TEB1113/TFB2023: ALGORITHM & DATA STRUCTURE

Performance Report on Drone Swarm Simulation

(Homework 4 - Binary Tree Implementation)

Prepared By:

Num.	Full Name	Student ID
1.	Manas Ismail Abdylas	22008600
2.	Syahir Amri bin Mohd Azha	22007728
3.	Adam Marwan bin Husin Albasri	22009203
4.	Safiqur Rahman bin Rowther Neine	22008929
5.	Danish Harith bin Ahmad Nizam	22009489

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1.0 DEVICE SPECIFICATIONS

Model: Legion S7
RAM: 32 GB
Storage: 1 TB
Processor: AMD Ryzen 9 5900HX
GPU: Radeon Graphics
Operating System: Windows 11

2.0 APPLICATION DOMAIN

2.1 Introduction

The purpose of this project is to create a fire-extinguishing drone swarm simulation in Unity, designed to mimic real-world scenarios where autonomous drones are deployed to fight fires in large, complex environments. Each drone in the swarm is equipped with a fire extinguisher, and the simulation focuses on monitoring and dynamically adjusting the swarm's behavior based on each drone's fire extinguisher capacity. This allows the simulation to showcase how these drones can effectively distribute resources during emergency situations.

One key aspect of the project is the implementation of an efficient O(N) algorithm to partition the drone swarm into two subgroups based on their fire extinguisher capacities. This partitioning ensures that drones with higher capacities are grouped separately from those with lower capacities, enabling the system to prioritize resources when needed. Drones with higher capacities are assigned blue sprites, while those with lower capacities are assigned red sprites for easy visualization of their roles within the swarm.

The simulation also integrates real-time performance monitoring, capturing key metrics such as partitioning time and frames per second (FPS) to assess the efficiency of the drone swarm in handling firefighting tasks. Additionally, visual enhancements have been made to the drones and the environment to improve the overall realism of the simulation, making it a more accurate representation of a fire emergency response system. The project not only demonstrates the potential of autonomous drone swarms in firefighting but also highlights the importance of optimizing resource allocation and maintaining performance in real-time operations.

2.2 Binary Tree Integration

Aside from the Linked List, we integrated a Binary Tree (BT) to manage drones by temperature, enhancing search efficiency. The BT allows faster search operations with an average complexity of O(log N) for balanced trees, significantly reducing search times compared to the Linked List's O(N). However, performance may degrade to O(N) if the tree becomes unbalanced.

The BT is especially useful for commands like SearchByTemperature, where it navigates efficiently through nodes based on temperature. Communication paths are visualized, and total communication time is calculated by tracking distances between nodes, providing insights into network speed and latency. Additionally, the BT supports efficient self-destruct commands by temperature or fire extinguisher capacity, eliminating the exhaustive searches needed in the Linked List.

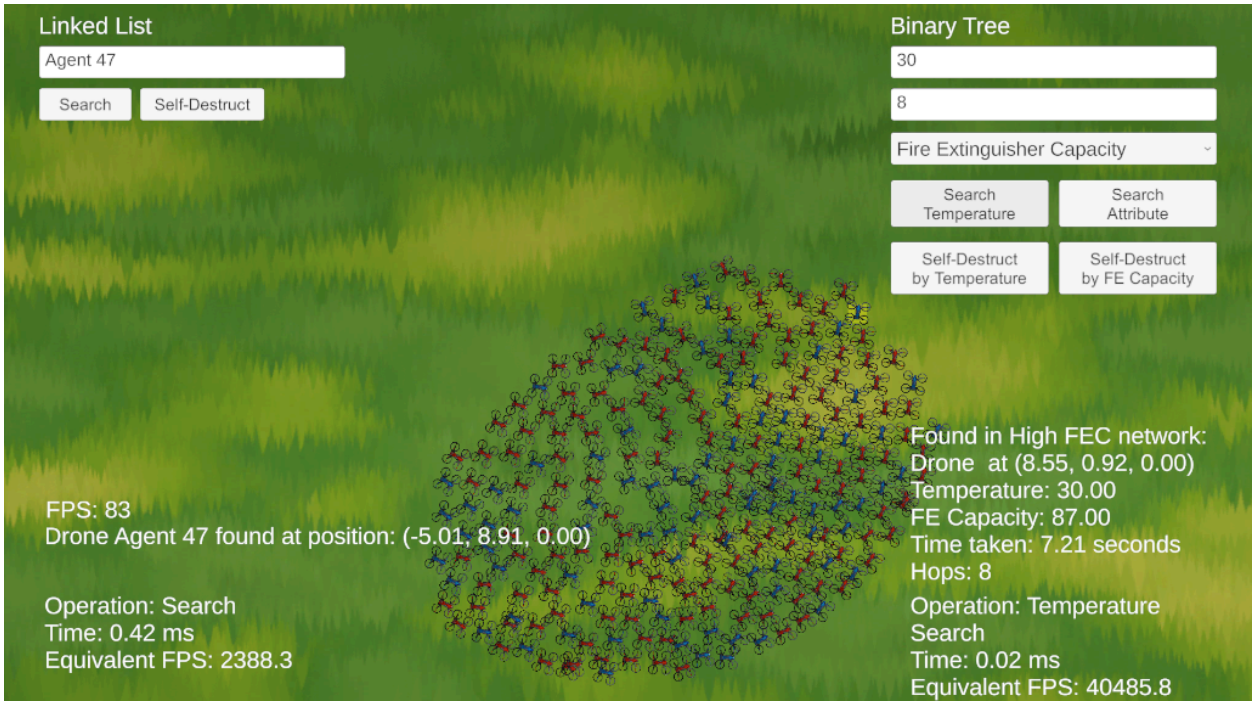
During the partitioning phase, drones are divided into high and low fire extinguisher capacity groups, each managed by both Linked Lists and BTs. This approach enables targeted searches within each group, enhancing the speed of command execution. Partitioning time and FPS data are recorded every frame, offering performance metrics that demonstrate the relationship between drone count and scene efficiency.

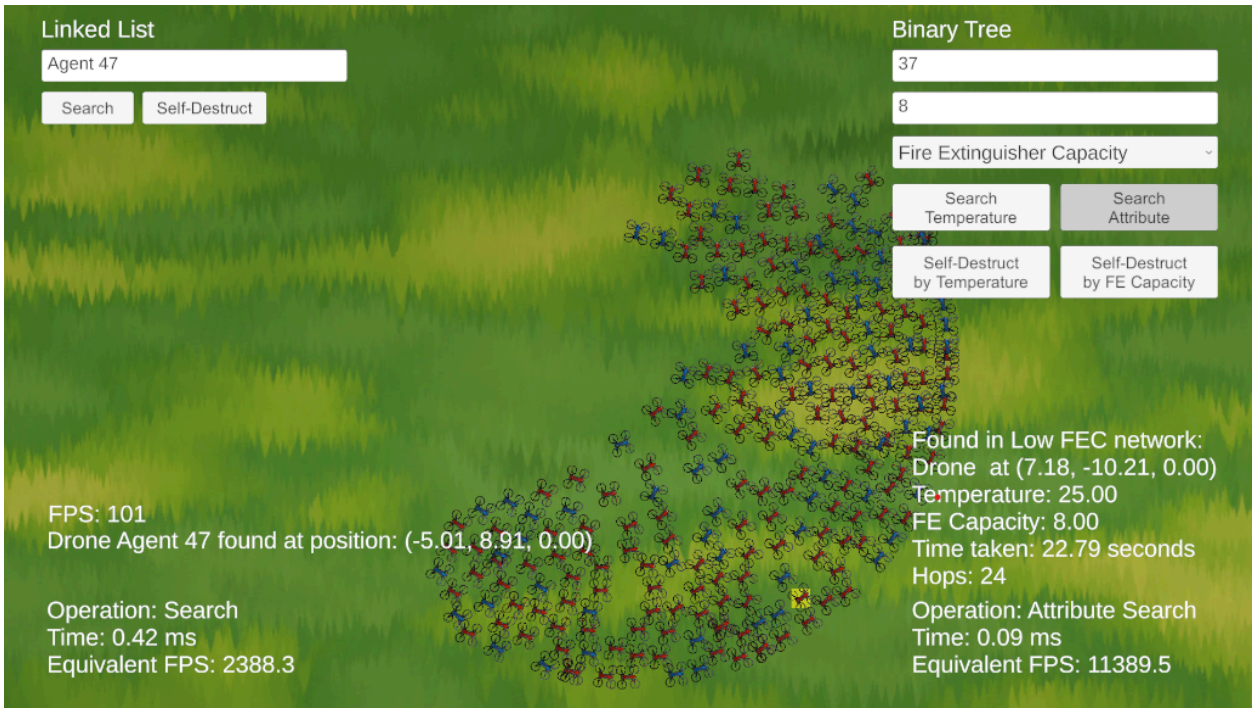
2.3 Perfomance Analysis

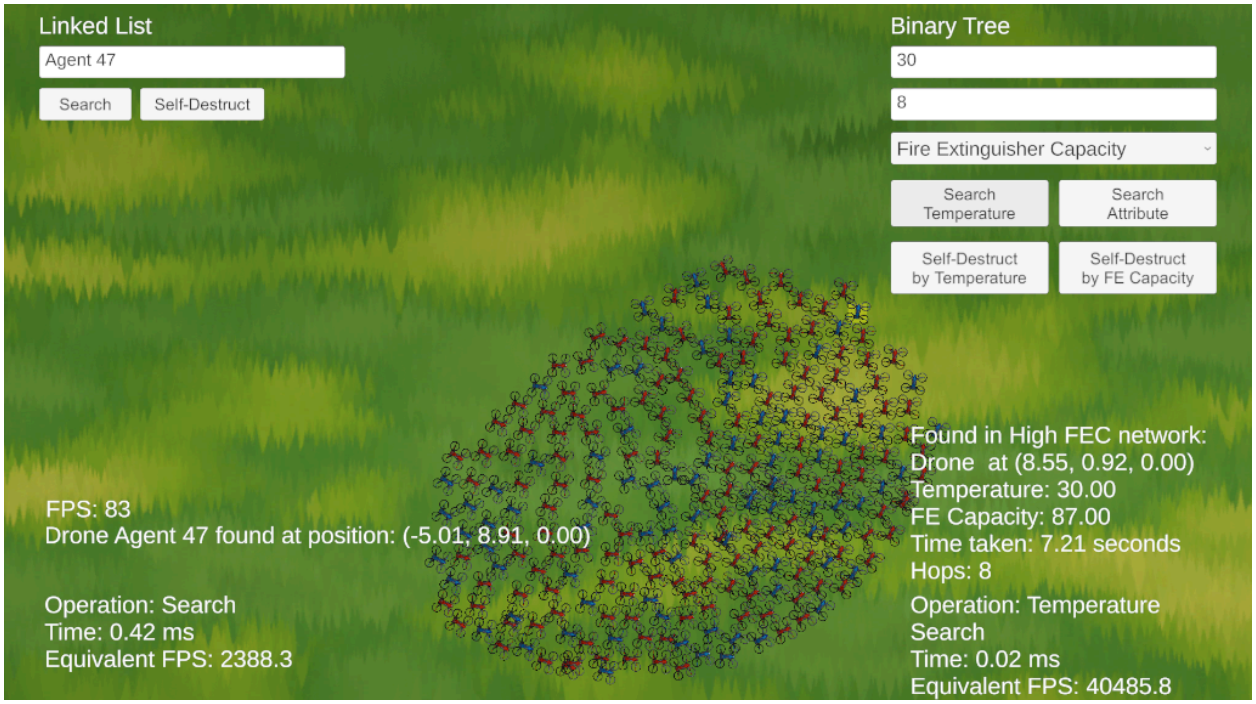
Running this drone swarm simulation on the Legion S7, equipped with an AMD Ryzen 9 5900HX processor, Radeon Graphics, 32 GB of RAM, and running Windows 11, demonstrates significant efficiency and high frame rates. The simulation maintains an FPS above 80 in most scenarios, reaching up to 101 FPS, suggesting that the Legion S7 is handling the computational load effectively. The equivalent FPS for search operations in the Binary Tree reaches up to 40485.8 when searching by temperature, indicating optimized performance for quick search results.

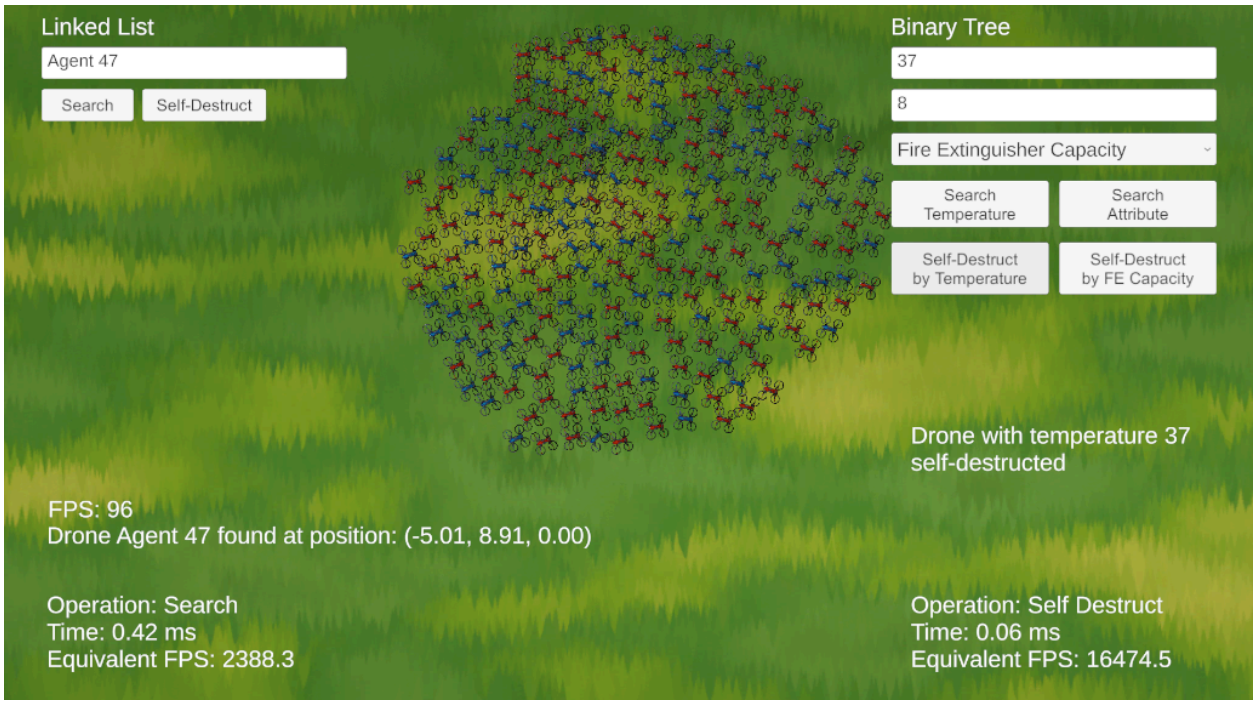
Linked List operations, like finding or terminating drones, consistently demonstrate low operation times (around 0.42 ms), showcasing the linear data structure's speed in accessing elements. However, Binary Tree operations vary depending on hops taken. For example, a high-FEC network search by temperature completes in 0.02 ms, while a low-FEC network attribute search takes 0.09 ms but incurs 24 hops, highlighting the impact of data structure and network complexity on performance.The Radeon Graphics GPU maintains high FPS under heavy graphical loads, showing that this GPU can handle extensive visual details in real time. Overall, the Legion S7's hardware specifications are well-suited for running and visualizing complex drone simulations with minimal performance degradation.

2.4 Screenshot(s)



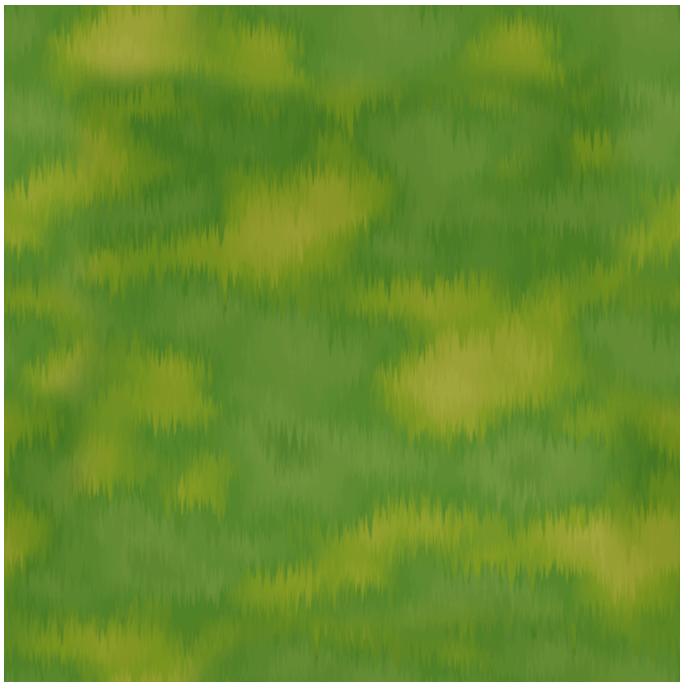



Linked List
Agent 47
Search
Self-Destruct
Binary Tree
30
8
Fire Extinguisher Capacity
Search Temperature
Search Attribute
Self-Destruct by Temperature
Self-Destruct by FE Capacity
FPS: 83
Drone Agent 47 found at position: (-5.01, 8.91, 0.00)
Operation: Search
Time: 0.42 ms
Equivalent FPS: 2388.3
Found in High FEC network:
Drone at (8.55, 0.92, 0.00)
Temperature: 30.00
FE Capacity: 87.00
Time taken: 7.21 seconds
Hops: 8
Operation: Temperature Search
Time: 0.02 ms
Equivalent FPS: 40485.8

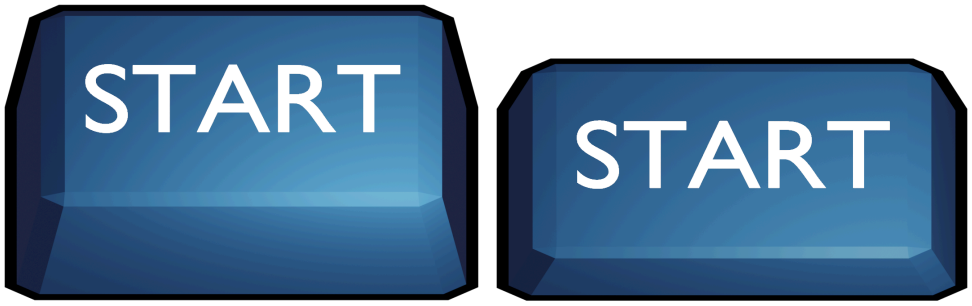

Linked List
Agent 47
Search
Self-Destruct
Binary Tree
37
8
Fire Extinguisher Capacity
Search Temperature
Search Attribute
Self-Destruct by Temperature
Self-Destruct by FE Capacity
FPS: 96
Drone Agent 47 found at position: (-5.01, 8.91, 0.00)
Operation: Search
Time: 0.42 ms
Equivalent FPS: 2388.3
Drone with temperature 37 self-destructed
Operation: Self Destruct
Time: 0.06 ms
Equivalent FPS: 16474.5

2.5 Asset Images

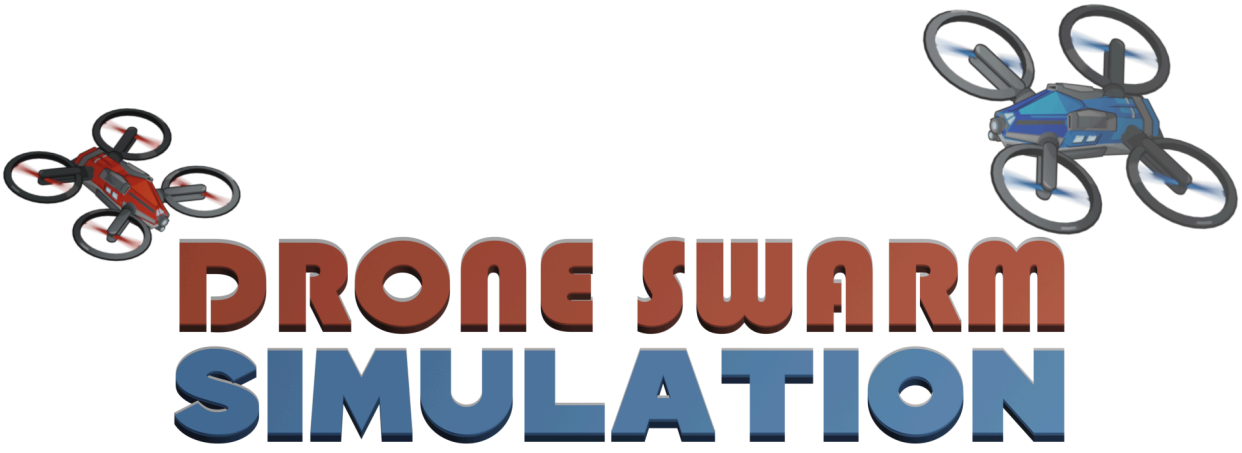
Drone Models (Isometric and Top/Plan View)



Background (Seamless Stylised Grass Texture)



Start Button (Unpressed and Pressed)



Title