Reliable Traffic Routing and Scheduling During Evacuation

Mukesh Rungta and Gino J. Lim
Department of Industrial Engineering
University of Houston, Houston, TX, 77204-4003
Tel: (713)743-7010 Email Address: mkrungta@uh.edu

Abstract In this study traffic routing and scheduling during hurricane evacuation is envisioned for scenarios when the underlying traffic parameters are not deterministic. A comparison is made for the clearance time obtained using the deterministic and stochastic scenario respectively. The evacuation plan proposed is more robust as compared to the one obtained assuming deterministic information.

1. Introduction

Large scale evacuations are important in the wake of natural disasters such as Hurricane. Planning to evacuate people towards safe areas and effective management of the plan using the limited set of resources is an integral part of disaster management. Effective implementation of an evacuation plan in the wake of a limited set of resources demands that a minimum number of paths are selected for loading the evacuation traffic. Also, traffic scenario is often non-deterministic and assumption of a deterministic capacity for the road links would result in poor quality evacuation plan in terms of paths and time required for evacuation. Apart from the random arc capacity, other uncertain parameters during an evacuation event are the transit time on the arcs and the number of people evacuating the region. This complex problem of evacuation traffic routing and scheduling is often addressed within mathematical optimization framework. We use mathematical models to come up with an evacuation plan for both deterministic and stochastic scenarios.

2. Objective

The objective of this study is to find a reliable evacuation plan by selecting paths and flows that results in minimum congestion probability for the given network within a given evacuation time.

3. Analyses

The transportation infrastructure of Houston area is represented using a network graph where nodes and arcs represent respectively, the major intersections and the corresponding road links between them. Mathematical formulation of the resulting routing and scheduling problem is done within a network optimization framework to find the clearance time and the minimum number of evacuation paths. Separate formulations were done for both deterministic and stochastic scenarios. For the deterministic case, the proposed model is a mixed integer linear programing model and formulation is done for *System Optimum (SO)* scenario where the emphasis is on complete network evacuation in minimum possible clearance time without any preset priority. For the stochastic model, only the uncertainty of the arc capacity is considered and the formulation of the resulting routing and scheduling problem is done within chance constrained programming framework. Experiments were conducted to find the minimum clearance time required to attain a desired confidence level ensuring free flow of traffic in the network. Results report the sensitivity of the congestion probability with respect to the evacuation time, minimum number of paths to be selected to achieve a desired reliability level, and the corresponding traffic flow on the selected paths.

4. Discussions

Considering the random arc capacity to be following the Weibull distribution, results for the clearance time for different reliability level for the stochastic model is shown in Figure 1. The clearance time considering deterministic model was found to be $T = 128$.

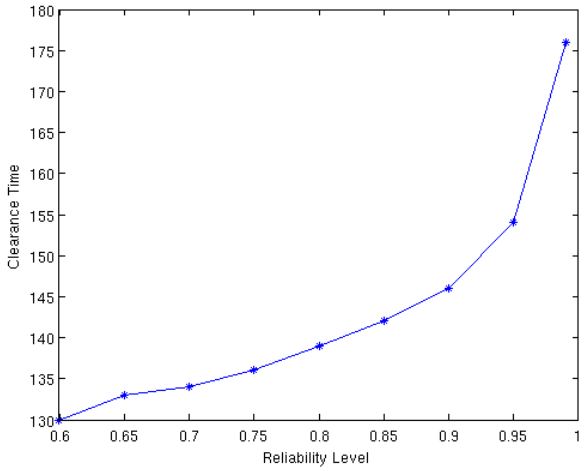

Figure 1: Clearance time for various values of reliability level

We also solve a model having an objective function for minimization of congestion probability with an added constraint of limiting the total number of paths to be used for evacuation to a value *N*. Solving the model for different values of *N*, we obtained the result as shown in Table 1.

Table 1: Congestion probability attainable for clearance time *T*

	Number of Paths (N)				
Clearance Time	20	21	22	23	24
130	0.468	0.468	0.468	0.468	0.467
135	0.322	0.322	0.321	0.321	0.317
140	0.209	0.208	0.208	0.207	0.200
145	0.144	0.144	0.144	0.143	0.141
150	0.091	0.089	0.089	0.087	0.087

5. Conclusions

It can be seen that a higher reliability level results in increasing of the clearance time. Also, increasing the evacuation paths do not significantly increase the reliability level for a given clearance time. By planning for a decreased capacity, the evacuation plan becomes more reliable in the sense that the probability of deviating from this plan due to degrading capacity of the road link gets smaller. This essentially shows that to ensure the desired reliability level, the network is loaded in a conservative manner so as to avoid future in-feasibility of the arc capacity constraint when the flow volume might exceed the capacity and result in congestion.

6. References

[1.] Rungta, M., Lim, G. J. and Baharanemati R. "*Optimal Egress Time Calculation and Path Generation for Large Evacuation Networks"*. IIE Annual Conference, Orlando, 2012.

[2.] Rungta, M., Lim, G. J. and Baharanemati R. "*Reliability Analysis of Evacuation Routes under Capacity Uncertainty of Road Links"*. Working paper.