ARENA OF RATINGS: ULTIMATE EDITION

Real-Time Matchmaking Engine with Persistent Data & Visual CLI

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1. THE ENGINE: INTRODUCTION

The **Arena of Ratings (Ultimate)** is a sophisticated matchmaking engine designed for competitive gaming. Unlike standard lists, it uses a **Binary Search Tree (BST)** with subtree sizing to ensure **O(h)** efficiency.

New in Ultimate Edition:

- **Persistent Storage:** Save/Load player data to files.
- **Visual Interface:** Color-coded CLI with tree topology.
- **Smart Metrics:** Real-time Duel Distance calculation.

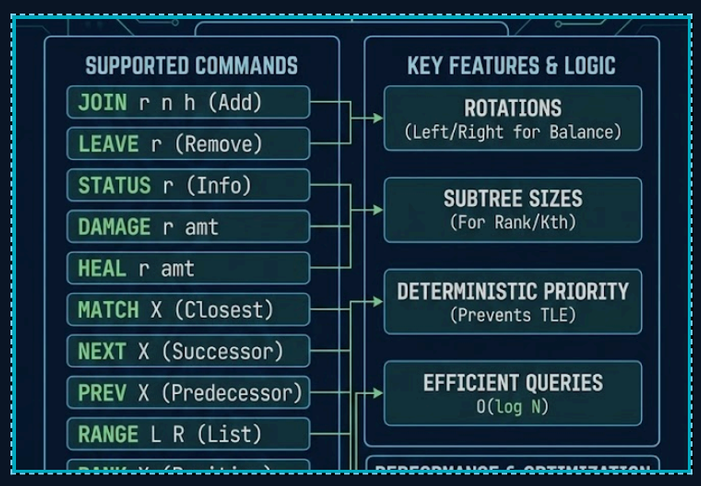
2. CORE DATA STRUCTURE

The system is built on a custom Node structure handling both game data and structural balancing metrics:

```
struct Node {
    int rating;      // The Key (Ordered)
    string name;     // Player ID
    long long hp;    // Dynamic Health
    int sz;          // Subtree Size (Ranking)
    Node *left, *right;
};
```

Rating: Determines tree position.
Subtree Size (sz): Enables finding the "K-th" best player in milliseconds.

3. MAIN VISUAL: DETERMINISTIC TREAP



"A glowing cybernetic Binary Search Tree on a dark blue background."

4. TREE INITIALIZATION

The engine initializes with an empty arena. The first command executed defines the Root Node.

```
Arena() : root(nullptr) {}

void join(int r, string n, long long h) {
    if (!root) {
        // Initialize Root Node
        root = new Node(r, n, h);
    } else {
        // Recursive Insertion
        root = _insert(root, r, n, h);
    }
}
```

5. ALGORITHMIC LOGIC

Recursive Efficiency: All major operations use recursion to traverse the tree efficiently.

- _insert(): Adds players while updating subtree sizes.
- _duel(): Calculates distance using Lowest Common Ancestor (LCA).
- _printDirectoryStyle(): Custom recursive function drawing the tree sideways in the terminal for debugging.

6. SUPPORTED COMMANDS

The engine supports a robust Command Line Interface (CLI):

JOIN / LEAVE	Dynamic player mgmt
MATCH <X>	Finds nearest rated opponent
DUEL <A> <B>	Calculates graph distance
SAVE / LOAD	Persist state to .txt
VISUAL	Draw Tree topology
STATS	Diagnostics & Metrics

7. PERFORMANCE METRICS

- **Time Complexity:** O(h) for Search, Insert, Delete.
- **Space Complexity:** O(N) space efficiency.
- **Real-Time Feedback:** Uses ANSI color codes (\033[32m) for immediate visual feedback (Green for Success, Red for Errors).

8. CONCLUSION

The **Ultimate Edition** transforms a standard BST into a production-ready engine. By integrating file persistence and visual diagnostics, it bridges the gap between theoretical data structures and real-world software application.