Multi-Agent Formation Control

For Implementation of Group Strategies

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Problem Formulation

Initial and Goal Positions in Multi-Robot System

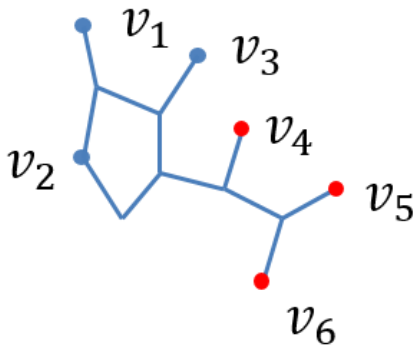
Agents move from initial to target nodes by travelling along edges in a connected graph.

Constraints:

- Optimize total distance travelled by all agents
- Avoid collision

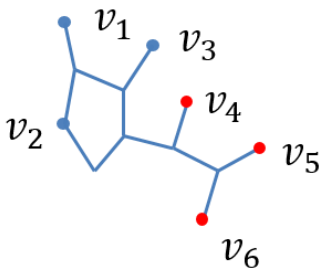
Allowances:

- Agents are indistinguishable - a given agent is allowed to be mapped to any goal node



Distance-Optimal Pairing

Perform a Breadth-First Search (BFS) to construct a distance matrix between each initial/goal node pair.



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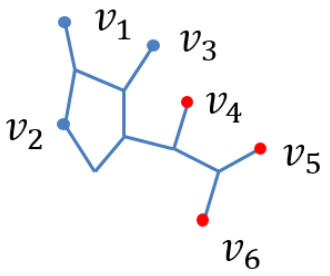
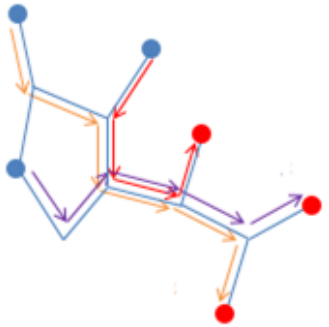


Perform Hungarian Algorithm to find optimal pairing

	v_4	v_5	v_6
v_1	5	6	6
v_2	4	5	5
v_3	4	5	5

Path Planning

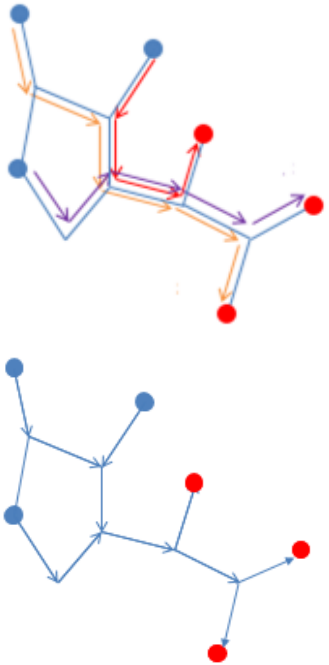
Creates a shortest- yet unscheduled- path set



Path Planning

Creates a shortest- yet unscheduled- path set

Path set induces a directed acyclic graph (DAG)



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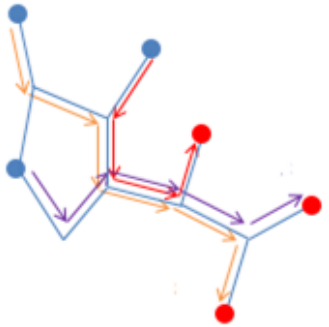

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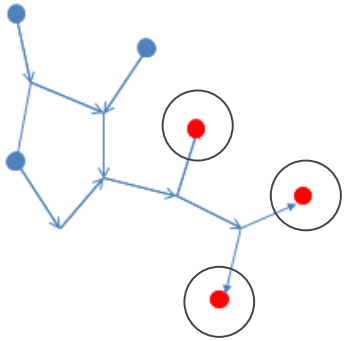
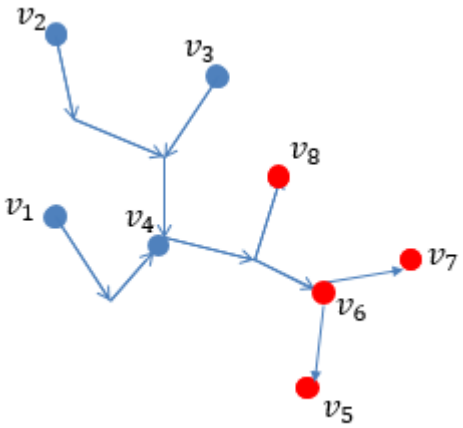


Identify **standalone** goal nodes- those goal nodes which lie in only one path.

Given priority in scheduling algorithm

Path Scheduling Process

Path Scheduling

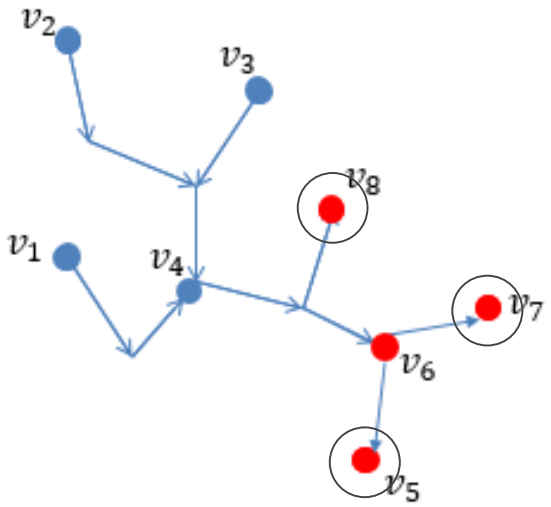


	v_5	v_6	v_7	v_8
v_1	5	4	5	4
v_2	6	5	6	5
v_3	5	4	5	4
v_4	3	2	3	2

Path Scheduling

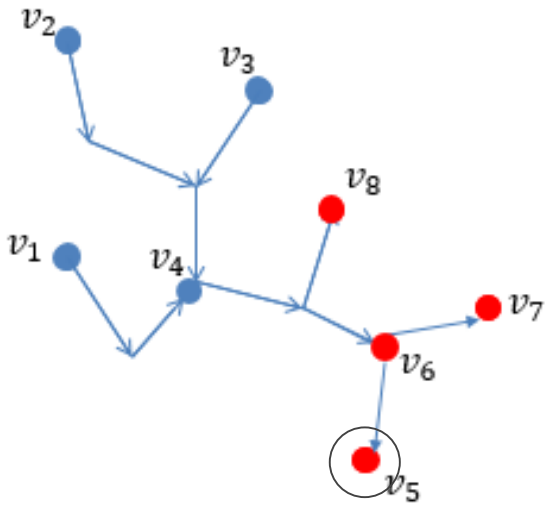
Identify standalone goal nodes

Standalones: {v_5, v_7, v_8}



Path Scheduling

WLOG, choose a standalone goal node to schedule an agent to.



Path Scheduling

Recall:

Hungarian Algorithm paired v_1 with v_5

	v_5	v_6	v_7	v_8
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v_2	6	5	6	5
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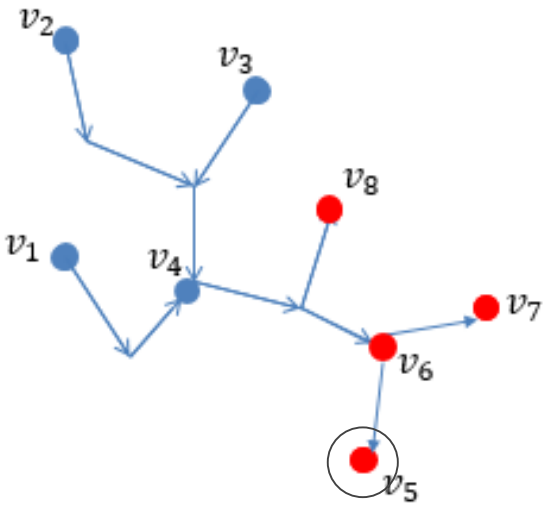
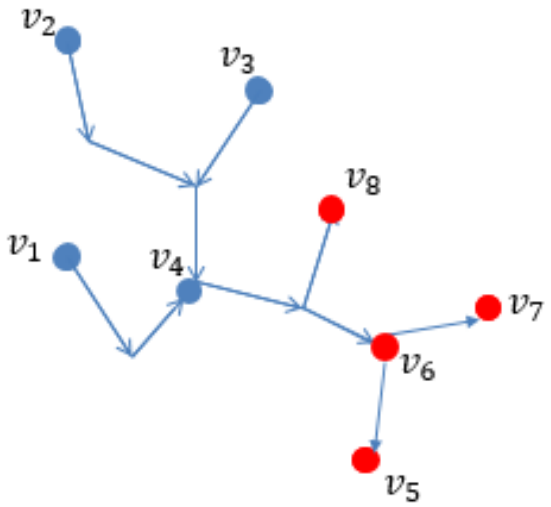


Path Scheduling

Perform “reverse” BFS on directed edges until first initial node is found.



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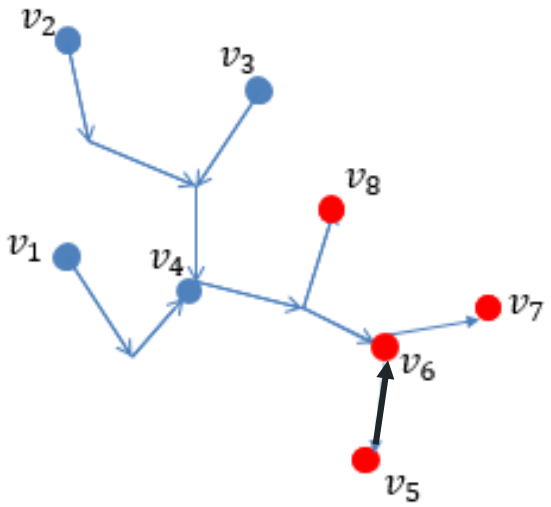

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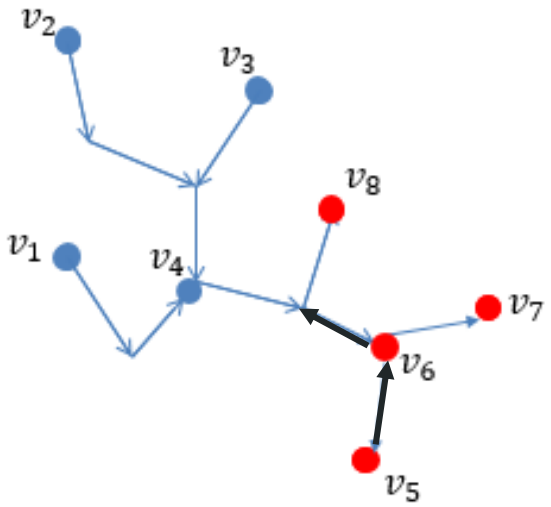

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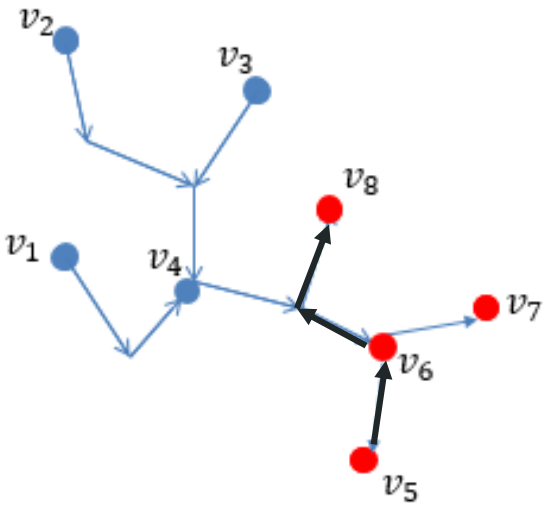
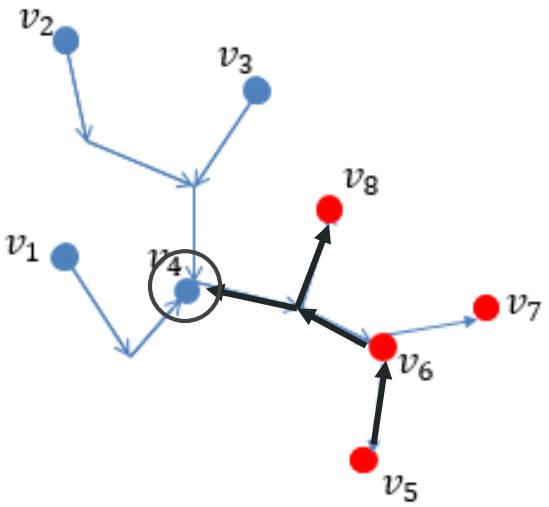


Path Scheduling

Perform “reverse” BFS on directed edges until first initial node is found.

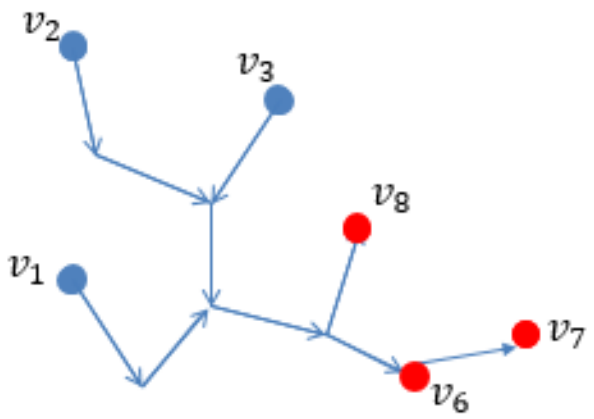
Agent present at v_4 is then assigned to move to v_5 and given start time t = 0



Path Scheduling

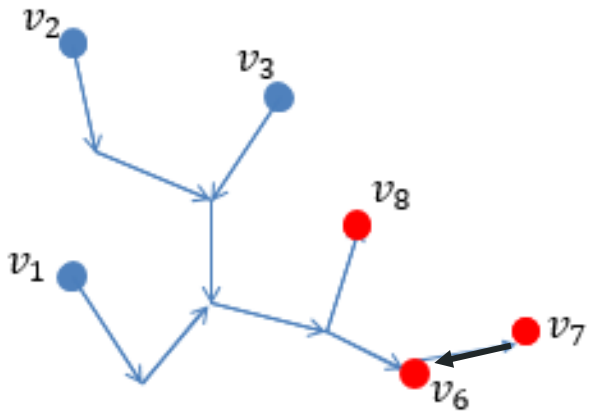
Prune the DAG so that the previously scheduled initial and goal nodes are now ignored.

Updated set of standalone goal nodes: $\{v_7, v_8\}$



Path Scheduling

Let’s do it again!



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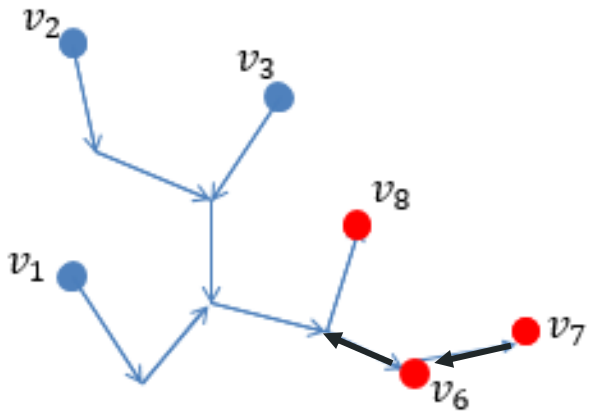

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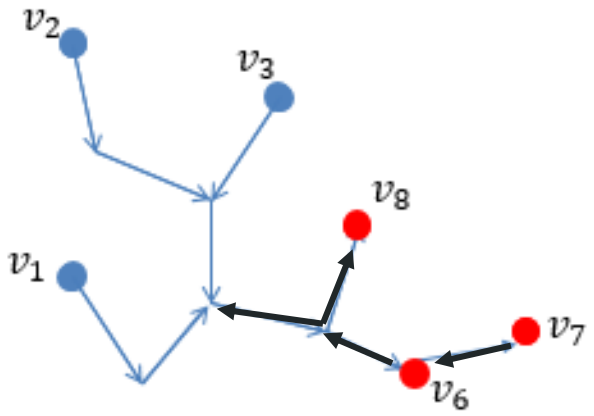

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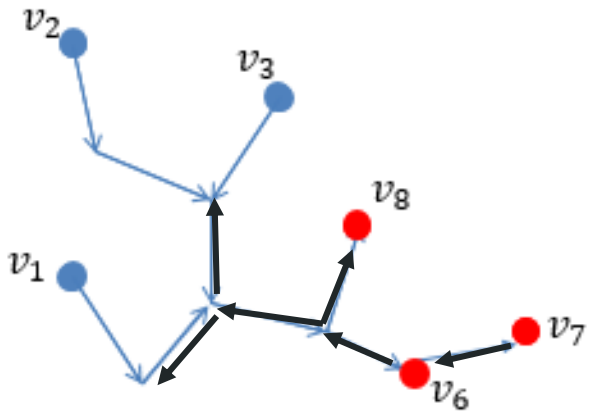
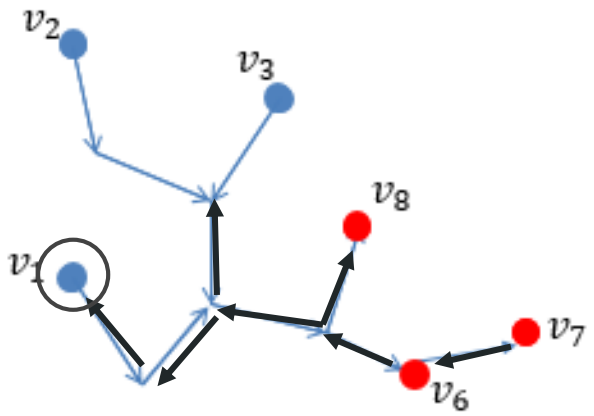


Path Scheduling

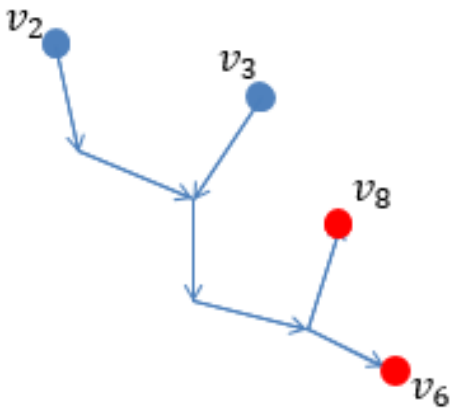
Let’s do it again!

Agent at v_1 moves to v_7 and is assigned start time t = 1

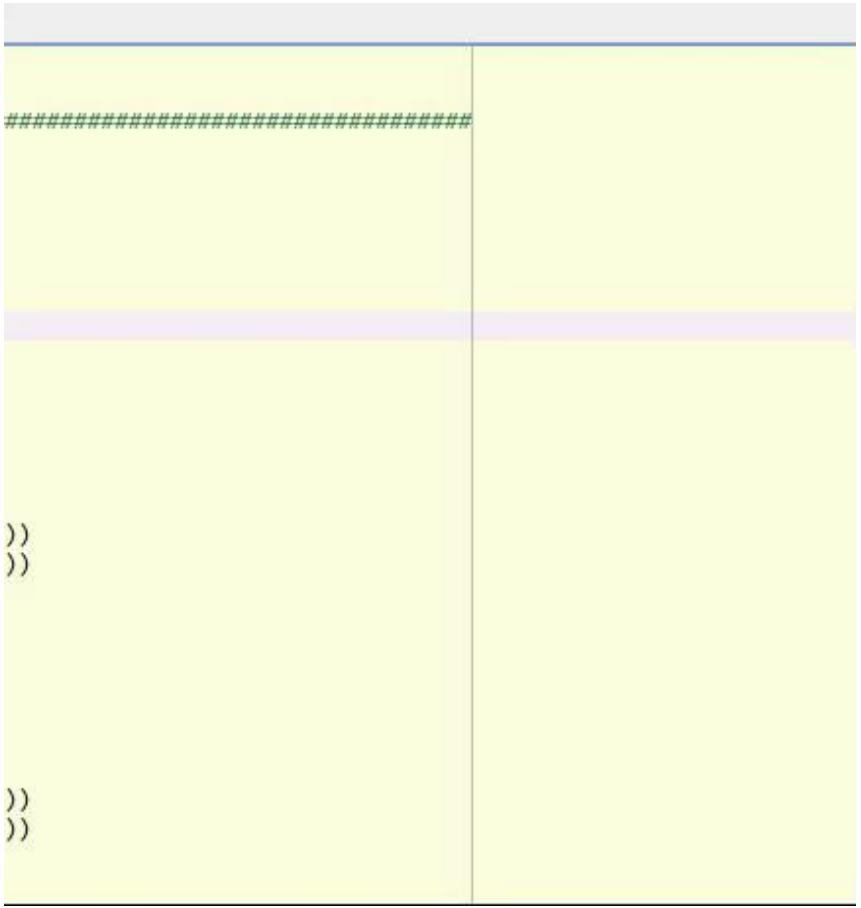


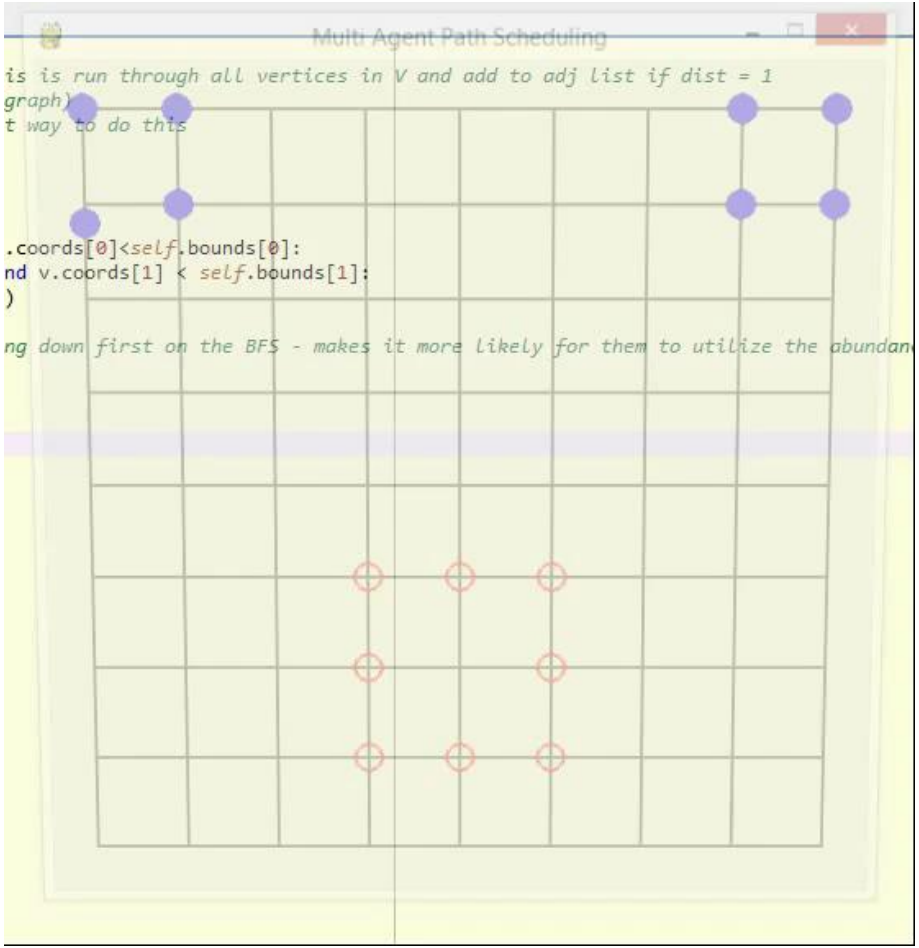
Path Scheduling

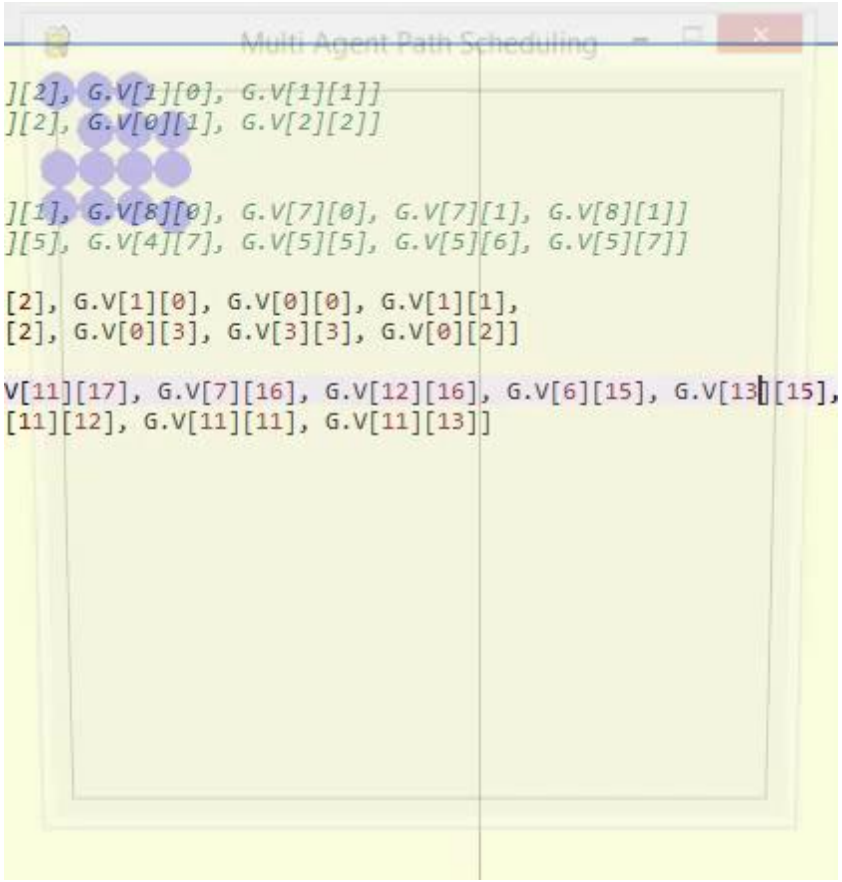
Updated standalone goal nodes: {v_6, v_8}



Simulations



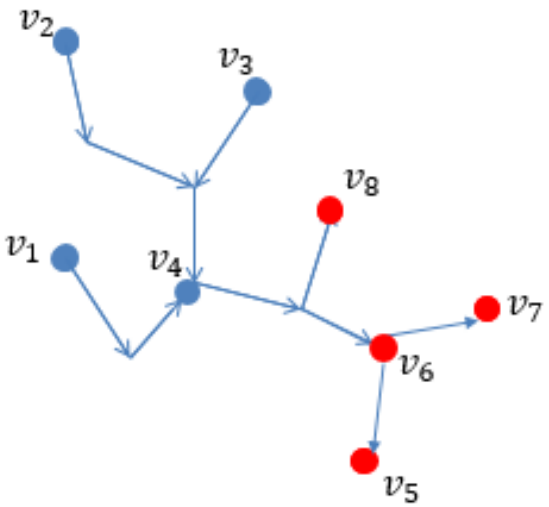

Multi-Agent Path Scheduling
is is run through all vertices in V and add to adj list if dist = 1
graph)
t way to do this
.coords[0]<self.bounds[0]:
nd v.coords[1] < self.bounds[1]:
)
ng down first on the BFS - makes it more likely for them to utilize the abundan


Multi Agent Path Scheduling
][2], G.V[1][0], G.V[1][1]]
][2], G.V[0][1], G.V[2][2]]
][1], G.V[8][0], G.V[7][0], G.V[7][1], G.V[8][1]]
][5], G.V[4][7], G.V[5][5], G.V[5][6], G.V[5][7]]
[2], G.V[1][0], G.V[0][0], G.V[1][1],
[2], G.V[0][3], G.V[3][3], G.V[0][2]]
V[11][17], G.V[7][16], G.V[12][16], G.V[6][15], G.V[13][15],
[11][12], G.V[11][11], G.V[11][13]]

Room for Improvement

Current Issues

- It is not necessary to assign each agent a different start time.



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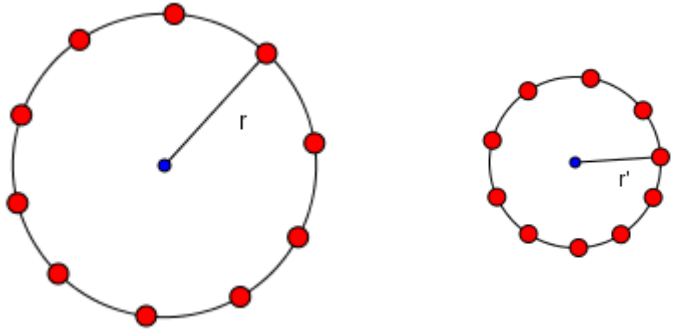
- Some randomly generated initial and goal formations break my algorithm for pruning the DAG.
    - But- I have some ideas :)

Next Step: Group Strategies

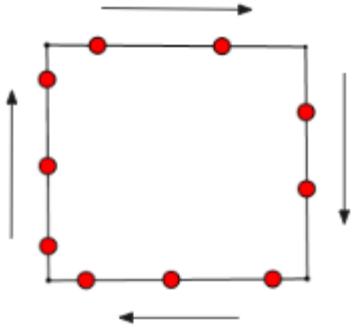
- Surround and close-in on a target



Next Step: Group Strategies

- Surround and close-in on a target

- Patrol a perimeter



Motivation

With enough data generated from implementation of specific tasks, we may train an autonomous model.

References & Acknowledgements

Special thanks to:

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National Science Foundation, funding provided through grant ISS-1734419

Reference:

Yu, J., & LaValle, S.M. (2012). Distance Optimal Formation Control on Graphs with a Tight Convergence Time Guarantee, presented at 51st IEEE Conference on Decision and Control, Maui, HA, December 10-13.