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ABSTRACT {in approximately 800 words}:

RELIABLE LOCATION-ROUTING DESIGN UNDER DEMAND UNCERTAINTY

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Every year, occurrences of large-scale emergencies such as fires, earthquakes, and floods could cause severe casualties and enormous economic losses. One of the most effective ways to reduce these losses is to construct a disaster relief network and deliver emergency supplies to affected areas as soon as possible. This means the following problems should be solved

properly: 1) given existing established distribution centers, which center(s) to open after a disaster, since not all distribution centers are necessarily open considering open cost and the demand; 2) provided a set of vehicles, how to assign these vehicles to each open distribution center; 3) how to route the assigned vehicles to travel from distribution centers to demand points as soon as possible; and 4) how much goods to be delivered at each demand point on condition that the relief allocation plan is made before real demand are obtained.

This paper proposes an α-reliable mean-excess regret model for solving the emergency location routing problem (ELRP) under demand uncertainty in which α is a confidence level pre-determined by the decision maker. The novelty of this study is to consider the regrets caused by high-consequence scenarios via minimizing the α-reliable mean-excess regrets of waiting time and system cost simultaneously. Given a set of demand scenarios and their occurrence probability, the regret associated with one scenario under an ELRP solution is defined as the difference between the objective value given by the solution and that given by the ideal solution can be achieved in the same scenario; the α-reliable mean-excess regret values (i.e., waiting time and system cost) are defined by the expectation of the regrets with respect to the scenarios in the tail whose collective probability of occurrence is less than 1-α.

The problem is formulated as a bi-objective mixed integer nonlinear programming and solved by a hybrid genetic algorithm. First, two single objective mixed integer nonlinear models are developed and linearized to find the minimum waiting time and system cost for each scenario with deterministic demand. Afterwards, the deterministic model is extended to the stochastic model via the scenario-based optimization approach and two α-reliable mean-excess regrets are developed to measure the decision maker's regrets due to implementing a non-optimal solution in a realized scenario. In addition, to assist the decision maker to select a solution from the Pareto frontier, a trade-off function which captures the decision maker's risk preference is introduced to find the Nash bargaining solution. To solve the bi-objective α-reliable mean-excess regret model, a hybrid genetic algorithm is developed, which integrates CPLEX/genetic algorithm to solve the deterministic ELRP when the network size is small/large, a heuristic to compute the α-reliable mean-excess regret measures, the NSGA-II to find Pareto frontier of the bi-objective model for determining the Nash bargaining solution.

Numerical examples with different sizes are generated to test the proposed model and algorithm. Firstly, solutions to the deterministic ELRP model solved by CPLEX and genetic algorithm are compared. The results demonstrate that the proposed genetic algorithm could obtain the exact solution as CPLEX in a small size network in a much shorter time. It can be concluded that, when the objective is to minimize the total waiting time, more distribution centers and vehicles will be selected since a lower waiting time can be achieved if more vehicles could start from the distribution centers that are close to demand points simultaneously. In contrast, when the objective is to minimize the total system cost, fewer distribution centers and vehicles are selected mainly due to the high setup cost for distribution centers. Secondly, the proposed hybrid genetic algorithm is applied in a large network to demonstrate the performance of the solution method and the property of the proposed α-reliable mean-excess regret model. Then, sensitivity analysis of confidence level and risk preference are conducted to explore the effects of different parameters on the solution. Results show that: 1) each Pareto frontier changes in a stepwise manner due to the different numbers of selected distribution centers despite the value of confidence level α; 2) the Pareto frontier moves towards upper right with the increase in the value of α. This is because a small value of α means a less confidence on the worst regrets value exceeding the α-quantile

of the regrets, and vice versa. 3) Nash bargaining solution changes in a stepwise manner with different risk preference parameters.

Keywords: Emergency location routing problem, Demand uncertainty, α-reliable mean-excess regret, Genetic algorithm, Nash bargaining solution.

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