**INTEGRATIVE TASK II**

**ENGINEERING DESIGN METHOD**

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<https://drive.google.com/file/d/1pLxAWU6AByXCs3OCBiwve3UbdZzsG4Bx/view>

**ENGINEERING DESIGN METHOD**

**PHASE 1: IDENTIFICATION OF THE PROBLEM (Software Requirement Specification-SRS)**

|  |  |
| --- | --- |
| **REQUIREMENT ANALYSIS TABLE** | |
| **Client** | Karthik Naru (Owner of PipeMania) (*see Google Play*) |
| **User** | Pipe Mania players |
| **Functional Requirements** | * RF1: Start a new game * RF2: View scores * RF3: Place pipe line * RF4: Verify sewer system |
| **Problem Context** | *The Pipe Mania game consists of a sewer system simulation.*  *In this game, the player can locate three different types of “pipes” within an 8x8 board, with the objective of connecting the “water source” to the “draining pipe”. The users can also view a players’ ranking according to the scores gained, with each of the players’ names.* |
| **Non Functional Requirements** | * The program must two different graphs implementations. * The program must use at least two different graph algorithms. * The program must be developed with a user interface. * The project must use a version control software such as git. |

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| **Identifier and Name** | ***RF1: Start a new game*** | | |
| **Summary** | *The system must start a new game when the user selects the option on the screen. Also, the user has to have an option to choose the game difficulty: 1.Easy (The user has to connect the pipes) 3. Hard (The user must connect the pipes in the shortest way possible, but the water flow has weight).*  *. The system will ask the user for their nickname and save it to showcase the game scores later. Then, the system will display an 8x8 board with an “F” and a “D”, each one representing the water source and the draining pipe respectively. Besides an option menu to play the game will be shown.* | | |
| **Input** | **Input name** | **Data type** | **Valid condition** |
| **User Nickname** | **String** | ***Can´t be empty*** |
| **Game Difficulty** | Int | *1.Easy*  *2.Hard* |
| **Result or Postcondition** | After the system receives the data entered by the user, it will show the game options (place pipe, verify and exit ) and the 8x8 board game, randomly locating an “F” and a “D”, each one representing the water source and the draining pipe respectively. It also takes the time in which the player started the game to calculate its game time. | | |
| **Output** | **Output name** | **Data type** | **Format** |
| gameBoard | Graph | X  X  X  X  X  X  X  X  X  X  X  X  X  X  **F**  X  X  X  X  X  X  X  X  X  X  X  X  X  X  X  X  X  X  X  X  X  X  X  X  X  X  X  X  X  X  X  X  X  X  **D**  X  X  X  X  X  X  X  X  X  X  X  X  X  X |
| gamePlayMenu | String | *1.Place a pipe*  *2.Verify game*  *3.Return (Exit)* |

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| **Identifier and Name** | ***RF2: View scores*** | | |
| **Summary** | *The system must show, in descending order, the final scores of the players that have played and finished a game. This will happen if the user chooses the “View scores” option (2) in the menu.* | | |
| **Input** | **Input name** | **Data type** | **Valid condition** |
| **User Nickname** | **String** | ***Can´t be empty*** |
| N/A |  |  |
| **Result or Postcondition** | After each successful game, the system calculates the user’s score. The system will calculates the player´s final score using the following formulas accordingly to the game difficulty:  1)Score= | 𝑢𝑠𝑒𝑑𝑃𝑖𝑝𝑒𝑠 \* 100 − (time in seconds) |  2)Score= | (valueOfEachStep\*100)-(time in seconds) |  The time each player takes to play the game will be calculated during the game. | | |
| **Output** | **Output name** | **Data type** | **Format** |
| Final Score List |  | *1)PlayerNickname = Score* |

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| **Identifier and Name** | ***RF3: Place Pipes*** | | |
| **Summary** | *After entering the option to Start a new game menu (see RF1), The system must allow the user to locate a “pipe” in a specific position of the 8x8 board, by asking for the coordinates in which the new pipe will be located and the type of pipe.* | | |
| **Input** | **Input name** | **Data type** | **Valid condition** |
| xCoordinate | int | Must be an Integer [1-8] |
| yCoordinate | int | Must be an Integer [1-8] |
| pipeType | int | Must be an Integer [1-3]  1.Horizontal ( = )  2.Vertical ( || )  3.Circular( o ) |
| **Result or Postcondition** | The system searches for the coordinate that the player chose. If said coordinate is located within the possible range of the board and it isn´t occupied by an “F” or “D”, the type of pipe that the player chose will be displayed in the [x,y] coordinate of the board. Else, the board will appear with no changes made. | | |
| **Output** | **Output name** | **Data type** | **Format** |
| gameBoard | graph | *8x8 board of “x” characters, contains an F (water source), a D (draining pipe) and the pipes (“=”,”| |”,”o”)* |

|  |  |  |  |
| --- | --- | --- | --- |
| **Identifier and Name** | ***RF4: Verify sewer system*** | | |
| **Summary** | *The system must verify that the pipes’ solution provided by the user is valid, meaning, the water source (“F”) is connected to the draining pipe (“D”) with a correct usage of the pipes (“=”,”||”,”o”). Then, the user will see if their option is correct or not, and depending on that, the game will close.* | | |
| **Input** | **Input name** | **Data type** | **Valid condition** |
| N/A | N/A | N/A |
| **Result or Postcondition** | The system checks that the pipes are located correctly according to their type and direction. The “F” and “D” must be connected, allowing the water flow, with the “=” pipes going one next to the other, and the “|  |” pipes going one under the other. Besides, an “o” cannot be next to another “o” or to the “F” and “D”, and it can only be used to do a 90° spin with the pipes.  If the solution is correct, the game is closed , the time is taken, calculated and the score saved; else, the game continues and the menu and board will be displayed again. | | |
| **Output** | **Output name** | **Data type** | **Format** |
| message | String | *Its whos wheter the user´s option were correct or not. It can be:*  *“The solution is correct”*  *“The sewer system is not correct”* |

**FASE 2: COMPILATION OF NECESSARY INFORMATION**

**Important Terminology**

Graph:

Graphs in data structures are non-linear data structures made up of a finite set of nodes or vertices and the edges that connect them. Graphs in data structures are used to address real-world problems in which it represents the problem area as a network. The graph is denoted by G(E, V).

* Vertex:

The vertices is the fundamental units of the graph, sometimes also denominated as node. Every node/vertex can be labeled or unlabeled.

* Edge:

Edges connect two nodes of the graph in any possible way. Depending on the type of graph, the set of vertices it connects must be ordered or not. Sometimes known as arcs, they can be labeled/unlabeled (also determined as weight of the edge).

* Path:

A path (of length n) in an (undirected) graph G is a sequence of vertices {v0, v1, ..., vn-1, vn} such that there is an edge between vi and vi+1 ∀i ∈ [0..n-1] along the path.

* Adjacency:

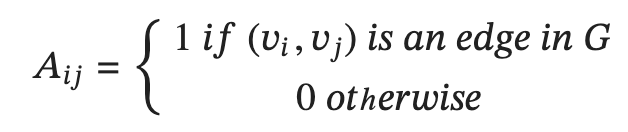
A vertex is said to be adjacent to another vertex if there is an edge in common connecting them.

Adjacency List:

An adjacency List (AL) is an array of V lists, one for each vertex (usually in increasing vertex number) where for each vertex i, AL[i] stores the list of i's neighbors or adjacent nodes. For weighted graphs, the list can store pairs of (neighbor vertex number, weight of this edge) instead.

Adjacency Matrix:

The adjacency matrix of a simple labeled graph G is the matrix *A* with A[[*i,j*]]=1 or 0 according to whether the vertex *vj*, is adjacent to the vertex *v*j or not. For simple graphs without self-loops, the adjacency matrix has 0 s on the diagonal. For undirected graphs, the adjacency matrix is symmetric.



User Interface:

User Interface (UI) is the point at which the human interacts with a computer, website and/or application. The UI must be intuitive and ease the user’s experience with the usage of the software product, requiring minimum effort on the user's part to receive the maximum desired outcome.

Dijkstra’s Algorithm:

Algorithm for finding the shortest path from a starting node to a target node in a weighted graph. The algorithm creates a tree of shortest paths from the starting vertex, the source, to all other points in the graph.

Pipe:

Connecting lines or tubes between (for the context of the program) other pipes. They act as edges between two of the vertices of the graph that represent the matrix of 8x8 that will be the playground for each of the user’s game.

They are classified in 4 different types (for more characterization of each one of them, look at phase 1: SRS).

* Default (x)
* Vertical ( | | )
* Horizontal (=)
* Circular ( ° )

**PHASE 3: RESEARCH OF CREATIVE SOLUTIONS**

**Alternative 1**

1. **User Interface:**

JavaFX is a modern library to create user interaction interfaces and can be used in various platforms such as Windows, macOS and Linux. Interactive Graphics can be created with this library.

1. **Game:**

Marlon Mania is a game that consists of a sewer system simulation. In this game, the player can locate three different types of “pipes” within an 8x8 board/matrix, with the objective of connecting the “water source” to the “draining pipe”. The users can also view a players’ ranking according to the scores gained, with each of the players’ names. There are two levels of difficulty: easy, where the player must complete the connect the water source to the draining pipe; and hard, where the player, to get points, must connect the last-mentioned pipes by using the shortest path.

1. **Versions of graph:**

For the first version of the graph, an adjacency list is considered.

An adjacency List (AL) is a representation of a graph through an array of V lists, one for each vertex (usually in increasing vertex number) where for each vertex i, AL[i] stores the list of adjacent nodes. For weighted graphs, the list can store pairs of (neighbor vertex number, weight of this edge) instead.

For the second version of the graph, an adjacency matrix is considered.

The adjacency matrix of a simple labeled graph G is the matrix A with A[[i,j]]=1 or 0 according to whether the vertex vj, is adjacent to the vertex vj or not.

1. **Graph Algorithms:**

For the first graph algorithm to be used, a graph-traversal algorithm is considered, specifically DFS.

Depth-first search (DFS) is an algorithm for searching a graph or tree data structure. The algorithm starts at the root (top) node of a tree and goes as far as it can down a given branch (path), then backtracks until it finds an unexplored path, and then explores it. The algorithm does this until the entire graph has been explored.

For the second graph algorithm to be used, a Single-Source Shortest Path (SSSP) algorithm (given a source vertex it finds the shortest path from the source to all other vertices) is considered, specifically Dijkstra’s algorithm.

Dijkstra's Algorithm works on the basis that, in a Graph G={A,B,C,D}, any subpath B -> D of the shortest path A -> D between vertices A and D is also the shortest path between vertices B and D. Dijkstra used this property in the opposite direction overestimating the distance of each vertex from the starting vertex. Then each node and its neighbors are visited to find the shortest subpath to those neighbors.

**Alternative 2**

1. **User Interface:**

It will be created using the GUI package, composed of the two classes AWT and Swing, which are rich in components and containers (Component, container, Jcomponent, Jframe, Jdialog, JApplet, Jpanel, Graphics), whose tools and classes are interactable and simple, making the user interface creating process more practical.

1. **Game:**

Pipe-Mania is a game that consists of a sewer system simulation. In this game, the player can locate three different types of “pipes” within an 8x8 board/matrix, with the objective of connecting the “water source” to the “draining pipe”. The users can also view a players’ ranking according to the scores gained, with each of the players’ names.

The player, to get points, must connect the water source to the draining pipe.

1. **Versions of Graph:**

For the first version of a graph, an incidence matrix is considered.

The incidence matrix A of an undirected graph has a row for each vertex and a column for each edge of the graph. The element A[[i,j]]=1 if the ith vertex is a vertex of the jth edge, otherwise A[[i,j]]=0.

For the second version of a graph, an edge list is considered.

An edge list is a list or array of all the edges in a graph. The underlying data structure for keeping track of all the nodes and edges is a single list of pairs. Each pair represents a single edge and is comprised of the two unique IDs of the nodes involved. Each line/edge in the graph gets an entry in the edge list, and that single data structure then encodes all nodes and relationships.

1. **Graph Algorithms:**

For the first graph algorithm to be used, a graph-traversal algorithm is considered, specifically BFS.

Breadth-first search is a graph traversal algorithm that starts traversing the graph from the root node and explores all the neighboring nodes. Then, it selects the nearest node and explores all the unexplored nodes. While using BFS for traversal, any node in the graph can be considered as the root node.

For the second graph algorithm to be used, a Shortest Path (SP) algorithm (finding a path between two vertices (or nodes) in a graph such that the sum of the weights of its constituent edges is minimized) is considered, specifically Floyd-Warshall’s algorithm.

It computes the computes the shortest distances between every pair (or a given pair) of vertices in the input graph.

**Alternative 3**

**1. Storing Tasks and Reminders:** An Open Addressing table is going to be used to store both tasks and reminders. Both Reminder and Task will be defined by their own class with the same name, and attributes of primitive data:

* Reminder: Id, Memo, Time, Location, Priority
* Task: Id, Title, Due Date, Description, Location, Priority

**2.User Interface:** It will be created using the GUI package, composed of the two classes AWT and Swing, which are rich in components and containers (Component, container, Jcomponent, Jframe, Jdialog, JApplet, Jpanel, Graphics), whose tools and classes are interactable and simple, making the user interface creating process more practical.

**3. Priorities Management:** Two types of categories are defined: priority and non-priority. Properties reminders or tasks will be stored in an arrayList, whose elements are sorted according to their importance; which is defined by the due date attribute. Secondly, a queue (FIFO) will be used to store those non-priority reminders or tasks.

**4. Undoing Actions Method:** The opposite action to a previous user action will be applied, in the case the user wants to undo something he has done. For example, if the user has deleted a task or reminder, then the undo method is going to apply the register method with the element that has been deleted.

**FASE 4: TRANSITION FROM IDEA FORMULATION TO PRELIMINARY DESIGNS**

**Alternativa 1 (Chosen):**

**1. Storing Tasks and Reminders:**

* When using hash tables of direct addressing, reduce the algorithmic time when adding, searching and deleting an element.
* Using Hash Tables allow us to modify the hash function according to the needs of space demanded by the system
* When using ADTs, attributes of both task and reminders can be adapted to the future needs of the user
* An ADTs allow us to easily manipulate the data referred to tasks and reminders, and adequate them to future changes

**2.User Interface:**

* Print methods alone lack the necessary features to create interactive and user-friendly interfaces. Displaying menus in the console simplifies the design process, resulting in practical, straightforward, and easily understandable interfaces for system users.
* Console-based menu displays enable organizations to interconnect methods in a practical and efficient manner, facilitating a chain of responsibility among employees.
* Learning to create console menus typically requires less time and effort compared to other design alternatives like JavaFX or Java GUI. Embracing this approach can lead to more efficient and accessible user interfaces.

**3.Priorities Management:**

* A priority queue ensures efficient task management by addressing high-priority tasks first. When implemented with a heap-based structure like a binary heap, it offers rapid task insertion and removal, optimizing resource allocation.
* When applying a queue (FIFO) to store non-priority tasks or reminders, then it will be easy for the user to consult those activities by its arrival order.

**4. Undoing Action Method:**

* Defining a new ADTs for user actions will allow the system to store predefined information, susceptible to change, registration, modification and deletion
* Using a stack (LIFO) to store those ADTs allows the system to have an accessible and simple reference to the previous state of a user action

**Alternative 2 (Discarded):**

**1. Storing Tasks and Reminders:**

* When using ArrayList to store the ADTs is going to increment the search complicity from O(1) to O(n)
* Using Hash Tables allow us to modify the hash function accordingly to the needs of space demanded by the system
* When suing ADTs, attributed of both task and reminders can be adapted to future needs of the user
* An ADTs allow us to easyfully manipulate the data referred to tasks and reminders, and adequate them to future changes

**2.User Interface:**

* Modern and Rich UI: JavaFX, offers modern and visually appealing user interfaces compared to Swing, giving the programmer more options and animations.
* JavaFX allows the application of CSS styling to the UI components, making it effortless to achieve a consistent and visually appealing look and feel across the program.
* A rich set of UI controls such as buttons, text fields, tables, and charts are offered and highly customizable. Allowing the developer to create a different and unique design of his application or program
* Multimedia Integration: JavaFX can interact with web technologies, audio, media-rich applications, educational software and entertainment applications.
* While Java fx is a good design tool, it requires some prior knowledge of its operation and structure. This will take some time for the developers of a programme to learn.

**3. Priorities Management**

* Not having s subcategory in the level of importance of priority tasks, makes it almost impossible to sort in a binary tree tasks according to their significance
* As tasks and reminders do not have a hierarchical dependence, and are going to be sorted according to a level of importance and not a numerical key value, binary trees will not be an adequate data structure to store these elements; as tasks and reminders can be stock up in a linear database form.

**4. Undoing Action Method:**

* Defining a new ADTs for user actions will allow the system to store predefined information, susceptible to change, registration, modification and deletion
* By using a stack (LIFO) to store those ADTs allow the system to have an accessible and simple reference to the previous state of user action
* An unnecessary use of memory is evidenced as this ADTs keep the information of the system as a whole, when just remembering the user action is requested

**Alternative 3 (Chosen):**

**1. Storing Tasks and Reminders:**

* When using an Open Addressing Table to store the ADTs will increment the algorithm complexity from O(1) to O(n)
* Creating just one ADTs for both reminders and tasks will note allow future specific changes (new methods, new attributes, etc) that could be applicable to tasks but not to reminders, and vice versa.

**2. User Interface:**

* Easy of Learning: The Gui package allows the developing team to create a User-Friendly Interaction more practically, as it can instantiate clickable buttons, fill-in forms, and graphical elements. Also, it is a facile Java tool for occasional programmers who are not familiar with it
* Improved Accessibility: The software interface can be adapted to the user context and abilities, presenting a clear data visualization and reducing errors.
* Customization: GUIs can be customized to each system, application or program content and context.

**3. Priorities Management**

* By creating an ArrayList of priority activities, a sorted method can be easily implemented to organize elements according to their importance
* When applying a queue (FIFO) to store non-priority tasks or reminders, then it will be easy for the user to consult those activities by its arrival order.
* Sorting priorities, according to the due date will not organize tasks and reminders suitably to their importance and relevance, but to the most urgent activity that has to be completed in terms of time

**4. Undoing Action Method:**

* Applying the opposite method to the previous user action, will demand storing specific information for the various cases (actions) that the user performs
* The modifying method will not have a direct opposite action to compare, thus it will demand creating a special method that stores the previous state of the task or reminder

PHASE 5: EVALUATION AND SELECTION OF THE SOLUTION

***5.1 Criteria Evaluation Definition in terms of Quality:***

|  |  |  |
| --- | --- | --- |
| **CRITERIA QUALITY EVALUATION DEFINITION** | | |
| **Criteria** | **Definition** | **Evaluation Scale** |
| Functionality | Assess how well the software meets the required functionality, including precision, adequacy, interoperability, conformance, and security. | -1: Does not meet functionality requirements  -2: Partially meets functionality requirements  -3: Moderately meets functionality requirements  -4: Adequately meets functionality requirements  -5: Fully and precisely meets functionality requirements |
| Reliability | Evaluate the software's reliability in terms of maturity, error tolerance, and recoverability. | -1: Highly unreliable and lacks maturity  -2: Moderately reliable with some maturity  -3: Reasonably reliable with good maturity  -4: Highly reliable and mature  -5: Exceptionally reliable and mature |
| Usability | Assess the usability of the software, including comprehensibility, learnability, operability, and attractiveness. | -1: Highly unusable, poor user experience  -2: Moderately usable but needs improvement  -3: Reasonably usable with a good user experience  -4: Highly usable with an excellent user experience  -5: Exceptionally usable and provides an outstanding user experience |
| Efficiency | Evaluate the software's efficiency in terms of response time (algorithmic complexity), memory usage, and resource utilization. | -1: Highly inefficient and consumes excessive resources  -2: Moderately efficient but could be more resource-friendly  -3: Reasonably efficient with acceptable resource usage  -4: Highly efficient with minimal resource consumption  -5: Exceptionally efficient, making optimal use of resources |

***5.1.2 Evaluation of the Chosen Alternatives in terms of Quality:***

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| --- | --- | --- | --- | --- |
| **ALTERNATIVE 1 EVALUATION** | | | | |
| **Requisit** | **Functionality Punctuation** | **Reliability**  **Punctuation** | **Usability**  **Punctuation** | **Efficiency**  **Punctuation** |
| *1. Storing Tasks and Reminders* | 4 | 4 | 5 | 5 |
| *2. User Interface* | 4 | 4 | 4 | 4 |
| *3. Priorities Management* | 4 | 4 | 4 | 4 |
| *4. Undoing Actions*  *Method* | 5 | 3 | 5 | 4 |
| ***Total Punctuation*** | **17** | **15** | **18** | **17** |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **ALTERNATIVE 3 EVALUATION** | | | | |
| **Requisit** | **Functionality**  **Punctuation** | **Reliability**  **Punctuation** | **Usability**  **Punctuation** | **Efficiency**  **Punctuation** |
| *1. Storing Tasks and Reminders* | 4 | 3 | 4 | 3 |
| *2. User Interface* | 4 | 3 | 3 | 4 |
| *3. Priorities Management* | 3 | 4 | 3 | 4 |
| *4. Undoing Actions*  *Method* | 2 | 2 | 3 | 2 |
| ***Total Punctuation*** | **13** | **12** | **13** | **13** |

***5.2 Criteria Evaluation Definition in terms of Algorithm Complexity (Worst Case):***

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Font:Medium

[*https://medium.com/@Hollyzhou/data-structure-the-big-o-notation-e3e2405bb8eb*](https://medium.com/@Hollyzhou/data-structure-the-big-o-notation-e3e2405bb8eb)

|  |  |  |
| --- | --- | --- |
| **BIG (O) EVALUATION SCALE** | | |
| **Complexity** | **Definition** | **Punctuation** |
| Quadratic |  | 1 |
| Lineal | O(n) | 2 |
| Log-linear Complexity | O(n Log(n)) | 3 |
| Logarithmic | O(Log(n)) | 4 |
| Constant | O(1) | 5 |

|  |  |  |
| --- | --- | --- |
| **ALGORITHMICAL EVALUATION CRITERIA** | | |
| **Criteria** | **Definition** | **Evaluation Scale** |
| **Storing Tasks and Reminders** | | |
| *Add Tasks or*  *Reminders Efficiency* | This criterion evaluates how efficiently the system allows users to add new tasks or reminders. It assesses the speed and resource utilization when inserting new items into the storage structure, such as hash tables, while maintaining data integrity. | BIG O CRITERIA |
| *Accessing Tasks or*  *Reminders Efficiency* | This criterion measures the system's efficiency in retrieving and accessing tasks or reminders. It assesses the speed and resource usage when querying and displaying stored items, ensuring that users can quickly and effectively find the information they need. | BIG O CRITERIA |
| *Deleting Tasks or*  *Reminders Efficiency* | This criterion examines how efficiently the system handles the removal of tasks or reminders. It assesses the speed and resource utilization when deleting items from the storage structure, ensuring that the process is swift and doesn't compromise the system's performance. | BIG O CRITERIA |
| **Priorities Management** | | |
| *Priority Tasks*  *and Reminders Management Efficiency* | This criterion focuses on the efficiency of managing priority tasks and reminders. It evaluates how well the system organizes and retrieves high-priority items, ensuring they are readily available for the user when needed, and whether this management incurs minimal overhead. | BIG O CRITERIA |
| *Non-Priority Tasks*  *and Reminders Management Efficiency* | This criterion assesses the system's efficiency in managing non-priority tasks and reminders. It evaluates how well the system handles the organization and retrieval of less critical items, utilizing data structures like queues to maintain efficiency and user satisfaction. | BIG O CRITERIA |
| **Undoing Action Methods** | | |
| *Undoing Action Method Efficiency* | This criterion evaluates the efficiency of the system's "undo" functionality. It assesses how quickly and reliably the system can revert to a previous state after a user-initiated action, ensuring a seamless user experience and minimal disruption to the workflow. | BIG O CRITERIA |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Criteria** | Functionality | Reliability | Usability | Efficiency | **Total** |
| **Alternative 1** | **17** | **15** | **18** | **17** | **67** |
| **Alternative 3** | **13** | **12** | **13** | **13** | **51** |

***5.2.1 Evaluation of Structures in Chosen Alternatives in terms of Algorithm Complexity***

***(Worst Case):***

**Alternative 1 Evaluation**

|  |  |
| --- | --- |
| **ALTERNATIVE 1 (Storing Tasks and Reminders)**  **HASH TABLE STRUCTURE:**  **Collisions Managed with Double Linked List** | |
| **Criteria** | **Evaluation Scale**  **(Big-O)** |
| *Add Tasks or*  *Reminders Efficiency* | 2 |
| *Accessing Tasks or*  *Reminders Efficiency* | 2 |
| *Deleting Tasks or*  *Reminders Efficiency* | 2 |
| ***Total Punctuation*** | **6** |

|  |  |
| --- | --- |
| **ALTERNATIVE 1 (Priorities Management)**  **Priority Queue (Heap Sort)** | |
| **Criteria** | **Evaluation Scale**  **(Big-O)** |
| *Priority Tasks*  *and Reminders Management Efficiency* | 3 |
| ***Total Punctuation*** | **3** |

|  |  |
| --- | --- |
| **ALTERNATIVE 1 (Priorities Management)**  **Non-Priority Queue** | |
| **Criteria** | **Evaluation Scale**  **(Big-O)** |
| *Non-Priority Tasks*  *and Reminders Management Efficiency* | 2 |
| ***Total Punctuation*** | **2** |

|  |  |
| --- | --- |
| **ALTERNATIVE 1 (Priorities Management)**  **Stack Structure (LIFO)** | |
| **Criteria** | **Evaluation Scale**  **(Big-O)** |
| *Undoing Action Method Efficiency* | 2 |
| ***Total Punctuation*** | **2** |

**Alternative 3 Evaluation**

|  |  |
| --- | --- |
| **ALTERNATIVE 3 (Storing Tasks and Reminders)**  **Hash Table:**  **Opening A Dressing Table** | |
| **Criteria** | **Evaluation Scale**  **(Big-O)** |
| *Add Tasks or*  *Reminders Efficiency* | 2 |
| *Accessing Tasks or*  *Reminders Efficiency* | 2 |
| *Deleting Tasks or*  *Reminders Efficiency* | 2 |
| ***Total Punctuation*** | **6** |

|  |  |
| --- | --- |
| **ALTERNATIVE 3 (Priorities Management)**  **ArrayList** | |
| **Criteria** | **Evaluation Scale**  **(Big-O)** |
| *Priority Tasks*  *and Reminders Management Efficiency* | 2 |
| ***Total Punctuation*** | **2** |

|  |  |
| --- | --- |
| **ALTERNATIVE 3 (Priorities Management)**  **Non-Priority Queue** | |
| **Criteria** | **Evaluation Scale**  **(Big-O)** |
| *Non-Priority Tasks*  *and Reminders Management Efficiency* | 2 |
| ***Total Punctuation*** | **2** |

**Comparison of Alternative 1 and Alternative 3 Algorithmical Time Complexity:**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Criteria** | **Storing Tasks and Reminders** | | | **Priorities Management** | | **Undoing Action Method** | **Total** |
| *Add Tasks or*  *Reminders Efficiency* | *Accessing Tasks or*  *Reminders Efficiency* | *Deleting Tasks or*  *Reminders Efficiency* | *Priority Tasks*  *and Reminders Management Efficiency* | *Non-Priority Tasks*  *and Reminders Management Efficiency* | *Undoing Action Method Efficiency* |
| **Alternative 1** | **2** | **2** | **2** | **3** | **2** | **2** | **13** |
| **Alternative 3** | **2** | **2** | **2** | **2** | **2** | **-** | **10** |

***5.3 Selection of the best Alternative:***

Alternative 1:

This solution has been selected due to its comprehensive approach to task and reminder management. It leverages hash tables for efficient storage, implements a user-friendly interface by console for broad platform compatibility, and introduces a sophisticated priority management system with both priority and non-priority categories. Additionally, the inclusion of an "Undo" feature through a stack ensures user flexibility and error correction. Overall, this solution excels in functionality, usability, and practicality, earning it the highest score.

PHASE 6: PREPARATION OF REPORTS AND SPECIFICATIONS

***6.1 General Problem Specification:***

Design a task and reminder management system allowing users to add, organize, and manage their pending tasks and reminders. The system comprises components such as task and reminder storage using a hash table with unique identifiers as keys, a user-friendly interface for adding, modifying, and deleting tasks and reminders, and sorting options based on deadlines or priorities utilizing heapsort. Tasks are categorized into "Priority" and "Non-priority," where prioritized tasks are managed through a priority queue, ensuring important tasks take precedence. Non-priority tasks are organized on a first-in, first-out (FIFO) basis. Additionally, implement an "Undo" feature using a stack (LIFO) to track user actions, allowing users to revert to the last performed action. This system efficiently addresses task and reminder management needs.

***6.2 SubProblems Specification:***

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| **Storing Tasks and Reminders** | |
| *Sub-Problem Specification* | The program has to store in a hash table the tasks and reminders established by the user; with its own identifier, title, description, due date and priority. |
| *Inputs* | * **Inp\_1:**Task or Reminder Identifier * **Inp\_2:**Task or Reminder Title * **Inp\_3:** Task or Reminder Description * **Inp\_4:** Task or Reminder due Date * **Inp\_5:** Task or Reminder Priority |
| *Outpust* | * **Out\_1:** Confirmation Message. Example Gratie: “*Successfully Stored”* |
| ***Considerations:***   * After the system receives the data entered by the user, it creates a new task, with its state as “UNDONE”. It uses the hash function to create the key of said task (for it to be accessed later). If the task is a “PRIORITY” it is saved in a Stack structure; otherwise, it will be saved in a Queue structure. The action is saved in the list of actions. * All inputs cannot be stored empty * Due date has to be in a future date according to the current date of task-reminder creation | |

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| **User Interface** | |
| *Sub-Problem Specification* | A comprehensible, useful and practical interface has to be shown to the user. Where he can add, modify and delete new or existing tasks and reminders. Also, the interface has to organize the activities according to their importance or due date. |
| *Inputs* | * **Inp\_1:** Option (*“Add new Task”*) * **Inp\_2:** Option (“Modify Task) * **Inp\_3:** Option (“Delete Task “) * **Inp\_4:** Option (“Organize Task by Priority) * **Inp\_5:** Option (“Organize Task by due Date) |
| *Outpust* | * **Out\_1:** List of tasks and reminders * **Out\_2:** List of tasks and reminders updated |
| ***Considerations:***   * After the system receives the data entered by the user, it searches the task with the key entered. If the task is found, the attribute chosen is modified according to the data entered by the user; otherwise, the user will be indicated that the task was not found. The action is saved in the list of actions. * After the system receives the data entered by the user, it searches for the task with the key entered. If the task is found, it is deleted from both the list of tasks and the pile of the priority where it belonged; otherwise, the user is indicated that the task wasn’t found. The action is saved in the list of actions. * After the system receives the data entered by the user, it searches the task with the key entered. If the task is found, its information is shown in the interface to the user; otherwise, the user is indicated that the task wasn’t found. The action is saved in the list of actions. | |

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| **Priorities Management** | |
| *Sub-Problem Specification* | There are two subcategories of tasks and reminders: priorities and non priorities:   * Prioritary Taks: Has to be stored in a queue according to their importance level; most important tasks have to be shown first. * Non-priority tasks: They have to be stored in a stack, where the user can manage them according to their arrival order. |
| *Inputs* |  |
| *Outputs* | * Out\_1: Tasks stored and sorted according to their importance level. |
| ***Considerations:***  -The tasks and priorities are shown to the user interface, according to their level of importance. If there are no tasks or reminders in both categories it has to show a message of emptiness, | |

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| **Undoing Actions Methods** | |
| *Sub-Problem Specification* | To implement an "Undo" function, the system utilizes a Last-In-First-Out (LIFO) stack to track user actions, encompassing tasks' addition, modification, and deletion. Each stack entry comprehensively records action specifics and associated task information. When a user executes an action, it is promptly documented in the stack. The system incorporates an "Undo" method, affording users the capability to reverse their latest action by extracting the most recent entry from the stack and subsequently undoing the corresponding action based on the logged data. This user-oriented "Undo" feature, available within the interface, significantly enhances the system's usability by providing seamless error correction. |
| *Inputs* | * **Inp\_1:** Undo action |
| *Outputs* | * **Out\_1:** The action is reversed to the previous stored status |
| ***Considerations:***   * If there are no previous states, the action does not change | |

**PHASE 7: Design Implementation**

**Diagram:**

[Task manager.pdf](https://drive.google.com/file/d/1EaBc4z791w61DxUYIFtVaLxQWyP1voVJ/view?usp=sharing)

**Hash Table Task to Implement:**

**HashEntry**

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| **HashEntry Subroutines** | |
| **Subroutine Specification** | **Construction** |
| |  |  | | --- | --- | | **Name:** | HashEntry () | | **Description** | It instantiates a new node that will be stored in the hash table. | | **Input** | <K> key <V> value | | **Return** | none  (Object of Hash Entry instantiated) | | **public HashEntry(K key, V value) {**  **this.key = key;**  **this.value = value;**  **this.next=null;**  **this.prev=null;**  **}** |

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| **Hash Table Subroutines** | |
| **Subroutine Specification** | **Construction** |
| |  |  | | --- | --- | | **Name:** | hashTable() | | **Description** | It instantiates a new hash table with a default size of 10 | | **Input** | none | | **Return** | none  (Hash Table Object instantiated) | | **public HashTable(){**  **table = new HashEntry[DEFAULT\_SIZE];**  **this.existingNodes = 0 ;**  **}** |
| |  |  | | --- | --- | | **Name:** | hashFunction() | | **Description** | converts any type of key into the index where the element will be inserted in the hash table | | **Input** | <K> key | | **Return** | int index | | **public int hashFunction(K key){**  **int hashCode;**  **hashCode = key.hashCode();**  **return Math.abs(hashCode) % table.length;**  **}** |
| |  |  | | --- | --- | | **Name:** | add() | | **Description** | inserts a new element into a hash table index, managing collisions if needed | | **Input** | <K> key <V> value | | **Return** | void | | **public void add(K key, V value){**  **int index= hashFunction(key);**  **HashEntry<K,V> newEntry= new HashEntry<>(key, value);**  **HashEntry<K,V> current=table[index];**  **if(current==null){**  **table[index]=newEntry;**  **}else{**  **while(current.getNext()!=null){**  **current=current.getNext();**  **}**  **current.setNext(newEntry);**  **newEntry.setPrev(current);**  **newEntry.setNext(null);**  **}**  **this.existingNodes++;**  **}** |
| |  |  | | --- | --- | | **Name:** | getFirst () | | **Description** | returns the first element that is stored in an index of the hash table | | **Input** | <K> key | | **Return** | (NODE) HashEntry<K,V>: if the node is founded  null: if the node is not stored in the hash table | | **public HashEntry<K,V> getFirst(K key){**  **if(table==null){**  **return null;**  **}**  **int index= hashFunction(key);**  **return table[index];**  **}** |
| |  |  | | --- | --- | | **Name:** | getValue () | | **Description** | returns the value of the first element that is stored in an index of the hash table | | **Input** | <K> key | | **Return** | <V> value: if the node is founded  null: if the node is not stored in the hash table | | **public V getValue(K key){**  **if(table==null){**  **return null;**  **}**  **int index= hashFunction(key);**  **if(table[index].getValue()==null){**  **return null;**  **}**  **return table[index].getValue();**  **}** |
| |  |  | | --- | --- | | **Name:** | find () | | **Description** | returns a node stored in an index that has more than one more stored; managing collisions. | | **Input** | <K> key | | **Return** | (NODE) HashEntry<K,V>: if the node is founded  null: if the node is not stored in the hash table | | **public HashEntry<K,V> find(K key){**  **int index= hashFunction(key);**  **HashEntry<K,V> current=table[index];**  **while(current!=null){**  **if(current.getKey().equals(key)){**  **return current;**  **}**  **current=current.getNext();**  **}**  **return null;**  **}** |
| |  |  | | --- | --- | | **Name:** | findValue () | | **Description** | returns a the value of a node stored in an index that has more than one more stored; managing collisions. | | **Input** | <K> key | | **Return** | <V> value: if the node if founded  null: if the node is not stored in the hash table | | **public V findValue(K key){**  **int index= hashFunction(key);**  **HashEntry<K,V> current=table[index];**  **while(current!=null){**  **if(current.getKey().equals(key)){**  **return current.getValue();**  **}**  **current=current.getNext();**  **}**  **return null;**  **}** |
| |  |  | | --- | --- | | **Name:** | delete () | | **Description** | delete a node that is stored in the hash table, managing also collisions: when there is more than one node stored in an index | | **Input** | <K> key <V> value | | **Return** | void | | **public void delete(K key, V value) {**  **int index = hashFunction(key);**  **if(table[index]==null){**  **System.out.println("Node not found!");**  **}else{**  **HashEntry<K, V> current = table[index];**  **while (current != null) {**  **if (current.getKey().equals(key) && current.getValue().equals(value)) {**  **if (current.getPrev() != null) {**  **current.getPrev().setNext(current.getNext());**  **}**  **if (current.getNext() != null) {**  **current.getNext().setPrev(current.getPrev());**  **}**  **if (current == table[index]) {**  **table[index] = current.getNext();**  **}**  **current.setNext(null);**  **current.setPrev(null);**  **this.existingNodes --;**  **return;**  **}**  **current = current.getNext();**  **}**  **}**  **}** |
| |  |  | | --- | --- | | **Name:** | isEmpty () | | **Description** | indicated if the hash table has or not has nodes stored | | **Input** | none | | **Return** | boolean  True if the hash table has no nodes  False if the hash table has at least one node | | **public boolean isEmpty(){**  **return this.existingNodes == 0;**  **}** |
| |  |  | | --- | --- | | **Name:** | showTable () | | **Description** | It converts the information (value) of the elements into a string, and stores it into a StringBuilder. To then convert it into a single string chain | | **Input** | none | | **Return** | String: value of the elements stored in a string chain.  String “No Elements Stored” Message | | **public String showTable(){**  **StringBuilder elements = new StringBuilder();**  **for(int i=0;i< table.length;i++) {**  **if (table[i] != null) {**  **elements.append("\t").append(table[i].getValue().toString()).append("\n");**  **HashEntry<K,V> current = table[i].getNext();**  **while (current != null) {**  **elements.append("\t").append(current.getValue().toString()).append("\n");**  **current = current.getNext();**  **}**  **}**  **}**  **if(elements.toString().isEmpty()){**  **return """**  **\t╔════════════════════╗**  **\t║ ANY TASKS ADDED ║**  **\t╚════════════════════╝**  **""";**  **}**  **else {**  **return elements.toString();**  **}**  **}** |
| |  |  | | --- | --- | | **Name:** | getElementsAsArray () | | **Description** | It stores all the elements of the hash table in a single array of nodes. If there is more than one node stored in an index, then it respect that order in the new array | | **Input** | none | | **Return** | (NodesArray)  HashEntry<K,V> allElements | | **public HashEntry<K,V>[] getElementsAsArray2(){**  **HashEntry<K,V>[] allElements = new HashEntry[this.existingNodes];**  **int j = 0;**  **for(int i = 0; i < table.length; i++) {**  **if (table[i] != null) {**  **allElements[j] = new HashEntry<>(table[i].getKey(),table[i].getValue());**  **j++;**  **HashEntry<K,V> current = table[i].getNext();**  **while (current != null) {**  **allElements[j] = new HashEntry<>(current.getKey(),current.getValue());**  **current = current.getNext();**  **j++;**  **}**  **}**  **}**  **return allElements;**  **}** |
| |  |  | | --- | --- | | **Name:** | showArray () | | **Description** | It shows the value of all the elements stored in the array previously generated in getElemenstAsArray(). | | **Input** | none | | **Return** | String: all the values of each stored in the array stored in one single string chain. | | **public String showArray2(){**  **String msg = "";**  **HashEntry<K,V>[] allElements = getElementsAsArray2();**  **if(allElements.length != 0) {**  **for(HashEntry<K,V> element : allElements){**  **if(element != null){**  **msg += "\n\t" + element.getValue().toString() ;**  **}**  **else {**  **msg += "\n\n\tnull";**  **}**  **}**  **}**  **else {**  **msg += "\n\tEMPTY";**  **}**  **msg += "\n\t" + allElements.length;**  **return msg;**  **}** |

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| **Stack Subroutines** | |
| **Subroutine Specification** | **Construction** |
| |  |  | | --- | --- | | **Name:** | Stack() | | **Description** | It instantiates a new Stack with no elements and size 0 | | **Input** | none | | **Return** | none  (Stack Object instantiated) | | **public Stack() {**  **this.top=null;**  **this.size=0;**  **}** |
| |  |  | | --- | --- | | **Name:** | push() | | **Description** | adds a new element into the stack | | **Input** | T element | | **Return** | none (element added to the stack) | | **public void push(T element) {**  **StackNode<T> created=new StackNode<T>(element);**  **if(top==null) {**  **top = created;**  **}else{**  **top.setTop(created);**  **created.setBottom(top);**  **top=created;**  **}**  **size++;**  **}** |
| |  |  | | --- | --- | | **Name:** | pop() | | **Description** | returns the first element in the structure and deletes it from the data structure | | **Input** | none | | **Return** | output (T): element at the top of the stack  null: if the stack has no elements | | **public T pop() {**  **if(top==null) {**  **return null;**  **}else {**  **T output = top.getContent();**  **StackNode<T> newKing = top.getBottom();**  **if (newKing != null)**  **newKing.setTop(null);**  **top.setBottom(null);**  **top = newKing;**  **size--;**  **return output;**  **}**  **}** |
| |  |  | | --- | --- | | **Name:** | peek() | | **Description** | returns the first element from the stack without deleting it | | **Input** | none | | **Return** | top (T): element at the top of the stack  null: if the stack has no elements | | **public T peek() {**  **return top!=null? top.getContent(): null;**  **}** |
| |  |  | | --- | --- | | **Name:** | isEmpty() | | **Description** | returns whether the stack has elements or not | | **Input** | none | | **Return** | (boolean)  true: the stack has no elements, meaning the top is null  false: the stack has elements, meaning the top is not null. | | **public boolean isEmpty() {**  **return top==null;**  **}** |
| |  |  | | --- | --- | | **Name:** | getSize() | | **Description** | returns the number of elements saved in the data structrue | | **Input** | none | | **Return** | (int)  number of elements saved in the stack | | **public int getSize() {**  **return this.size;**  **}** |

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| |  |  | | --- | --- | | **Name:** | getTop() | | **Description** | returns the element saved at the top of the stack | | **Input** | none | | **Return** | (StackNode<T>)  top: element at the top of the stack  null: if the stack is empty | | **public StackNode<T> getTop() {**  **return top;**  **}** |

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| |  |  | | --- | --- | | **Name:** | getTop() | | **Description** | returns the element saved at the top of the stack | | **Input** | none | | **Return** | (StackNode<T>)  top: element at the top of the stack  null: if the stack is empty | | **public StackNode<T> getTop() {**  **return top;**  **}** |

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| |  |  | | --- | --- | | **Name:** | setTop() | | **Description** | sets a new Node as the top of the stack | | **Input** | StackNode<T> top | | **Return** | none  (new StackNode<T> set as the top of the Stack) | | **public void setTop(StackNode<T> top) {**  **this.top = top;**  **}** |

**MinHeap Subroutines**

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| **Subroutine Specification** | **Construction** |
| |  |  | | --- | --- | | **Name:** | MinHeap() | | **Description** | It instantiates a new Heap with no elements | | **Input** | none | | **Return** | none  (MinHeap Object instantiated) | | **public MinHeap() {**  **heap = new ArrayList<>();**  **}** |
| |  |  | | --- | --- | | **Name:** | insert() | | **Description** | adds a new element into the MinHeap | | **Input** | T element | | **Return** | none (element added to the heap, keeping its property) | | **public void insert(T element) {**  **heap.add(element);**  **int index = heap.size() - 1;**  **while (index > 0) {**  **int parentIndex = (index - 1) / 2;**  **if (heap.get(index).compareTo(heap.get(parentIndex)) < 0) {**  **// Swap with parent**  **T temp = heap.get(index);**  **heap.set(index, heap.get(parentIndex));**  **heap.set(parentIndex, temp);**  **index = parentIndex;**  **} else {**  **break;**  **}**  **}**  **}** |
| |  |  | | --- | --- | | **Name:** | peekMin() | | **Description** | returns the first element in the structure (the “smallest” one) | | **Input** | none | | **Return** | (T): element at the beginning of the heap  null: if the heap has no elements | | **public T peekMin() {**  **if (heap.isEmpty()) {**  **return null;**  **}**  **return heap.get(0);**  **}** |

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| |  |  | | --- | --- | | **Name:** | isEmpty() | | **Description** | returns whether the heap has elements or not | | **Input** | none | | **Return** | (boolean)  true: the stack has no elements, meaning the ArrayList<T> is empty  false: the heap has elements, meaning the ArrayList<T> is not empty | | **public boolean isEmpty() {**  **return heap.isEmpty();**  **}** |

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| |  |  | | --- | --- | | **Name:** | addElements() | | **Description** | adds a group of elements to the MinHeap while keeping its property | | **Input** | ArrayList<T> elements | | **Return** | none  (elements added to the heap) | | **public void addElements(ArrayList<T> elements) {**  **for (T element : elements) {**  **insert(element);**  **}**  **}** |

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| |  |  | | --- | --- | | **Name:** | extractMin() | | **Description** | returns the smallest element from the Heap and deletes it from the structure | | **Input** | none | | **Return** | (T)  min: smallest element from the heap  null: if the heap has no elements | | **public T extractMin() {**  **if (heap.isEmpty()) {**  **return null;**  **}**  **T min = heap.get(0);**  **heap.set(0, heap.get(heap.size() - 1));**  **heap.remove(heap.size() - 1);**  **int index = 0;**  **while (true) {**  **int leftChildIndex = 2 \* index + 1;**  **int rightChildIndex = 2 \* index + 2;**  **int largest = index;**  **if (leftChildIndex < heap.size() && heap.get(leftChildIndex).compareTo(heap.get(largest)) > 0) {**  **largest = leftChildIndex;**  **}**  **if (rightChildIndex < heap.size() && heap.get(rightChildIndex).compareTo(heap.get(largest)) > 0) {**  **largest = rightChildIndex;**  **}**  **if (largest != index) {**  **// Swap with the largest child**  **T temp = heap.get(index);**  **heap.set(index, heap.get(largest));**  **heap.set(largest, temp);**  **index = largest;**  **} else {**  **break;**  **}**  **}**  **return min;**  **}** |

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| |  |  | | --- | --- | | **Name:** | getHeap() | | **Description** | returns all of the elements from the Heap | | **Input** | none | | **Return** | (ArrayList<T>)  heap: list of elements from the heap  null: if the heap is empty | | **public ArrayList<T> getHeap() {**  **return heap;**  **}** |

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| |  |  | | --- | --- | | **Name:** | setHeap() | | **Description** | set new elements as part of the heap structure | | **Input** | ArrayList<T> heap | | **Return** | none  (new heap set) | | **public void setHeap(ArrayList<T> heap) {**  **this.heap = heap;**  **}** |

**Queue Subroutines**

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| **Subroutine Specification** | **Construction** |
| |  |  | | --- | --- | | **Name:** | Queue() | | **Description** | It instantiates a new Queue with top and last with the value of null and size 0 | | **Input** | none | | **Return** | none  (Queue Object instantiated) | | **public Queue() {**  **this.top = null;**  **this.last = null;**  **this.size = 0;**  **}** |
| |  |  | | --- | --- | | **Name:** | add() | | **Description** | adds a new element into the Queue | | **Input** | T element | | **Return** | void | | **public void add(T element){**  **QueueNode<T> newNode = new QueueNode<>(element);**  **// The list is empty**  **if(top == null){**  **top = newNode;**  **}**  **else{**  **this.last.setNext(newNode);**  **newNode.setPrevious(this.last);**  **}**  **last = newNode;**  **size++;**  **}** |
| |  |  | | --- | --- | | **Name:** | poll() | | **Description** | returns the first element that was added to the structure and deletes it from the data structure | | **Input** | none | | **Return** | output (T): the first element that was added. (Top)  null: if the Queue has no elements | | **public T poll(){**  **if(top == null){**  **return null;**  **}**  **else {**  **T firstOut = top.getContent();**  **if(top == last){**  **top = null;**  **last = null;**  **}**  **else {**  **QueueNode<T> newTop = top.getNext();**  **newTop.setPrevious(null);**  **top.setNext(null);**  **top = newTop;**  **}**  **size--;**  **return firstOut;**  **}**  **}** |
| |  |  | | --- | --- | | **Name:** | peek() | | **Description** | returns the first element from the Queue without deleting it. (Top) | | **Input** | none | | **Return** | top (T): top element content.  null: if the Queue has no elements | | **public T peek(){**  **return top.getContent();**  **}** |
| |  |  | | --- | --- | | **Name:** | isEmpty() | | **Description** | returns whether the Queue has elements or not | | **Input** | none | | **Return** | (boolean)  true: the Queue has no elements, meaning the size = = 0  false: the Queue has elements, meaning  size != 0 | | **public boolean isEmpty(){**  **return size == 0;**  **}** |
| |  |  | | --- | --- | | **Name:** | getSize() | | **Description** | returns the number of elements saved in the data structure | | **Input** | none | | **Return** | (int)  number of elements saved in the Queue | | **public int getSize() {**  **return size;**  **}** |

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| |  |  | | --- | --- | | **Name:** | getTop() | | **Description** | returns the element saved at the top of the stack | | **Input** | none | | **Return** | (QueueNode<T>)  top: element at the top of the Queue  null: if the Queue is empty | | **public QueueNode<T> getTop() {**  **return top;**  **}** |

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| |  |  | | --- | --- | | **Name:** | showQueue() | | **Description** | returns the toString of all the elements in the Que | | **Input** | none | | **Return** | String with all the toStrings.  if the Queue is empty returns a message stating the queue is empty | | **public String showQueue(){**  **if(this.top == null){**  **return "Queue is empty";**  **}**  **else{**  **return showQueue(top);**  **}**  **}** |