Civilian Evacuation and Route Planning Coordinated with Emergency Response

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***Abstract*—Evacuation Route Planning (ERP) has grown ever more imperative due to the increasing impact of natural disasters on modern infrastructure and due to threats of terrorism. To meet these and similar large-scale situations such as nuclear disasters, ERP tasks are becoming more complex. Other complicating elements include increasing population densities, larger structures within urban environments served by multifaceted transportation networks. Because of the multitude of factors, all driving the problem toward greater scales, the ability to handcraft ideal ERPs has become nearly infeasible. This has led emergency planners to turn to artificial intelligence and algorithms to quickly generate optimal paths for large-scale civilian evacuations under multiple scenarios. The authors propose extending the method of Capacity Constrained Route Planning (CCRP) [1] to include optimal paths for incoming emergency responders as well as for evacuees.**

Keywords*—*Evacuation Route Planning, Emergency Response, Artificial Intelligence, Multi Agent System.

I. Related Work

RECENT work within ERP falls into three methods: network flow methods, simulation methods and heuristic methods [1]. Network flow methods consist of minimizing total evacuation time under constraints through time expanded graphs (TEG) or using iterative algorithms optimizing cost functions [2]. Simulation methods focus on individual movements to such a labor-intensive extent that the effort attenuates into the game of "herding cats." Heuristic methods have proved recently to be most promising, including CCRP, which uses quick and dirty time-aggregated graphs with the capacity constraints to rapidly and repetitively identify workable routes [3].

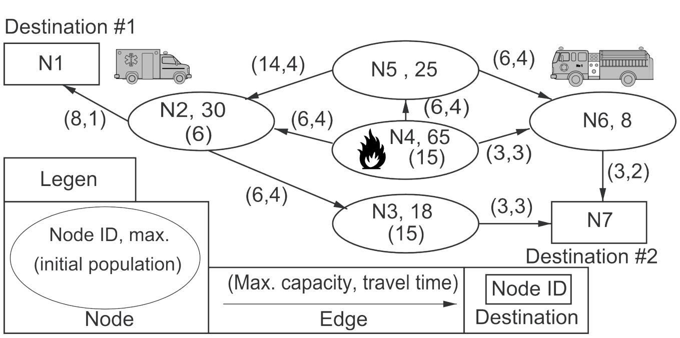

Fig. 1. ERP problem: Network Model for simple ERP scenario. (Adapted from S. Shekhar et al [1])

II. Implementation Description

The authors of this paper propose that ERP algorithms such as CCRP should also include optimal paths for incoming emergency responders as well as outgoing escape routes for evacuees. As crucial as it can be to distance a population from danger, it can also be crucial to rescue incapacitated victims, mitigate loss of other resources and preempt further escalation of disorder. An improved algorithm is proposed to add a constraint differentiating evacuees and responders into separate parties with separate objectives moving over common transportation networks. The authors propose to design a simulation, with this added constraint and evaluate the algorithm given different random evacuation times and measure results to see the effect on evacuation time and the feasibility of solving both the problem of response and evacuation simultaneously.

III. Evaluation

For evaluating the algorithms performance, random evacuation zones are generated within an invariable graph representing the transportation grid. Each emergency simulation will continue until evacuation is complete and the responders reach the disasters perimeter. Simulations will be repeated and results tabulated. The important metrics to be compared are evacuation time to reach safety, response time to reach the disaster perimeter, and total time to complete both tasks [1]. To account for various population densities, the population of the invariant graph could be non-uniform. The evacuation time will then be compared to the original CCRP algorithm outputs for the same graph. The authors theorize that this algorithm will help improve disaster response by avoiding collisions or bottlenecks between incoming responders and outgoing evacuees but may suffer slightly in evacuation time due to counter-flow of response teams.

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. [Online]. Available: http://www.tandfonline.com/doi/abs/10.1080/13658816.2012.719624

[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.