siouxfalls_network

Description This problem is based on the work by Ng [1]. The case study uses the Sioux Falls transportation network with designated origin and shelter nodes.

Model Formulation Let $G = (V, A)$ be the transportation network with node set V and arc set A. The Bureau of Public Roads (BPR) function defines arc travel times:

$$t_a(v_a) = t_a^0 \left(1 + \alpha_a \left(\frac{v_a}{c_a}\right)^{\beta_a}\right), \quad a \in A,$$

where t_a^0 is the free-flow travel time, c_a the capacity, and α_a, β_a calibration parameters.

Upper-level (Central Planner) The central authority assigns evacuees from origins $r \in R \subseteq V$ to shelters $s \in S \subseteq V$:

$$\min_{q_{rs}} \sum_{a \in A} v_a t_a(v_a)$$

subject to

$$\sum_{s \in S} q_{rs} = O_r, \quad \forall r \in R,$$

$$0 \le q_{rs} \le \overline{q}_{rs}, \quad \forall r \in R,\ s \in S,$$

where O_r is the population at origin r and $\overline{q}_{rs}$ the shelter capacity bound.

Lower-level (User Equilibrium Traffic Assignment) Given q_{rs}, evacuees choose shortest paths selfishly:

$$\min_{f_{rs}^k} \sum_{a \in A} \int_0^{v_a} t_a(x)\, dx$$

subject to

$$\sum_k f_{rs}^k = q_{rs}, \quad \forall r \in R,\ s \in S,$$

$$v_a = \sum_{r,s} \sum_k \delta_{ars}^k f_{rs}^k, \quad \forall a \in A,$$

$$f_{rs}^k \ge 0, \quad \forall r, s, k,$$

where f_{rs}^k is the flow of evacuees from origin r to shelter s on path k, and $\delta_{ars}^k = 1$ if arc a is on path k connecting (r, s) and 0 otherwise.

Data The Sioux Falls network has 24 nodes and 76 arcs. Origins are nodes 14, 15, 22, and 23 (with $O_r = 2000, 9000, 7000, 2000$). Shelters are nodes 4, 5, 6, 8, 9, 10, 11, 16, 17, and 18, with capacities 5000, 4000, 6000, 5000, 4000, 4000, 4000, 4000, 1000, 5000 respectively.

References

[1] ManWo Ng, Junsik Park, and S Travis Waller. A hybrid bilevel model for the optimal shelter assignment in emergency evacuations. *Computer-Aided Civil and Infrastructure Engineering*, 25(8):547–556, 2010.