# T14: MPI Implementation of Diffusion-Limited Aggregation (DLA) for Procedural Generation of Resources

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## 1 Introduction

MPI implementation of a variation of Diffusion-Limited Aggregation (DLA) simulation for procedural resource generation. The simulation models the behavior of particles (walkers) moving randomly on a grid and aggregating to form clusters, where each cluster indicates a particular type of resource (red and blue in our environment, including purple depending on requirements). Implementation is run on WSL.

## 2 Performance Comparison

### 2.1 Serial Implementation

- **Execution Time**: 21.4311 seconds

### 2.2 MPI Implementation

- **Execution Time (2 processes)**: 29.3078 seconds

- **Execution Time (3 processes)**: 20.8180 seconds

- **Execution Time (4 processes)**: 25.5186 seconds

### 2.3 Speedup

The speedup is calculated as the ratio of the serial execution time to the parallel execution time:

$$\text{Speedup}_{3 \text{ proc}} = \frac{\text{Serial Time}}{\text{Parallel Time}} = \frac{21.4311}{20.8180} \approx 1.0295$$

## 2.4 Parallelization Factor

Using Amdahl's Law:

$$\text{Parallelization Fraction} = \frac{P \cdot (1 - \frac{1}{S})}{P - 1}$$

where $P = 3$ and $S = 1.0295$, we get:

$$\text{Parallelization Fraction} \approx \frac{3 \cdot (1 - \frac{1}{1.0295})}{3 - 1} \approx 0.0426$$

This low parallelization fraction suggests that the current implementation has limited performance gain from parallelism, potentially due to communication overhead, load imbalance, or insufficient parallel work.
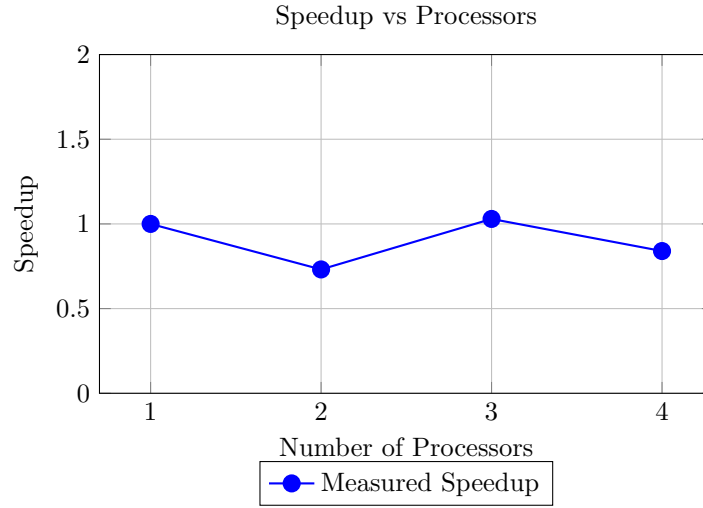
# 3 Speedup vs Number of Processors



Figure 1: Measured Speedup vs Number of MPI Processes

# 4 Generated Grid Images

The following figures represent the generated diffusion-limited aggregation (DLA) grids for different numbers of MPI processes:
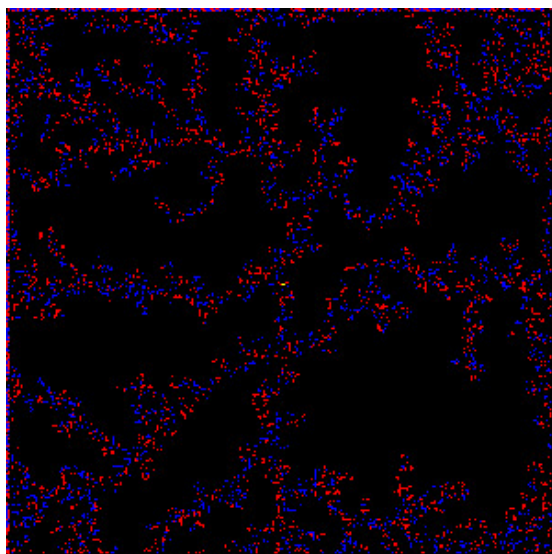
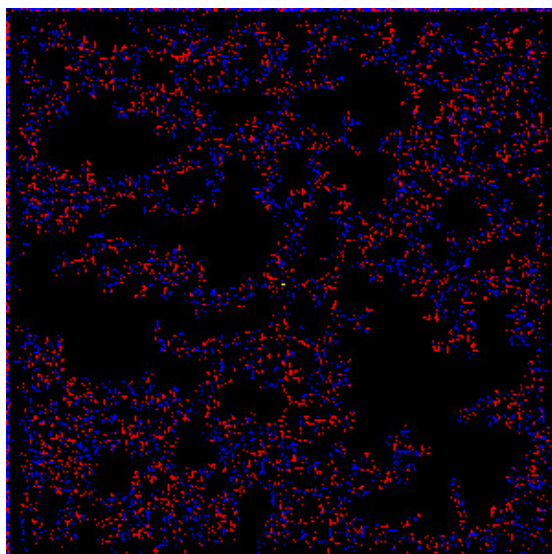Figure 2: Generated grid with 1 process
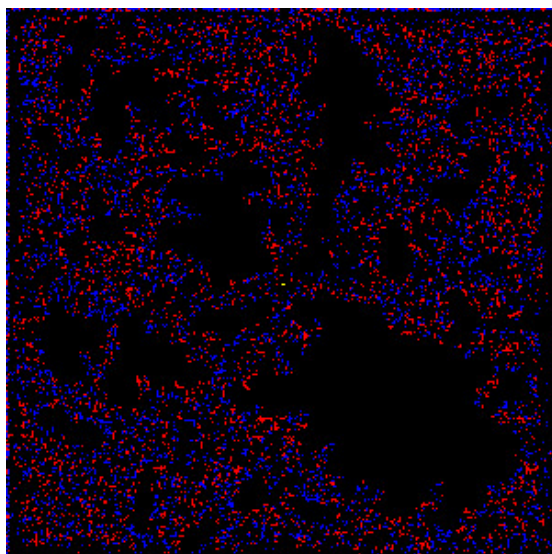


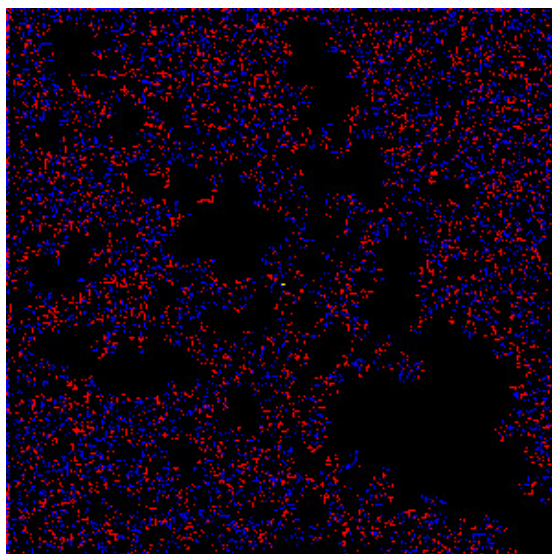Figure 3: Generated grid with 2 processes

Figure 4: Generated grid with 3 processes



Figure 5: Generated grid with 4 processes