Civilian Evacuation Route Planning Coordinated Emergency Response

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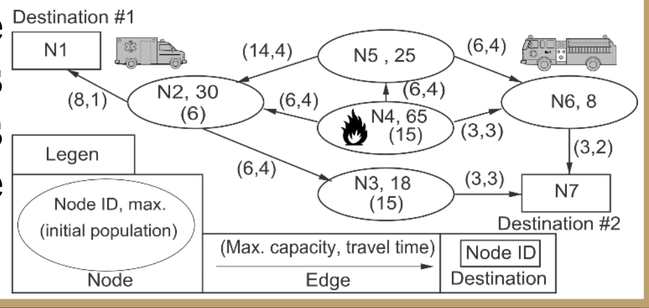
Introduction

Evacuation Route Planning has grown in complexity due to the increasing impact of natural disasters and threats to modern infrastructure. Large scale handcrafted ERPs are becoming nearly infeasible, but with the help of Artificial Intelligence we wish to improve evacuation plans and response times to better mitigate catastrophes.



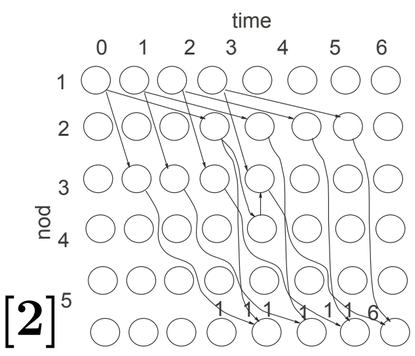
Related Work

[1] Network flow: O(nT logT+mT)
Using Time Expanded Graphs

[2] Simulation methods: Require Estimates
Model each agent and agent interactions

[3] Heuristic methods: O(np logn)
Using quick and dirty time-aggregated graphs such as in Capacity Constrained Route Planning (CCRP)

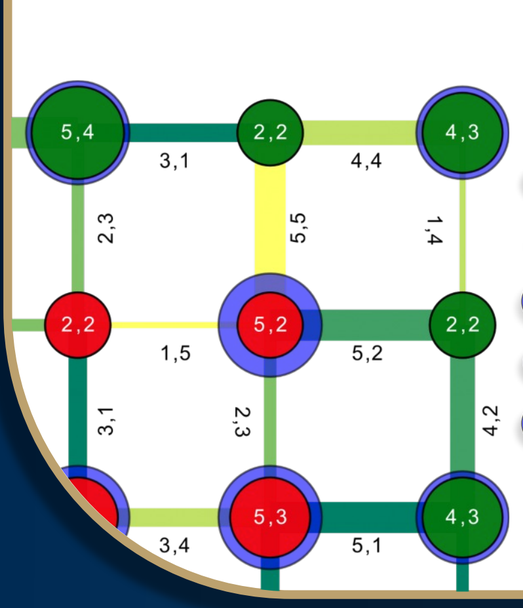
Where n: number of nodes
m: number of edges,
p: number of evacuees,
T: number of time-instants

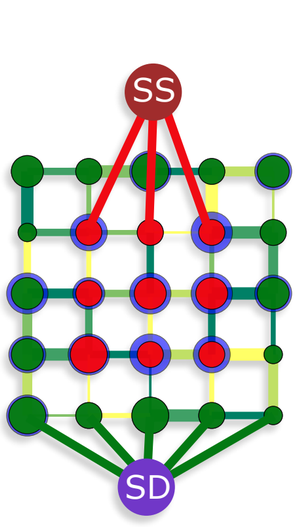


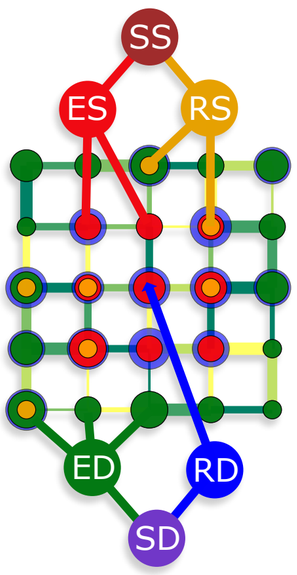
[2]

Approach

1. Capacity Constrained Network
2. Add multiple parties with separate goals and objectives
3. Overhaul population and reservation bookkeeping
4. Overhaul Dijkstra s algorithm for Multi-Party-CCRP search
5. Verify all new solution plans adhere to capacity constraints

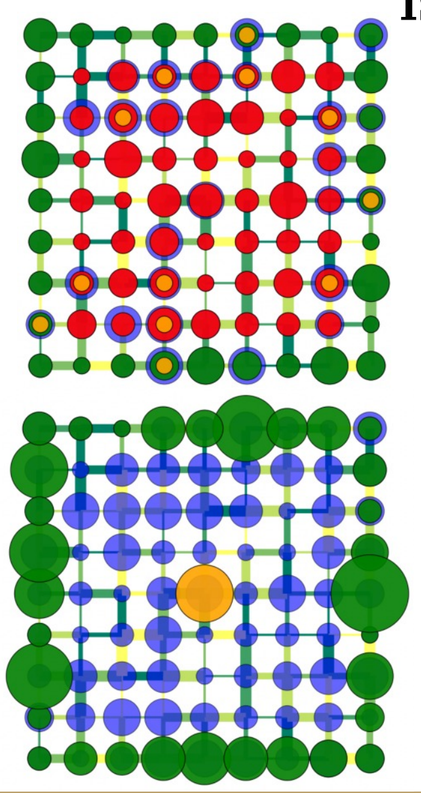


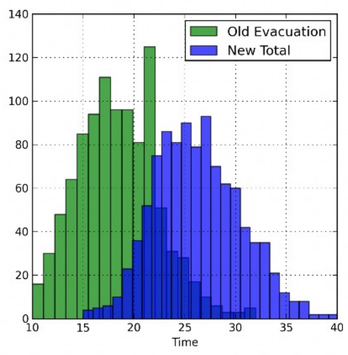


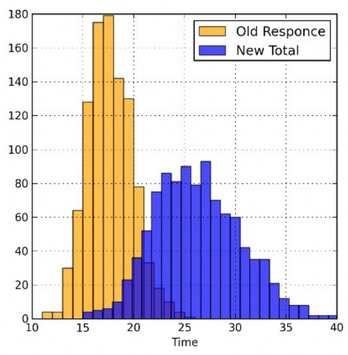


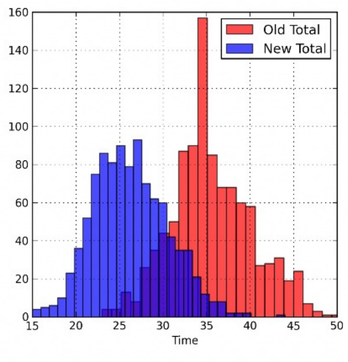
Results

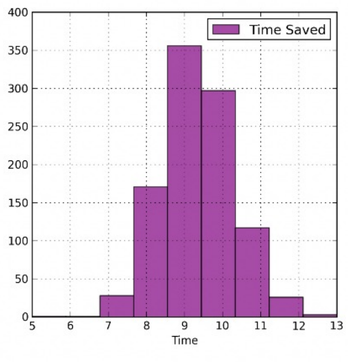
- Old CCRP vs New MPCCRP
- 1000 randomized 9x9 networks
- CCRP applied consecutively
- MPCCRP parallelizes parties
- Trial by trial time MPCCRP saves is shown in purple











Conclusion

Pros: MPCCRP provides better total completion times for multiple parties yet shares the original CCRP's simplicity.

Cons: Still suffers from the same sub-optimality of CCRP, as the plan is not guaranteed to be the quickest possible.

Future: Examination on N number of party interactions and route planning times. Apply weighted priorities to better address the non-uniform urgency of evacuations.

	Mean	Std Dev	Min	Max
Evacuation Old	18.408	3.910	10	32
Response Old	17.168	2.223	11	26
Total Old	35.576	4.722	23	56
Total New	26.189	4.421	15	44
Time Saved	9.3870	1.098	5	13

References

[1] S. Shekhar, K. Yang, V. M. Gunturi, L. Manikonda, D. Oliver, X. Zhou, B. George, S. Kim, J. M. Wolff, and Q. Lu, "Experiences with evacuation route planning algorithms, "International Journal of Geographical Information Science, vol. 26, no. 12, pp. 2253–2265, Dec. 2012.

[2] F. Itwm, "Mathematical Modelling of Evacuation Problems : A State of Art," vol. 24, no. 24, 2001.

[3] B. George and S. Shekhar, "Time-Aggregated Graphs for Modeling," pp. 85–99, 2006.