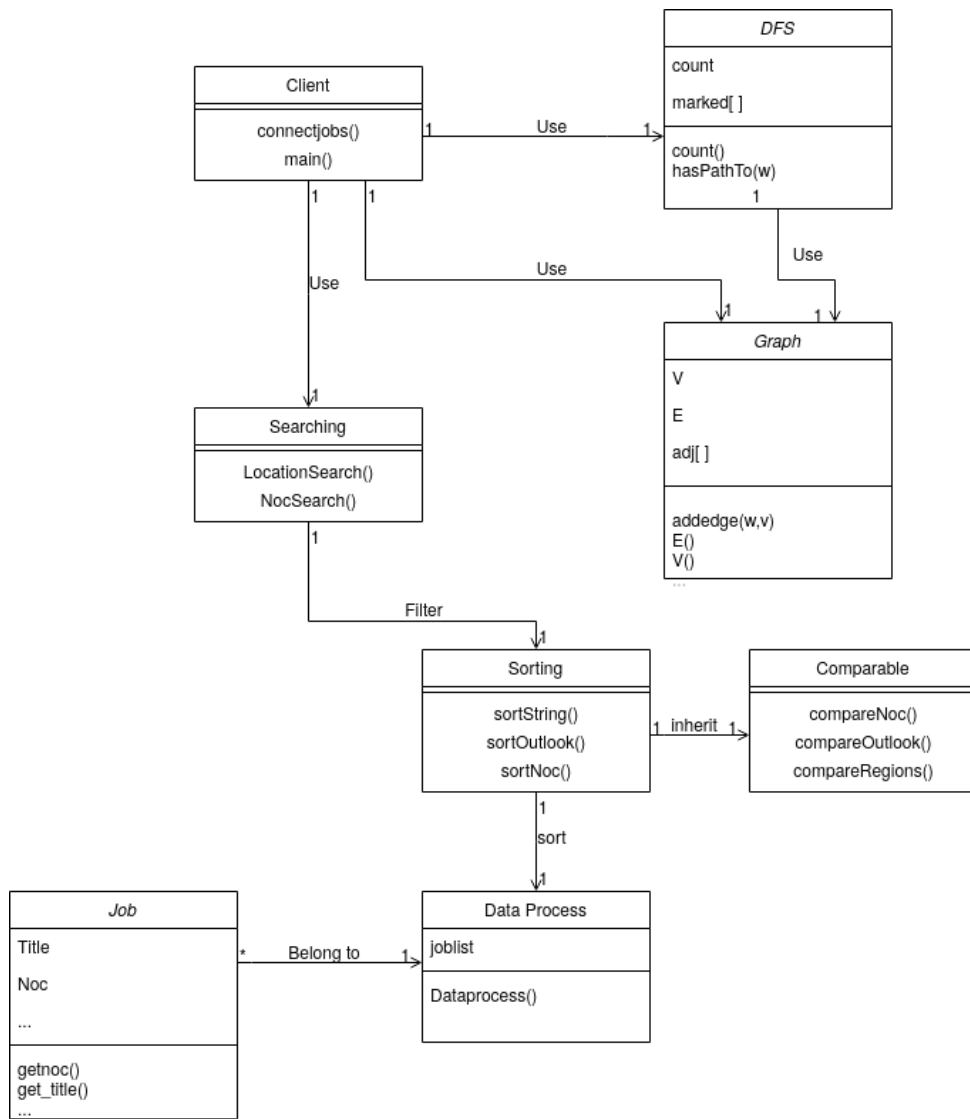
Job class and Dataprocess class belongs to Data Processing, which make use of data from the database and store that into some data structures in Java. Job class defines state variables for an object Job, which is an important and fundamental object for the design. The methods in Job class are all getters. Dataprocess class takes no input and use Job class to store information from dataset into its state variable "joblist".

Sorting catagory contains two classes: Comparable and Sorting. Since we need to sort by different criteria, the Comparable class provides different compareTo methods. The Sorting class inherits these methods and use quicksort algorithm to sort the input ArrayList.

Searching catagory contains only a single module Searching. Just like Sorting class, it provides static functions instead of creating objects. It uses binary search assuming that the ArrayList is already sorted to get the kind of Job the user want and return them in an ArrayList.

The Graphing part is a trival one. It contains two classes: Graph and DFS. Graph creates an undirected graph class while DFS is an object exploring reachable nodes with depth-frist search algorithm based on a Graph class.

The client module part uses outputs of Searching, Sorting and Graphing parts. It also makes use of a class called Noc which provides a list of job catagories for user selection and demonstration.



## 2 Detailed description of interfaces

### Job ADT Module

#### Template Module

Job

#### Uses

N/A

#### Syntax

#### Exported Types

Job = ?

#### Exported Access Programs

Routine name	In	Out	Exceptions
Job	seq of $\mathbb{Z}$ , String, $\mathbb{Z}$ , $\mathbb{Z}$ ,String, $\mathbb{Z}$ ,String	Job	
get_noc	$\mathbb{Z}$	$\mathbb{Z}$	
getnoc		seq of $\mathbb{Z}$	
get_title		String	
get_location		String	
get_region		$\mathbb{Z}$	
get_outlook		$\mathbb{Z}$	
get_year		$\mathbb{Z}$	
get_regions		String	
getInfo		String	
getbriefInfo		String	
printInfo			
printbriefInfo			

#### Semantics

#### State Variables

*noc*: seq of  $\mathbb{Z}$

*title*: String



*outlook*:  $\mathbb{Z}$   
*year*:  $\mathbb{Z}$   
*region*:  $\mathbb{Z}$   
*regions*: String  
*location*: String

## State Invariant

None

## Assumptions

The constructor Job is called for each object instance before any other access routine is called for that object. The constructor cannot be called on an existing object.

## Access Routine Semantics

Job(*noc*, *title*, *outlook*, *year*, *location*, *region*, *regions*):

- transition: *noc*, *title*, *outlook*, *year*, *location*, *region*, *regions* := *noc*, *title*, *outlook*, *year*, *location*, *region*, *regions*
- output: *out* := *self*
- exception: None

get\_noc(*index*):

- output: *out* := *noc*[*index*]
- exception: None

getnoc( ):

- output: *out* := *noc*[0] \* 1000 + *noc*[1] \* 100 + *noc*[2] \* 10 + *noc*[3]
- exception: None

get\_title( ):

- output: *out* := *title*
- exception: None

get\_location( ):

- output: *out := location*

- exception: None

get\_region( ):

- output: *out := region*

- exception: None

get\_outlook( ):

- output: *out := outlook*

- exception: None

get\_year( ):

- output: *out := year*

- exception: None

get\_regions( ):

- output: *out := regions*

- exception: None

printbriefInfo( ):

- exception: None

getbriefInfo( ):

- output: *out := "Job title : " + this.get\_title() + "Noc\_" + this.get\_noc(0) + "" + this.get\_noc(1) + "" + this.get\_noc(2) + "" + this.get\_noc(3)*

- exception: None

printInfo( ):

- exception: None

getInfo( ):

- output: *out := "Job title : " + this.get\_title() + "\nNoc\_" + this.get\_noc(0) + "" + this.get\_noc(1) + "" + this.get\_noc(2) + "" + this.get\_noc(3) + "\nOutlook : " + this.get\_outlook() + "\nProvince : " + this.get\_location() + "\nEconregioncode : " + this.get\_region() + "\nEcon region name : " + this.get\_regions() + "\nYear" + this.get\_year() + "\n"*

- exception: None

# DataProcess Module

## Module

DataProcess

## Uses

Job

## Syntax

### Exported Types

DataProcess = ?

### Exported Access Programs

Routine name	In	Out	Exceptions
DataProcess			FileNotFoundException
get_data		seq of Job	

## Semantics

### State Variables

*dataset*: seq of Job

### State Invariant

None

### Assumptions

The constructor DataProcess is called only once for only one object for reading the dataset files.

## Access Routine Semantics

DataProcess( ):

- transition:  $dataset + Job$
- output:  $out := self$
- exception: FileNotFoundException

get\_data( ):

- output:  $out := dataset$
- exception: None

# Comparator Module

## Module

Comparable

## Uses

Job

## Syntax

### Exported Access Programs

Routine name	In	Out	Exceptions
CompareString	Job, Job	$\mathbb{Z}$	
CompareOutlook	Job, Job	$\mathbb{Z}$	
CompareNOC	Job, Job	$\mathbb{Z}$	
CompareRegionS	Job, Job	$\mathbb{Z}$	

## Semantics

### Access Routine Semantics

CompareString(a, b):

- output:  $out := a.get\_title.compare\_To(b.get\_title)$
- exception: None

*// compareTo is a build in method to compare String in lexicographical order.*

CompareOutlook(a, b):

- output:  $out := (a.get\_outlook > b.get\_outlook) \Rightarrow 1 \mid (a.get\_outlook < b.get\_outlook) \Rightarrow -1 \mid 0$
- exception: None

CompareNOC(a, b):

- output:  $out := (a.get\_noc(0) > b.get\_noc(0)) \Rightarrow 1 \mid (a.get\_noc(0) < b.get\_noc(0)) \Rightarrow -1 \mid 0$

- exception: None

CompareRegionS(a, b):

- output: *out* := a.get\_regions.compareTo(b.get\_regions)
- exception: None

*// compareTo is a build in method to compare String in lexicographical order.*

# Sorting Module

## Module

Sorting

## Uses

Comparable

## Syntax

### Exported Access Programs

Routine name	In	Out	Exceptions
sortString	Seq of Job		
sortOutlook	Seq of Job		
sortNOC	Seq of Job		
sortRegionS	Seq of Job		

## Semantics

### Access Routine Semantics

sortString(a):

- transition: sortString(a, 0, |a|-1)
- exception: None

sortOutlook(a):

- transition: sortOutlook(a, 0, |a|-1)
- exception: None

sortNOC(a):

- transition: sortNOC(a, 0, |a|-1)
- exception: None

sortRegionS(a):

- transition: sortRegionS(a, 0, |a|-1)
- exception: None

# Searching Module

## Module

Searching

## Uses

Job

## Syntax

### Exported Constants

None

### Exported Types

Searching = seq of Job

### Exported Access Programs

Routine name	In	Out	Exceptions
LocationSearch	seq of Job, String	seq of Job	
NocSearch	seq of Job, $\mathbb{Z}$	seq of Job	

## Semantics

### State Variables

None

### State Invariant

None

### Assumptions

None



## Access Routine Semantics

LocationSearch(*jobs*, *location*):

- output:  $out := \langle e : Job | e \in jobs \wedge e.get\_regions() = location : e \rangle$  Return a sequence of all the elements from input location in the input sequence jobs
- exception: None

// *get\_regions()* is a method from Job ADT class.

NocSearch(*jobs*, *noc*):

- output:  $out := \langle e : Job | e \in jobs \wedge e.get\_noc(0) = noc : e \rangle$  Return a sequence of all the elements with same input noc number in the input sequence jobs
- exception: None

// *get\_noc(int index)* is a method from Job ADT class.

# Graph Module

## Module

Graph

## Uses

N/A

## Syntax

### Exported Constants

None

### Exported Types

Graph = ?

*//An undirected graph with unweighed edges*

### Exported Access Programs

Routine name	In	Out	Exceptions
Graph	$\mathbb{Z}$	Graph	NegativeArraySizeException
addedge	$\mathbb{N}, \mathbb{N}$		IllegalArgumentException
V		$\mathbb{N}$	
E		$\mathbb{N}$	
adj	$\mathbb{N}$	Seq of $\mathbb{N}$	IllegalArgumentException

## Semantics

### State Variables

$V: \mathbb{N}$

$E: \mathbb{N}$

$adj: \text{Seq of Seq of } \mathbb{N}$

### State Invariant

None

## Assumptions

The constructor `Graph` is called for each object instance before any other access routine is called for that object. The constructor cannot be called on an existing object.

## Access Routine Semantics

*//Constructor of Graph class*

`Graph(v):`

- transition:  $V, E, adj := v, 0, \text{Seq of Seq of } \mathbb{N} \text{ with length } v$
- output:  $out := self$
- exception:  $exc := v < 0 \Rightarrow \text{NegativeArraySizeException}$

*//Connect vertex w and vertex v*

`addedge(w, v):`

- transition:  $E, adj[w], adj[v] := E + 1, adj[w] || v, adj[v] || w$
- exception:  $exc := w < 0 \vee w > V \vee v < 0 \vee v > V \Rightarrow \text{IllegalArgumentException}$

*//Getter, get the number of edges*

`E():`

- output:  $out := E$
- exception: `None`

*//Getter, get the number of vertices*

`V():`

- output:  $out := V$
- exception: `None`

*//Getter, get a list of nodes that are conneted with vertex v*

`adj(v):`

- output:  $out := adj[v]$
- exception:  $exc := v < 0 \vee v > V \Rightarrow \text{IllegalArgumentException}$

# DFS Module

## Module

DFS

## Uses

Graph

## Syntax

### Exported Constants

None

### Exported Types

DFS = ?

*//Detect the reachable vertices from a source vertex*

### Exported Access Programs

Routine name	In	Out	Exceptions
DFS	Graph, $\mathbb{N}$	DFS	IllegalArgumentException
hasPathTo	$\mathbb{N}$	$\mathbb{B}$	IllegalArgumentException
count		$\mathbb{N}$	

## Semantics

### State Variables

*count*:  $\mathbb{N}$

*marked*: Seq of  $\mathbb{B}$

### State Invariant

None

## Assumptions

The constructor DFS is called for each object instance before any other access routine is called for that object. The constructor cannot be called on an existing object.

## Access Routine Semantics

*//Constructor of DFS class*

Graph( $g, s$ ):

- transition:  $count, \text{marked} := \text{number of reachable nodes}, \text{Seq of } \mathbb{B} \text{ recording if a vertex is reachable}$
- output:  $out := self$
- exception:  $exc := s < 0 \vee s \geq g.V() \Rightarrow \text{IllegalArgumentException}$

*//Determine if vertex  $w$  is reachable from the source vertex*

hasPathTo( $w$ ):

- output:  $out := \text{marked}[w]$
- exception:  $exc := w < 0 \vee w \geq V \Rightarrow \text{IllegalArgumentException}$

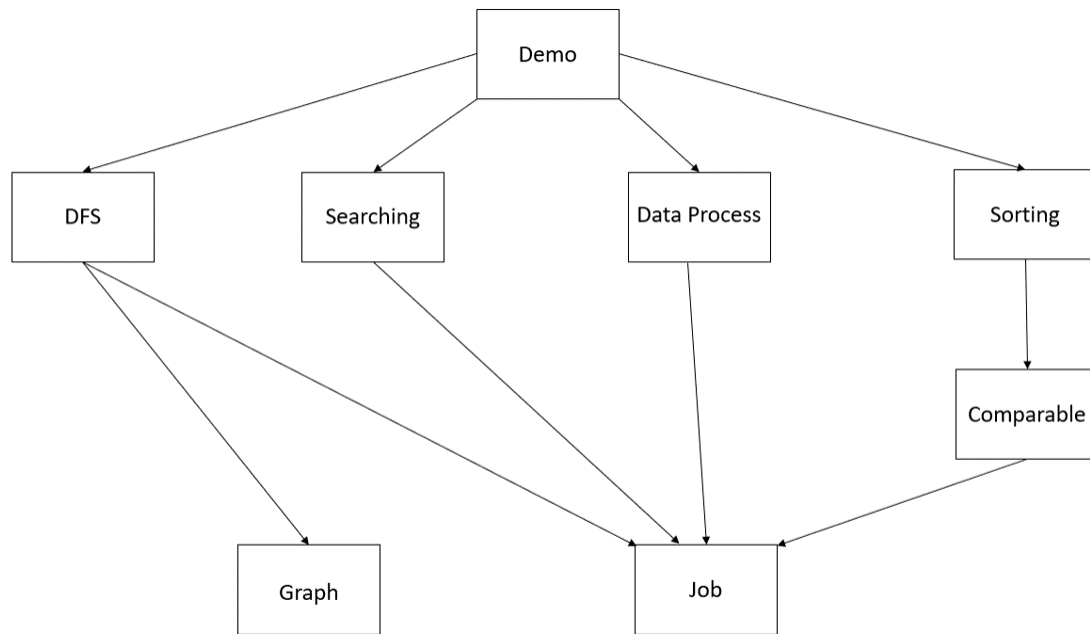
*//Getter, get the number of reachable vertices*

count():

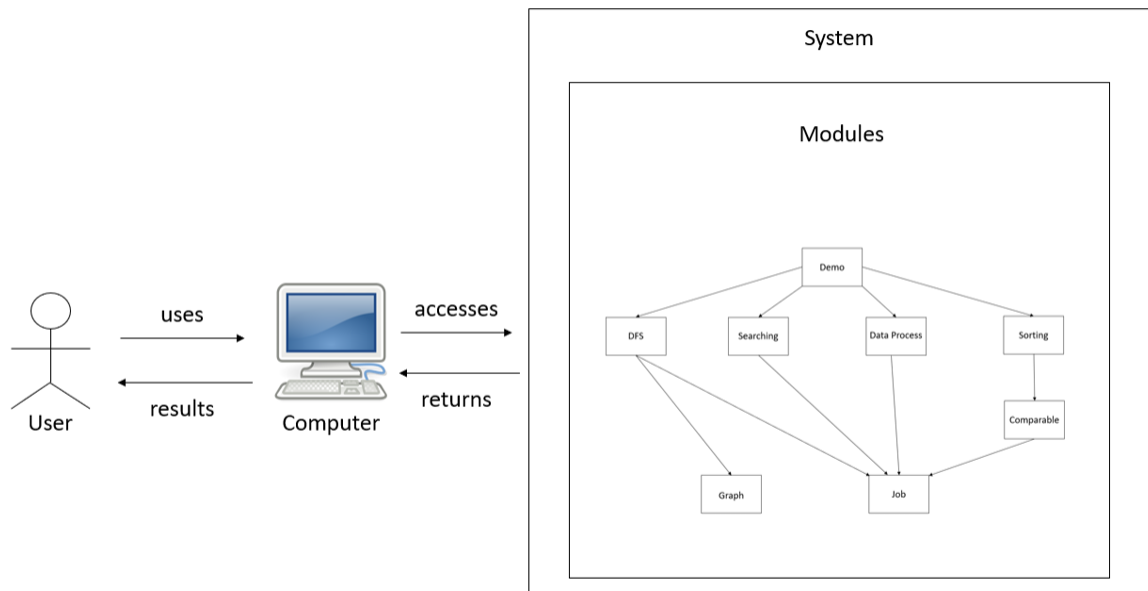
- output:  $out := count$
- exception: None

### 3 View of uses relationship

#### Uses Hierarchy



## Use case



## 4 Trace back to requirements

Demo Module (User Interface) : This module is used to do data processing operation which uses methods from DataProcess Module to read data from database files, and store data as expected type (Job ADT). Then it will give users instructions to use methods from other modules to sort, search, and create graph for the expected data. Demo Module satisfies the I/O requirements and User Interface requirements addressed in functional requirements. If users give unavailable inputs during using, the wrong inputs will not be taken and error messages will be displayed. So it also supports the robustness, usability, and understandability addressed in non-functional requirements.

DataProcess Module: As mentioned above, this module is used to read data from database files, and store data as expected type (Job ADT). It satisfies the I/O requirements addressed in functional requirements.

Job ADT Module: This module is used to build the ADT from the data in database files. The Job ADT is important to correctly use methods from other Modules like Sort, Searching, and Graph. Because the programmer provided detailed comments, thus the code is easy to understand and modify. So Job Module supports the understandability and maintainability addressed in non-functional requirements.

Comparator Module: This module is used to compare the comparable attributes (like job name, noc-code) of Job ADT. Sort module will use methods from this module to sort the dataset based on the selected attribute. The code includes clear doxygen comments. Therefore it is easy to understand and modify. Comparator Module supports the understandability and maintainability addressed in non-functional requirements.

Sort Module: This module is used to sort the dataset based on String, Outlook, NOC, and Regions by quick sort. Therefore it satisfies the sorting requirements addressed in functional requirements. Because it uses quick sort algorithm, so the performance requirements addressed in nonfunctional requirements is supported. The programmers also did Junit tests for this module, the correctness of results can be promised. Also, this programmer provided detailed comments in code for others to read and understand the code. Therefore the understandability and accuracy addressed in non-functional requirements are also satisfied.

Searching Module: This module is used to search the expected Job set based on the given location or given noc number by using binary search. Binary search algorithm can support the performance requirements. And like sort module, the code of this module



has clear comments and Junit tests to ensure the understandability and accuracy.

Graph Module: This module is an ADT class used to create an undirected graph. Because the programmer provided detailed comments, thus the code is easy to understand and modify. So Job Module supports the understandability and maintainability addressed in non-functional requirements.

DFS Module: This module is used detect the reachable vertices from a source graph and source vertex by depth-first search. The algorithm satisfies the the performance requirements. Like above modules, the code of this module has clear comments and Junit tests to ensure the understandability and accuracy.

Overall: The product satisfies all the functional requirements. By the description above, the product also supports the reliability, robustness, performance, usability, maintainability, understandability, and accuracy. Besides, all the codes are implemented by Java, therefore the product can run on OS such as Windows, Mac OS, and Linux. Thus the portability is also supported.

## 5 Description of implementation

### DFS Module

#### Module

DFS

#### Uses

Graph

#### Local Functions

dfs:  $Graph \times \mathbb{N}$

*//The private dfs method recursively call itself to detect deeper layer of the graph until it hits a sink vertex, then it will turn back to the previous layer and detect again. It updates the state variable "count" and "marked[]" to avoid repeatation of exploration*

# Sorting Module

## Module

Sorting

## Uses

Comparable

## Local Functions

exch: Seq of  $\text{Job} \times \mathbb{Z} \times \mathbb{Z} \rightarrow \text{None}$

$\text{exch}(a, i, j) \equiv$  exchange  $a[i]$  and  $a[j]$  in the array

sortString: Seq of  $\text{Job} \times \mathbb{Z} \times \mathbb{Z} \rightarrow \text{None}$

$\text{sortString}(a, lo, hi) \equiv (hi \leq lo) \Rightarrow \text{return} \mid \text{sortString}(a, lo, j-1) \ \&\& \ \text{sortString}(a, j+1, hi)$  where  $j = \text{partitionString}(a, lo, hi)$

partitionString: Seq of  $\text{Job} \times \mathbb{Z} \times \mathbb{Z} \rightarrow \text{None}$

$\text{partitionString}(a, lo, hi) \equiv$  partition on array  $a$  using ComapreString, see detail in code

sortOutlook: Seq of  $\text{Job} \times \mathbb{Z} \times \mathbb{Z} \rightarrow \text{None}$

$\text{sortOutlook}(a, lo, hi) \equiv (hi \leq lo) \Rightarrow \text{return} \mid \text{sortOutlook}(a, lo, j-1) \ \&\& \ \text{sortOutlook}(a, j+1, hi)$  where  $j = \text{partitionOutlook}(a, lo, hi)$

partitionOutlook: Seq of  $\text{Job} \times \mathbb{Z} \times \mathbb{Z} \rightarrow \text{None}$

$\text{partitionOutlook}(a, lo, hi) \equiv$  partition on array  $a$  using ComapreOutlook, see detail in code

sortNOC: Seq of  $\text{Job} \times \mathbb{Z} \times \mathbb{Z} \rightarrow \text{None}$

$\text{sortNOC}(a, lo, hi) \equiv (hi \leq lo) \Rightarrow \text{return} \mid \text{sortNOC}(a, lo, j-1) \ \&\& \ \text{sortNOC}(a, j+1, hi)$  where  $j = \text{partitionNOC}(a, lo, hi)$

partitionNOC: Seq of  $\text{Job} \times \mathbb{Z} \times \mathbb{Z} \rightarrow \text{None}$

$\text{partitionNOC}(a, lo, hi) \equiv$  partition on array  $a$  using ComapreNOC, see detail in code

sortRegionS: Seq of  $\text{Job} \times \mathbb{Z} \times \mathbb{Z} \rightarrow \text{None}$

$\text{sortRegionS}(a, lo, hi) \equiv (hi \leq lo) \Rightarrow \text{return} \mid \text{sortRegionS}(a, lo, j-1) \ \&\& \ \text{sortRegionS}(a,$

$j+1, hi)$  where  $j = \text{partitionRegionS}(a, lo, hi)$

`partitionRegionS`: Seq of Job  $\times \mathbb{Z} \times \mathbb{Z} \rightarrow \text{None}$

`partitionRegionS( $a, lo, hi$ )`  $\equiv$  partition on array  $a$  using `ComapreRegionS`, see detail in code

# Searching Module

## Module

Searching

## Uses

Job

## Local Functions

Location\_Search: Seq of Job  $\times$  String  $\rightarrow \mathbb{N}$

Location\_Search( $jobs, location$ )  $\equiv (m : \mathbb{N} | m \in [0..|jobs| - 1] \wedge jobs.get(m).get\_regions() = location] : m)$

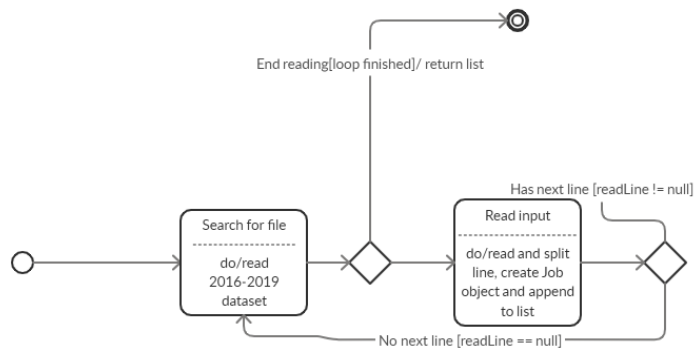
*//The private Location\_Search method is based on binary searching algorithm. It will first create two int variables,  $l = 0$  and  $r = jobs.size() - 1$ . Then it will process a while loop : create a int variable  $m = l + (r - l) \div 2$ , then it will create another int variable  $res = noc.compareTo(jobs.get(m).get\_noc(0))$ . If  $res = 0$ , return  $m$ ; if  $res < 0$ , then  $r = m - 1$ , continue the loop; if  $res > 0$ , then  $l = m + 1$ , continue the loop.*

noc\_Search: Seq of Job  $\times \mathbb{Z} \rightarrow \mathbb{N}$

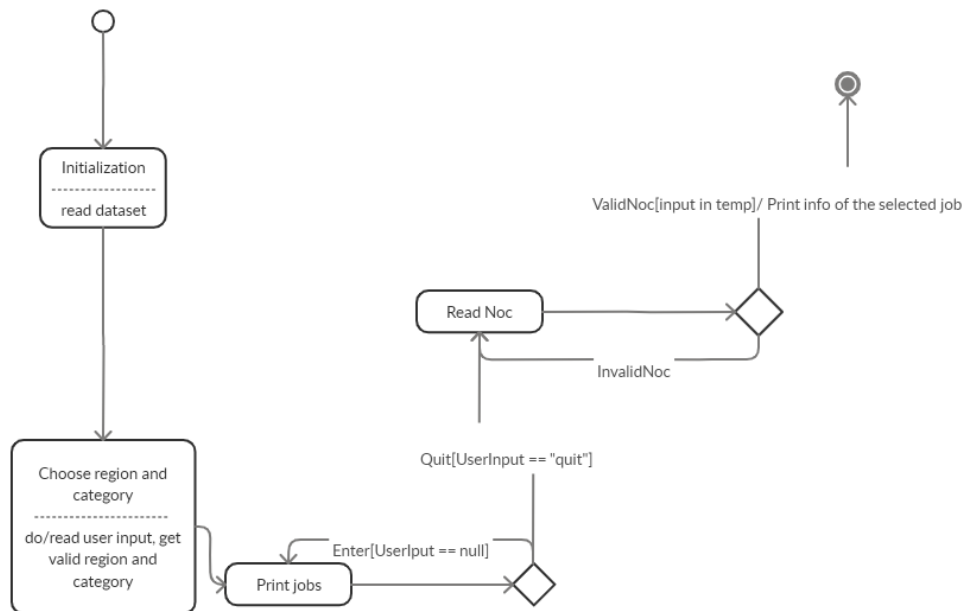
noc\_Search( $jobs, noc$ )  $\equiv (m : \mathbb{N} | m \in [0..|jobs| - 1] \wedge jobs.get(m).get\_noc(0) = noc : m)$

*//The private Location\_Search method is based on binary searching algorithm. It will first create two int variables,  $l = 0$  and  $r = jobs.size() - 1$ . Then it will process a while loop : create a int variable  $m = l + (r - l) \div 2$ , then it will create another int variable  $res = location.compareTo(jobs.get(m).get\_regions())$ . If  $res = 0$ , return  $m$ ; if  $res < 0$ , then  $r = m - 1$ , continue the loop; if  $res > 0$ , then  $l = m + 1$ , continue the loop.*

state machine diagram of DataProcess class



state machine diagram of DemoClient class



## 6 Internal review

- JobSeeker is designed to provide information about different kinds of jobs in different regions in recent years for those who are seeking for jobs or investigate the job market. The design is robust and always has a exception class for different illegal inputs. But the user interface is not very user-friendly. It's better to use MVC model here. For the implementaion part, sorting and searching functions are implemented by static functions instead of creating new objects. This reduces the dependency between modules. We put to many methods which we should have separated into different classes in the Demo class like addedge() and read input, which violates the principle of modularity and information hiding. A possible future improvement: allow the user type the region he/she is interested in and find the nearest region in the dataset using Geocoding API instead of choosing from regions the dataset has.
- The modules provide concrete methods in implementation and performance for this design. Due to some practical reason, in some modules' implementation of the prototype we do not use the fastest algorithm, such as the binary search algorithm in the searching module; we will leave that for further improvement and maintainance. In the prototype of the design, once the user select a perticular job, the relative jobs will be presented; however, refer to our original plan, there should be a brief description about the job; we couldn't collect information for each job in such a large database in limit amount of time. Thus we will leave that for further improvement as well. Another improvement could be done is better input modules. For example, the DataProcess class needs more robustness. The current version can only read datasets of specific file names and with limited format of content. A dataset file with different format will be better handled in a improved version.
- The product meets most of the requirements we had addressed. The performance is not optimized for some algorithms we used but it can be improved in future. An important problem is that our product can only search job by its region and first noc-number, thus the result may contain jobs from same field but still irrelevant. Also, we ignored the exceptionality of management occupation, which is that the specific field of a management job is represented by second noc-number, not like all other jobs are represented by first noc-number. A possible future improvement is to improve our searching module to solve the problems above.

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