# Scalable Multi-Agent Pathfinding in Large Environments

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## Introduction

Multi-agent pathfinding (MAPF) involves navigating multiple agents through a shared space without collisions. Solving MAPF optimally is computationally expensive, especially at scale. With applications in areas like warehouse automation and drone coordination, there is a growing need for efficient, scalable solutions.

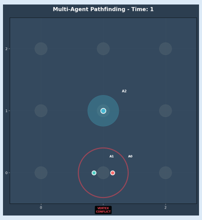
## Goal

Optimal solvers are only fast on small problem instances and are incredibly time-consuming on large maps. We aim to explore a different approach which will start with a sub-optimal algorithm and then call an optimal solver locally on smaller, problematic parts of the map.

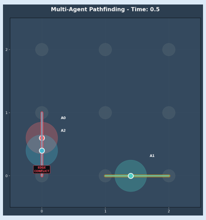
## Terminology

**Conflict**

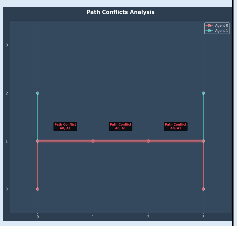
Multiple agents sharing an edge or vertex at the same timestep.




*Ex. Vertex Conflict*



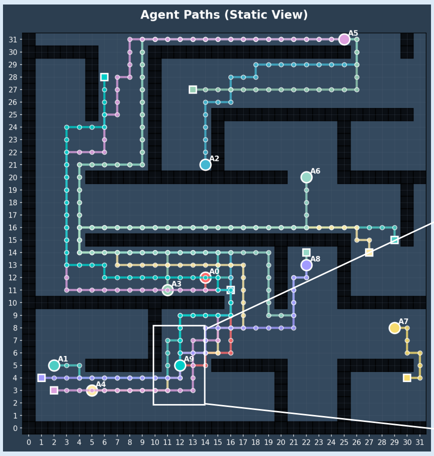

*Ex. Edge Conflict*




*Ex. Path Conflict*

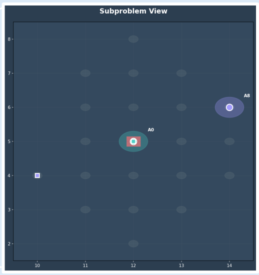
## Approach

Use a modified version of A* to naively find initial paths for all agents.

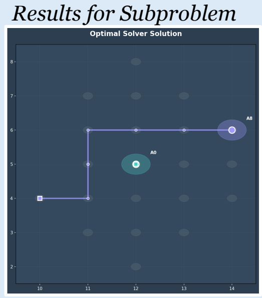



Then, iterate over conflicts in order of time of occurrence, isolate a small portion of the surrounding map, and use the optimal solver to solve it.

*Ex. Subproblem*




*Ex. Optimal Solver Results for Subproblem*



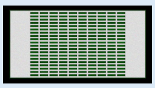

### Experiment Setup

Five different map types:

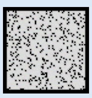
- Warehouse (170 x 84)
- Room (64 x 64)
- Random (64 x 64)
- Empty (48 x 48)
- City (256 x 256)

Five different agent counts:

- 100, 200, 300, 400, 500
- Random and even placements

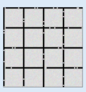


*Warehouse*



*Random*

*City*

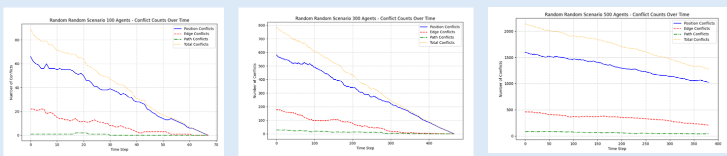


*Room*

*Empty*

## Results

We can see how the number of conflicts changes over the number of iterations. From the graphs we can deduce that the solver works well on the smaller agent counts while performance declines on larger counts, and ultimately times out for most of them.



*Graphs for Random map with random placements of 100, 300, and 500 agents*

**Conclusion**

Despite its simplicity, the hybrid solver effectively resolves a wide range of conflicts, even on challenging maps like the warehouse and city scenarios. While there are clear areas for improvement, the results suggest strong potential for practical use.

https://github.com/vpokludova/projects/tree/main/mapf_combined_solver

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