Application of minimum spanning tree on maps in Penacony for Optimizing Treasure Chest Collection Routes in Honkai: Star Rail

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***Abstract*—Minimum Spanning Tree (MST) algorithm to model and optimize the Treasure Chest collection route within the The Reverie sub-area of Penacony, a major explorable region introduced in version 2.0 of Honkai: Star Rail, a turn-based RPG developed by HoYoverse. The exploration map is formally modeled as an undirected weighted graph in which Space Anchors and Chest Cluster zones serve as vertices, while traversable paths between them are represented as edges with Euclidean distance weights derived from normalized 2D coordinate data. Kruskal's algorithm is applied to construct the MST.**

Keywords—Honkai: Star Rail; Minimum Spanning Tree; Graph; Optimizing

I. INTRODUCTION

Honkai: Star Rail is a turn-based role-playing game developed by HoYoverse and released globally in April 2023. Set in a science-fantasy universe, the game follows a group of travelers known as the Trailblazers as they journey across multiple star systems. Each planetary destination constitutes a distinct explorable region with its own map structure, storyline, and collectible content. The game has garnered significant global attention, accumulating over 20 million registered players within its first two days of release and maintaining a strong active player base across subsequent updates.

Penacony that known as Planet of Festivities, first launched in version 2.0 of Honkai: Star Rail. Among Penacony's multiple sub-areas, The Reverie is one of the place that we will face in the early story in Penacony. The map has 2 Space Anchor teleportation points and 16 Treasure Chests distributed across the map that reason this map become one of the easiest map that player will complete all of the chest early. Space Anchors function as fast-travel waypoints that allow players to teleport instantly to key locations within the map, effectively serving as hubs in the exploration network.

This treasure chest is one of the items that players in Honkai: Star Rail really aim for. By getting it, players will receive Stellar Jade, a premium currency used to gacha characters or weapons in the game, as well as other items needed to level up characters or weapons, like Credits and Materials. Because of these rewards, grabbing chests efficiently becomes one of the key points for progressing your account. If you don't collect chests efficiently, players will end up backtracking, which takes much longer to get all the chests.

To solve this problem, one of the theories from the discrete math course can be applied, which is the minimum spanning tree. By considering each teleportation point and chest as nodes and the distances between all these objects as edges, finding the minimum distance to collect all the chests can be done using Kruskal's algorithm to find the minimum spanning tree.

The remainder of this paper is organized as follows. Section II presents the theoretical basis of graph theory, tree structures, and MST algorithms. Section III describes the methodology, including map data collection, graph construction, and algorithm implementation. Section IV presents the experimental results and provides a detailed analysis of the findings. Section V concludes the paper with a summary of key contributions and directions for future research.

II. THEORETICAL BASIS

A. Graph

Graphs are usually used to represent relationships between discrete objects. A graph can be formulated as G = (V, E) where V is a non-empty set of nodes or points and E is a set that can be empty of edges.

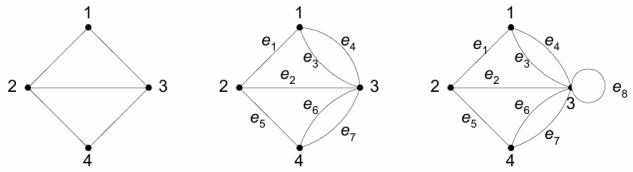

Fig. 1. simple graph, multigraph, and pseudograph
Source: [2]

Each vertex can have more than one edge with the same pair of vertices, which is later called a multigraph. Edges can also be arranged with the same 2 vertices, these edges are called loops and the entire graph is called a pseudograph. A graph can also have a direction from which vertex to which vertex. This kind of graph is called a directed graph.

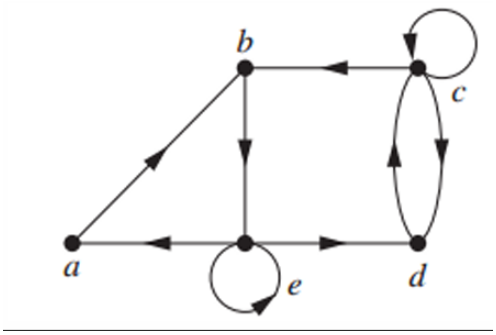

Fig. 2. Directed graph
Source: [2]

A graph can have a Hamiltonian path and a Hamiltonian circuit. A Hamiltonian path is a path that goes through each vertex in the graph exactly once, while a Hamiltonian circuit is a path that goes through each vertex in the graph exactly once except for the starting vertex, which is visited twice.

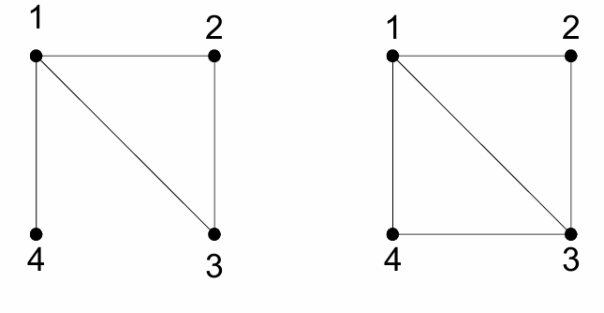

Fig. 3. Hamiltonian path and Hamiltonian circuit
Source: [7]

B. Tree

A tree is an undirected graph that is fully connected and does not contain any circuits inside. To move from one vertex to another, there is only one path that connects them. Every tree that has n vertices will always have n-1 edges.

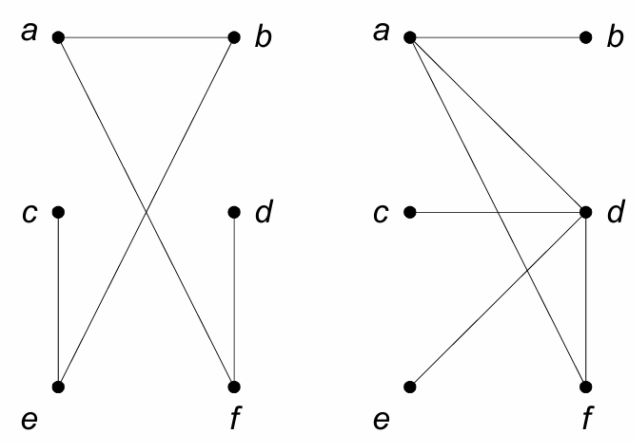

Fig. 4. Tree and not a tree
Source: [3]

Next, there is the spanning tree. A spanning tree is a subgraph of a free graph that forms a tree. A spanning tree must include all the vertices in the graph. A single graph can have many spanning trees within it.

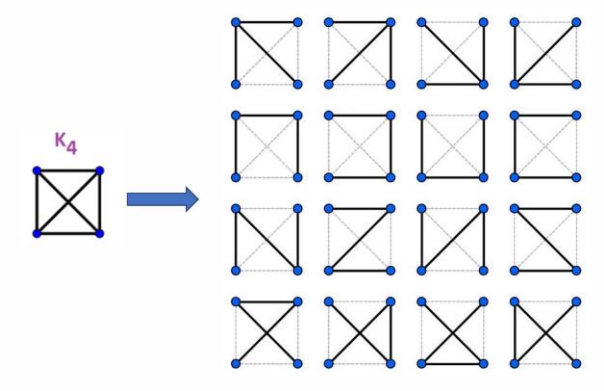

Fig. 5. Spanning tree of K4 graph
Source: [3]

When we use a weighted graph instead of an unweighted graph, we can create a tree with a certain total weight of edges. If we look for the minimum total weight among all the edges in that spanning tree, it will result in a minimum spanning tree.

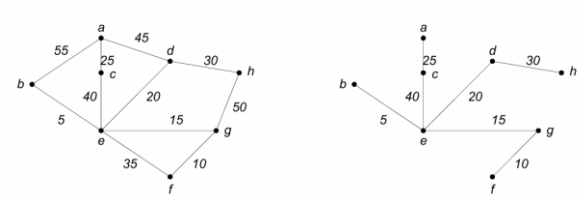

Fig. 6. Spanning tree of K4 graph
Source: [3]

C. MST Algorithm

There are two algorithms to find a minimum spanning tree in a graph, which are Prim's algorithm and Kruskal's algorithm. In this paper, we will use Kruskal's algorithm to determine the optimal chest path. Here are the steps to find a minimum spanning tree using Kruskal's algorithm.

(Step 0: the edges of the graph are already sorted in increasing order based on their weights – from smallest to largest)

Step 1: T is still empty

Step 2: choose the edge (u, v) with the minimum weight that doesn't form a cycle in T. Add (u, v) to T.

Step 3: repeat step 2 a total of n – 1 times.

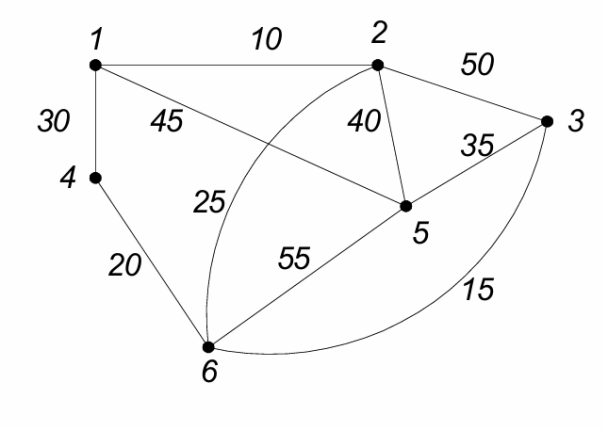

Fig. 7. Graph normal
Source: [3]

Sisi	(1,2)	(3,6)	(4,6)	(2,6)	(1,4)	(3,5)	(2,5)	(1,5)	(2,3)	(5,6)
Bobot	10	15	20	25	30	35	40	45	50	55

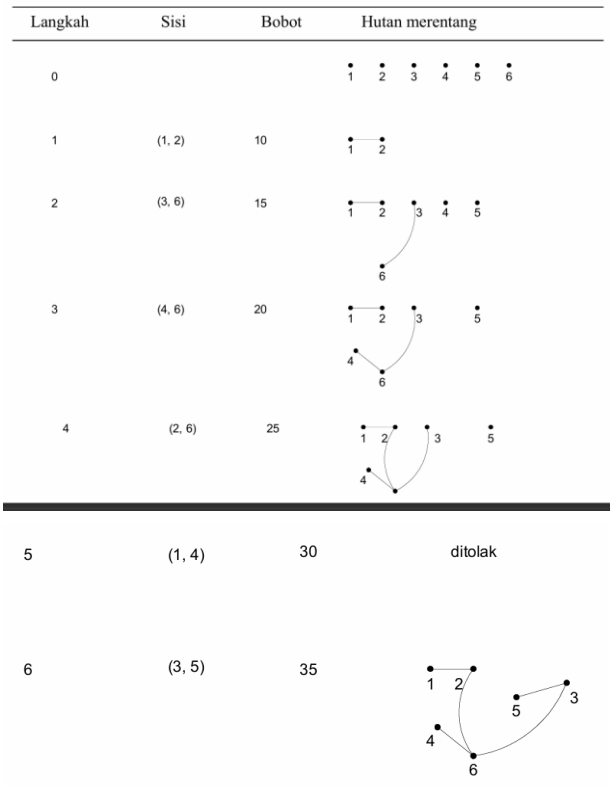

Fig. 8. Kruskal's Algorithm
Source: [3]

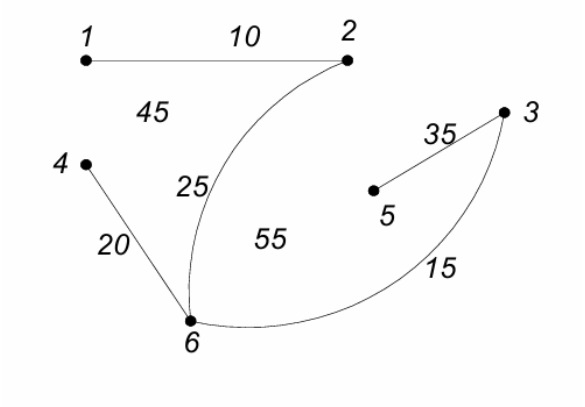

Fig. 9. Minimum Spanning Tree
Source: [3]

III. METHODE

This study focuses on the Dream's Edge sub-area of Penacony in Honkai: Star Rail. The Reverie is a simple multi-zone exploration area introduced in version 2.0 of the game. It features a total of 16 Treasure Chests distributed across multiple spatial clusters, accessible via two distinct Space Anchor teleportation points.

Node positions were reconstructed from community-sourced guides published by Game8, Hoyolab, and Pro Game Guides, which provide detailed descriptive location data for all Space Anchors and Treasure Chests in The Reverie.

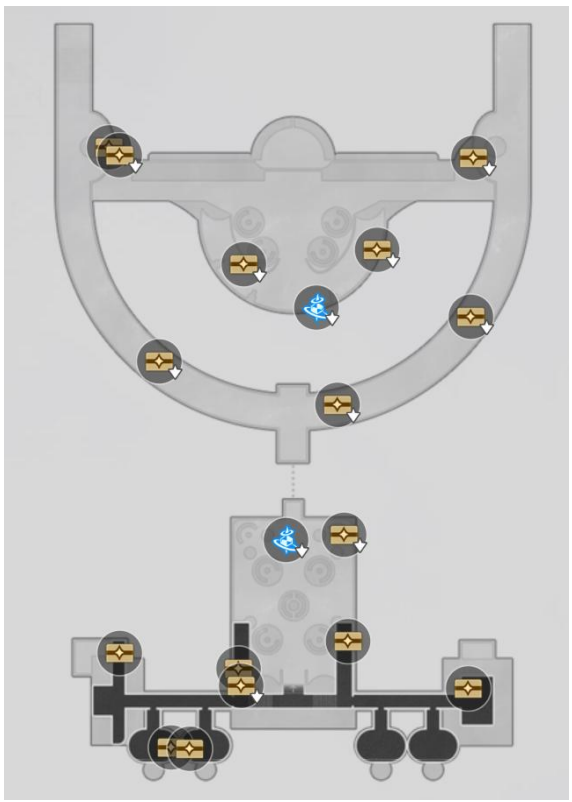

Fig. 1. Map distribution in The Reverie, Penacony
Source: https://act.hoyolab.com/sr/app/interactive-

map/index.html#/map/146?zoom=-2.00&center=28.99,-210.00&shown_types=24,659

IV. Result

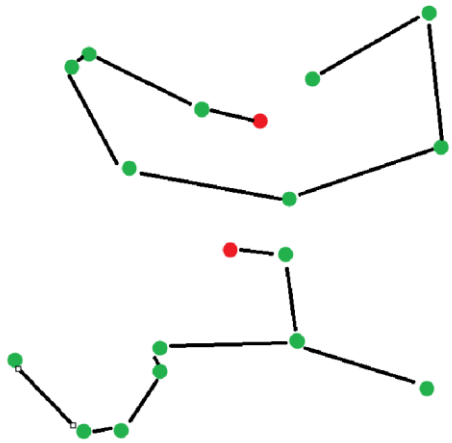

Fig. 2. Optimal Chest Route with Kruskal Algorythm
Source: Author

After using the Kruskal's Algorithm we get the optimal result for the player to collect all of the chest in The Reverie with the minimum trackback. It become 2 distinct tree because the red is the anchor teleport point, so player can teleport in there and travel across map to collect the chest.

V. Conclusion

This paper has successfully demonstrated the application of Minimum Spanning Tree theor, implemented by Kruskal's algorithm, to the problem of optimizing Treasure Chest collection routes in the The Reverie sub-area of Penacony in Honkai: Star Rail. The exploration map was formally modeled as an undirected weighted graph with 18 nodes representing 2 Space Anchor teleportation points and 16 Chest, and 16 edges representing traversable paths with Euclidean distance weights derived from community-sourced minimap coordinate data.

Acknowledgment

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STATEMENT

I hereby declare that this paper I wrote is my own work, not an adaptation or translation of someone else's paper, and not plagiarism.

Bandung, 1 June 2025

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