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RESEARCH SERVICES

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TECHNICAL SUMMARY

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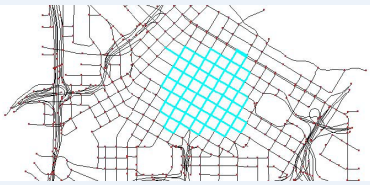
PROJECT COST:

$150,000



This screen shot from the evacuation software tool shows how the extent of the user-specified disaster area is highlighted after the user enters the desired radius.

Responding to the Unexpected: Development of a Dynamic Data-Driven Model for Effective Evacuation

Researchers developed an evacuation software tool for small-scale, no-notice evacuations that determines evacuee departure rates, time schedules, shortest paths and critical intersections for police officer deployment. The tool provides substantially improved network clearance times.

What Was the Need?

By their very nature, no-notice emergency events such as chemical spills and unanticipated structural failures are unexpected and unpredictable. Predetermined evacuation scenarios may not apply given a no-notice emergency's unique set of circumstances, when things can change quickly and driver behavior is difficult to predict. To address this dilemma, emergency managers need a tool that manages evacuation traffic efficiently in real time—in just seconds to only a few minutes—and allows for adjustments as facts on the ground change.

What Was Our Goal?

The objective of this research is to develop a decision-support tool for smaller-scale emergency evacuation traffic management, with the primary objective of minimizing the total system travel time. The tool will be used to develop models for evacuee routing calculations and optimal intersection control through the placement of limited numbers of police officers to guide traffic at critical network locations.

What Did We Do?

Researchers developed algorithms and software along with a user's guide to create a framework with three components:

- A prescriptive model that represents the desired response of traffic under evacuation. This model creates only short-term traffic forecasting of a few minutes, with a rolling time horizon.
- A descriptive, real-world model that describes, in a short-term fashion, the real-world traffic flow pattern under evacuation as accurately as possible.
- An adaptive control system that integrates output from the prescriptive model—the desired state of traffic—and the current prevailing traffic conditions described by the descriptive model to generate a traffic control strategy for evacuation.

What Did We Learn?

The adaptive control system developed is a heuristic algorithm for staged traffic evacuation, or HASTE, that determines evacuee departure rates, time schedules and dynamic shortest paths. The basic idea in HASTE is that through departure rate control, travelers will use the same facilities at different times to avoid delay. HASTE keeps the problem size relatively small and results in faster computation than is seen with other traffic assignment models. A preincident calculation component creates efficient transportation subnetworks to simplify shortest-path search operations.

The evacuation software developed to test HASTE includes a geographic information systems-based traffic network for a one-mile radius network of downtown Minneapolis, with signal timing parameters based on different settings for different times of day in-

continued

"Our testing demonstrated that HASTE evacuation routing solutions provide substantial improvement in network clearance times when compared to an all-or-nothing assignment. All routing computations were completed within two minutes, illustrating the efficiency of HASTE."

–Henry Liu,
University of Minnesota
Department of Civil Engineering

"The evacuation software tool is designed to address smaller-scale evacuations. Emergency managers can use the tool to place officers at critical intersections and identify locations for detour signs to implement contraflow traffic."

–Ernest Lloyd,
Director, Financial & Support Services, Mn/DOT Office of Maintenance

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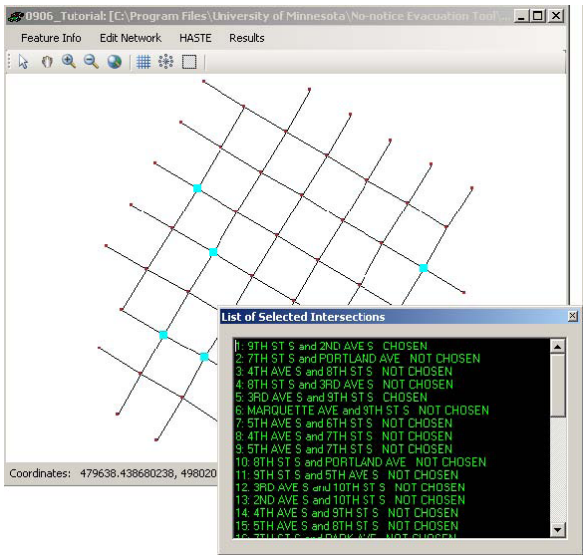

In this screen shot from the evacuation software tool, the signalized intersections selected for officer deployment are highlighted on the map. A list of all network signalized intersections identified as "CHOSEN" and "NOT CHOSEN" appears in the "List of Selected Intersections" window.

tegrated into the model. Users enter data or make selections in the software that reflect the emergency scenario by selecting the affected area from the base map; editing the scenario network to represent lane drops and minimize the use of certain roads as part of the evacuation strategy; entering network demands with estimated numbers of vehicles to reflect evacuee concentration points in the network; identifying the network destinations—or boundaries—that constitute safe zones in the evacuation model; and selecting a signal timing period, as different times of the day are associated with different signal timing plans.

The software combines vehicle routing with a determination of critical intersections to which a limited number of police officers can be deployed; signal timing optimization was left for future research. Users may have more intersection candidates than the available number of officers, so HASTE tackles the problem of finding the best combination of intersections and officers.

All routing and officer deployment results of the evacuation software are saved as text files. A departure schedule includes a route index and the number of evacuees assigned to each route. A second text file provides a list of paths, with the total number of evacuees assigned to each path. Some results are displayed graphically.

Using a hypothetical evacuation scenario, researchers found that the software tool is capable of producing results in less than one minute compared to traditional procedures using commercial linear programming solvers that required nearly four hours. When comparing network clearance times of traffic assignment scenarios, clearance times ranged from 248 minutes and 15 seconds for an all-or-nothing traffic assignment where all evacuees use the shortest path to safety, to 102 minutes and 15 seconds using HASTE with no officers, to 68 minutes using HASTE optimized with 20 officers. The results indicate that HASTE provides substantially improved network clearance times.

What's Next?

Mn/DOT will provide the evacuation software tool and its accompanying user's guide to emergency managers in the seven-county Twin Cities metropolitan area for additional testing of evacuation scenarios and future application. Since the system addresses small-scale evacuations, it may be further developed for city and county use with the support of the Local Road Research Board.

This Technical Summary pertains to Report 2009-36, "Responding to the Unexpected: Development of a Dynamic Data-Driven Model for Effective Evacuation," published December 2009. The full report can be accessed at http://www.lrrb.org/PDF/200936.pdf.