**PROBLEM IDENTIFICATION**

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| --- | --- |
| Clients | HackTech Group |
| User | Hackers y jugadores |
| Funcitonal Requirements | The system must allow:  R1: Display the shortest route between the hacker's starting point and the presidential network.  R2: Verify the possibility of reaching the presidential network from a specific point.  R3: Navigate from a specific point to another point of interest within the network. |
| Context | A group of elite hackers, renowned for their skills in breaching high-security systems, has been hired by the mysterious syndicate "The Syndicate" to develop a hacking simulation game. The main objective of the game is to infiltrate the secure network of the presidential system of a fictional country, known for its advanced cybersecurity measures. The storyline of the game involves the need to navigate through the smartphones of 50 government employees to access the highly secure network. |
| Process requierements: | ➔ R1: The game must be developed by a team of 3 hackers.  ➔ R2: The system must be uploaded to the Github version control system and kept private until the day of the release. |
| Non-functional requirements | Non-functional Requirements  ● R1: The user interface must be simple and easy to understand to ensure player comfort.  ● R2: The game must be developed in Java to guarantee software compatibility and security. |

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| Name | R1: Show the Shortest Path Between the Hacker's Starting Point and the Presidential Network. | | |
| Summary | The system must allow displaying the shortest path between the hacker's starting point and the presidential network. | | |
| Input | Name of input | Data type | Selection of condition or repetition |
|  |  |  |
| General or necessary activities to obtain the result | The system must calculate and visualize the shortest path using the hacker's starting point and the presidential network. | | |
| Result or postcondition. | The shortest path between the hacker's starting point and the presidential network is shown. | | |
| Output | Output name | Date type | Selection of condition or repetition |
| message | String |  |

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| --- | --- | --- | --- |
| Name | R2: Verify the Possibility of Reaching the Presidential Network from a Specific Point. | | |
| Summary | The system must allow verifying the possibility of reaching the presidential network from a specific point. | | |
| Input | Input name | Data type | Selection of condition or repetition |
|  |  |  |
| General or necessary activities to obtain the result | The system must calculate and demonstrate the feasibility of reaching the presidential network from a specific point. | | |
| Result or postcondition. | The possibility of reaching the presidential network from the specified point is verified. | | |
| Output | Output name | Data type | Selection of condition or repetition |
| message | String |  |

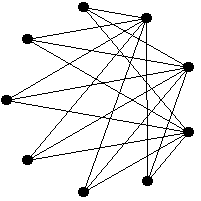
|  |  |  |  |
| --- | --- | --- | --- |
| Name | R3: Navigate from a Specific Point to Another Point of Interest Within the Network. | | |
| Summary | The system must allow navigating from a specific point to another point of interest within the network. | | |
| Input | Input name | Data type | Selection of condition or repetition |
|  |  |  |
| General or necessary activities to obtain the result | The system must calculate and demonstrate the feasibility of navigating from a specific point to another point of interest within the network. | | |
| Result or postcondition | The most efficient path to navigate from the initial point to the point of interest within the network is obtained. | | |
| Output | Output name | Data type | Selection of condition or repetition |
| message | String |  |

**Information Gathering**

In tackling the challenge of infiltrating the presidential network, we will employ graph theory. To comprehend the development of our solution, it is crucial to understand the graph theory, specifically its Breadth-First Search (BFS) and Dijkstra algorithms.

What is a Graph and How Does It Work?

In this context, a graph represents the discrete structure of the presidential network, comprising vertices (representing network nodes) and edges (depicting the pathways the hacker will navigate). The graph can be visually represented as follows:



Our chosen graph type is a Directed Weighted Multigraph, allowing various routes to reach the same network node, each constrained to a specific direction.

BFS and Dijkstra Algorithms:

BFS Algorithm:

Systematically searches network elements, visiting all neighbors of the starting node before exploring neighbors of the initially visited nodes.

Finds and displays the shortest path between the hacker's starting point and the presidential network.

Dijkstra Algorithm:Finds the shortest path between the initial node (hacker's starting point) and all nodes in the network.Determines the most efficient path from the hacker's starting point to the target point within the presidential network.

Glossary:

BFS: Breadth-First Search

Reference: : <https://www.educative.io/answers/what-is-breadth-first-search>

Dijkstra:

Named after its creator, Dutch computer scientist Edsger Dijkstra.

Reference: Dijkstra's Algorithm

References: <https://www.analyticssteps.com/blogs/dijkstras-algorithm-shortest-path-algorithm>

Menéndez Velázquez, A. (1998). "Una breve introducción a la teoría de grafos." Suma.

**Phase 3: In Search of Creative Solutions for Presidential Network Infiltration**

Alternative 1: **Use of Dijkstra and BFS Algorithms in a Simple Weighted Graph**

In our first proposal, we suggest employing the Dijkstra and BFS algorithms in a simple weighted graph. In our context, the vertices represent nodes in the presidential network, and the edges indicate the connections between them. Dijkstra will be used to find the shortest route from the hacker's starting point to the presidential network, considering distances as weights on the edges. Additionally, BFS will be employed to systematically explore all stations (nodes), although in this case, the edges will not have numeric weights representing distances.

Alternative 2: **Prim and Kruskal Algorithms in a Simple Weighted Graph**

The second alternative proposes the use of the Prim and Kruskal algorithms in a simple weighted graph. Prim will create a minimum spanning tree that connects with all stations in the presidential network, selecting the smallest distances without forming loops. Kruskal, on the other hand, seeks the optimal option in each phase, organizing distances from least to greatest and building a minimum spanning tree without forming loops.

Alternative 3: **Floyd Warshall and DFS Algorithms in a Simple Weighted Graph**

The third alternative suggests using the Floyd Warshall and DFS algorithms in a simple weighted graph. The Floyd Warshall algorithm, adapted to our context, will be applied through a matrix containing stations in pairs as rows and columns. Distance updates will be made considering the potential for infiltration into the presidential network. However, the DFS algorithm may not be entirely effective, as it does not seek the fastest route between stations and the presidential network. Instead, it displays a path exploring various possibilities of infiltration into the network.

**Phase 4: Transition from Ideas to Preliminary Designs**

Upon careful consideration, all proposed ideas are deemed viable, as each accurately models the problem within the given context. Below is additional information on the ideas that were not discarded.

Alternative 1: **Utilizing Dijkstra and BFS Algorithms**

The use of Dijkstra and BFS ensures the selection of the shortest path while disregarding longer distances. Dijkstra's algorithm opts for the edge with the smallest weight, identifying the shortest path to the destination. On the other hand, BFS operates without a weighted graph, visiting each level and all its neighbors. By recording the parents, it can trace back the shortest path.

Alternative 2: **Applying Prim and Kruskal Algorithms**

The application of Prim and Kruskal is also considered viable, as it facilitates the identification of the shortest path. The Prim algorithm discovers the shortest path without creating cycles. Starting from an initial vertex, edges are incrementally added until the point of interest is reached. Kruskal organizes distances from smallest to largest, adding the smallest distance to the spanning tree. Routes that form loops are rejected, and if all vertices are reached, they are also added to the spanning tree.

Alternative 3: **Leveraging DFS and Floyd Warshall Algorithms**

Although DFS does not prioritize the shortest path, it explores all vertices and corresponding edge lengths, revealing all possible paths. The Floyd Warshall algorithm is constructed with a matrix containing each vertex as a coordinate in rows and columns. The coordinate is updated if a distance smaller than the current one is encountered.

**Step 5: Evaluation and Selection of the Best Solution:**

**Criteria:**

The criteria that will allow evaluating the alternative solutions must be defined and based on this result choose the solution that best meets the needs of the problem. The criteria we chose in this case are the ones we list below. Next to each one a numerical value has been established with the aim of establishing a weight that indicates which of the possible values of each criterion have the most weight (i.e., they are more desirable).

***- Criteria 1:***  
 Uses distances according to the context.

o [2] Yes

o [1] No

***- Criteria 2:***Less quantity of vertexes.

o [3] Has the fewest vertices

o [2] Has more vertices than expected

o [1] Has too many vertices

***- Criteria 3:***

Temporal complexity.

o [2] Fast

o [1] Slower

***- Criteria 4:***   
Coding efficiency.

o [2] Yes

o [1] No

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| --- | --- | --- | --- | --- | --- |
|  | Criteria 1 | Criteria 2 | Criteria 3 | Criteria 4 | Total |
| Alternative 1 | 2 | 3 | 2 | 2 | 9 |
| Alternative 2 | 2 | 2 | 1 | 1 | 6 |
| Alternative 3 | 2 | 1 | 1 | 1 | 5 |

*Selection:*

According to the previous evaluation, Alternative 1 should be selected since it obtained the highest score according to defined criteria.