Project 6 - MultiSet Design

Data Structure and Algorithm

December 1, 2025

Abstract

1 Introduction

Based on what I understand from description of project 6, I had two options: an RPG game or a tower defense game. An RPG game is about a hero's journey, while Tower Defense is about strategic defense. I decided to go with the "Tower Defense" game. I like this kind of game more. This design will propose a class named "DefenseTower", a multiset data structure for core logic of Tower Defense game system. The player will manages defense strategies and structures to stop the incoming enemies. As mentioned in the project pdf, multiset (DefenseTower) will support multiple instances of same item e.g. a player likes to have 5 cannons and 2 towers to attack. As mentioned in Table 1, the comparison between Hash Table and AVL Tree bring me to the decision of choosing Hash Table (HashMap)(¡string, unsigned int¿).

Comparison Criteria	Hash Table	AVL Tree
Search Time Complexity	O(1)	O(log n)
Insertion Time Complexity	O(1)	O(log n)
Deletion Time Complexity	O(1)	O(log n)
Memory Overhead	High	Low
Range Searches	Requires special implementation	Efficient
Re-balancing	Not necessary	Required
Recursion	Not Inherently RS	RS
Implementation	Mostly relies on Libraries	Easily Customizable
Suitability for Small Data Sets	Less suitable due to memory overhead	More suitable

Table 1: Comparison of HahsTable vs AVL-Tree[Gee]

Hash Table for game design is perfect because it will check the inventory (game loop Figure 1) thousands of times in a simple game. A Hash Table is the only structure fast enough to do this instantly (O(1)) so the game doesn't lag/stutter.

2 Design Philosophy

There are three primary qualities in designing the DefenseTower: ***Efficiency***, ***Simplicity***, and ***Extensibility***. But before talking about them, let us define the latency, and compaction in the operation system.

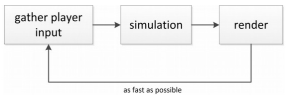

Figure 1: Simple game loop[VCF16]

Latency is a measurement of delay in a system.Network latency is the amount of time it takes for data to travel from one point to another across a network. The higher the latency, the slower the response times[IBM]. Compaction is a technique to collect all the free memory present in the form of fragments into one large chunk of free memory, which can be used to run other processes. It does that by moving all the processes towards one end of the memory and all the available free space towards the other end of the memory so that it becomes contiguous[Gee24].

2.1 Efficiency:

I believe in a game, latency (response time) is more important than memory compactness. In a tower defense game, operations like checking if a tower is available (contains) or removing a tower (remove) occur frequently.

2.2 Simplicity:

Just imagine: you want to drive a car home. As a driver, is it more important to you how the cylinder works inside the engine or how the oil circulates inside it? The answer is NO. The same thing is happening here, The client code which can be the Game UI or Level Manager, should not need to manage the underlying hashing logic. The interface of the game should only focus on concepts like adding or removing the tower, not low-level data manipulation.

2.3 Extensibility:

It is said that "No single platform can provide everything out of the box to meet business needs. To drive product and quality excellence, the extensibility of the chosen software platform is critical". Therefore, an extensible software platform should be flexible, configurable, customizable, upgradeable, accessiblem and collaborative[Raz24]. The game is designed to support future expansions, which dynamically add new features like towers without recompliling the core structure.

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$$S_n = \frac{X_1 + X_2 + \cdots + X_n}{n} = \frac{1}{n}\sum_{i}^{n} X_i$$

denote their mean. Then as n approaches infinity, the random variables $\sqrt{n}(S_n - \mu)$ converge in distribution to a normal $\mathcal{N}(0, \sigma^2)$.

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