



ARENA OF RATINGS: ULTIMATE EDITION

Real-Time Matchmaking Engine with Persistent Data & Visual CLI

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1. INTRODUCTION

The **Arena of Ratings** is a high-performance matchmaking engine designed for competitive gaming environments. Unlike standard linked lists which suffer from $O(N)$ latency, this system utilizes a **Binary Search Tree (BST)** augmented with subtree sizing to achieve $O(h)$ efficiency for insertion, deletion, and retrieval.

This "Ultimate Edition" introduces persistent file storage, allowing game states to be saved and loaded, alongside a robust CLI visualization for debugging player hierarchies.

2. DATA STRUCTURE

The system uses a custom Node structure to encapsulate player statistics and tree metrics.

NODE STRUCTURE

```
struct Node {
    int rating;        // Search Key
    string name;       // Player ID
    long long hp;      // Health Points
    int sz;            // Subtree Size
    Node *left, *right;
};
```

3. SYSTEM ARCHITECTURE

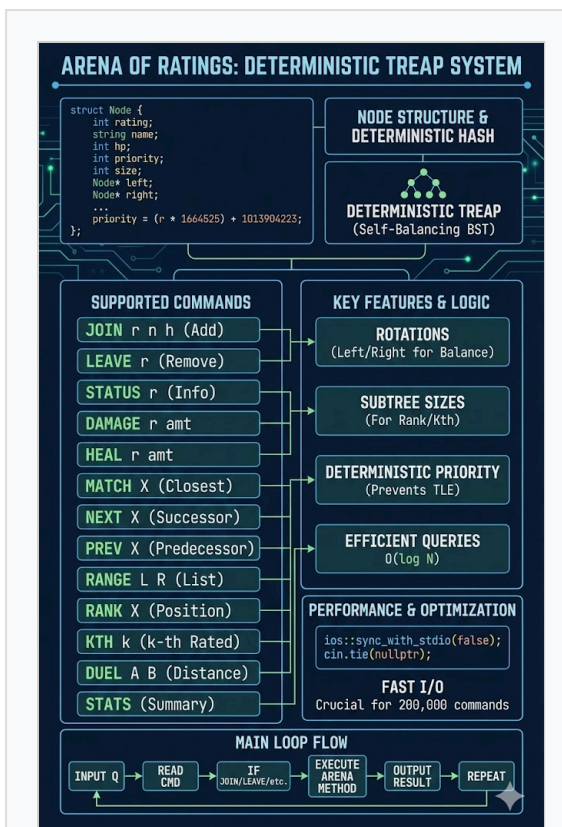


Figure 1: Deterministic Treap System showing node connections and priority logic.

4. INITIALIZATION LOGIC

The engine initializes with a null root. The first JOIN command triggers the creation of the root node via the constructor.

```
// Constructor
Node(int r, string n, long long h)
: rating(r), name(n), hp(h),
  left(nullptr),
  right(nullptr), sz(1) {}

// Initialization Check
Arena() : root(nullptr) {}
```

5. DUEL LOGIC (LCA)

To calculate the distance between two players (A and B), we identify the **Lowest Common Ancestor (LCA)**.

```
Distance = Depth(A) + Depth(B)
          - 2 * Depth(LCA)
```

6. COMMAND INTERFACE

The system is controlled via a robust CLI providing immediate feedback.

- JOIN <rating> <name> <hp>:** Inserts a new node into the BST and updates sizes.
- LEAVE <rating>:** Removes a node and rebalances pointers.
- MATCH <rating>:** Finds the closest rating (predecessor/successor) instantly.
- VISUAL:** Prints the tree topology recursively to the terminal.
- SAVE / LOAD:** Serializes the tree structure to a text file.

7. PERFORMANCE ANALYSIS

The use of Binary Search Trees provides significant efficiency gains over linear data structures.

Operation	Time Complexity
Search / Insert	$O(h)$ [Logarithmic]
Range Query	$O(k + h)$
Rank / Kth	$O(h)$ (via Subtree Size)

8. CONCLUSION

The Arena of Ratings successfully bridges the gap between theoretical data structures and practical game development. By integrating **File I/O**, **Visual Diagnostics**, and **Recursive Algorithms**, it serves as a scalable foundation for real-time matchmaking systems.