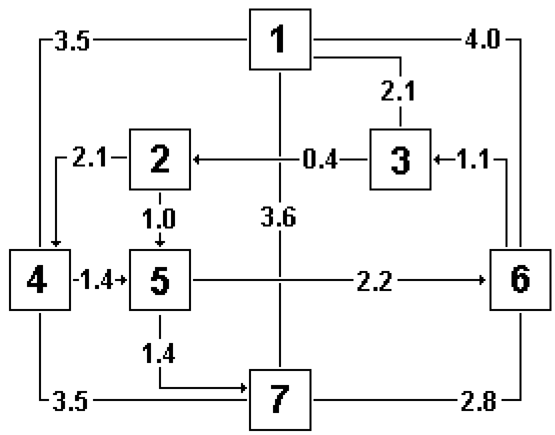
CEE 228a Urban Transportation Networks I Spring 2023
Project 1. Tromaville AGT Dr MG McNally

Project 1. Tromaville Automated Guideway Transit System

The Tromaville Automated Personal Rapid Transit (TAGPRT) system operates in downtown Tromaville with seven stations (nodes) and nineteen connecting links, as shown in the figure below. The length of each link (in miles) is shown on the link (labeled by its origin and its destination). Note that there are both one-way (arrows) and two-way links.



AM-peak Origin/Destination Demand (Person-trips/hour)

from\to	1	2	3	4	5	6	7	O(i)
1	0	20	30	5	20	5	20	100
2	0	0	0	5	10	0	5	20
3	7	5	0	0	3	0	5	20
4	10	0	20	0	15	5	20	70
5	0	0	0	0	0	5	5	10
6	3	25	20	0	2	0	20	70
7	0	10	20	15	0	25	0	70
D(j)	20	60	90	25	50	40	75	360

Assume a capacity of one person per vehicle. Inspection of the trip table indicates an imbalance in vehicle movements during the AM-peak, with generally more origins than destinations at nodes (stations) around the system perimeter, and more destinations than origins at the central nodes. This imbalance implies that empty vehicles will have to be shuttled in the system, since there are not enough vehicles to maintain a net outflow from any station for any extended period.

TAGPRT wants an optimal routing scheme for <u>empty vehicles</u> in the system during the AM-peak.

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1. Formulate the conceptual problem for the optimal distribution of empty vehicles. You should have your conceptual model approved by me prior to engaging in subsequent tasks (since you might have the wrong formulation).

2. *Compute* the <u>Shortest Paths</u> in the network. Be sure to consider one-way links. Assume that sufficient capacity exists for any routing plan:
   1.1 *Solve* using Dijkstra's Algorithm [one node by hand; *verify* all]
   1.2 *Solve* using Floyd's Algorithm [start by hand; may *finish* via software]
   1.3 *Discuss* the two algorithms and the results.Which is more efficient here?

3. *Formulate* this as a <u>Transportation Problem</u> for solution via a **Linear Program**:
   2.1 *Provide* the complete model specification and discuss.
   2.2 *Set up* the SIMPLEX Tableau; *solve* by hand if you've never done this before. *Solve* the problem using any software package. *Provide* all intermediate results.
   2.3 *Discuss* the optimal solution(s) and the associated sensitivity analysis.
   2.4 *Reformulate* the problem by specifying the **Dual**. *Discuss* this formulation relative to the sensitivity analyses and relative to potential solution algorithms.

4. *Formulate* this as a <u>Transportation Problem</u> for solution via Hitchcock's algorithm (HTA):
   4.1 *Produce* an initial feasible solution and solve (perform at least two iterations of the Transportation Algorithm by hand). *Verify* with LP2 or other software.
   4.2 *Produce* an initial feasible solution using an alternative rule.
   4.3 What assumptions are implied concerning the optimal allocation and the capacity of the system? *Discuss*.
   4.4 *Compare and discuss* the LP and HTA solution techniques.

Reformulate the TAGPRT *empty vehicle* routing problem to more accurately depict the role of independent links and their capacities (link-based). The representation of the problem according to the standard format of the <u>Transshipment Problem</u> (TP) resolves the capacity-related problems and allows for the extension of the problem to a multi-commodity transshipment problem, a stage which enables us to properly formulate the problem of network equilibrium assignment.

5. *Formulate* the problem as a standard <u>Transshipment Problem</u> (NOT an extended HTP).
   5.1 *Develop* the problem's system of equations. **Discuss** the problem as a linear program. *Draw and compare* the "network" for HTP and TP.
   5.2 *Solve* the LP-problem using any available software package.
   5.3 *Reformulate* the problem for an Out-of-Kilter solution. *Draw* the OKA network and **discuss** the process and the results. No need to solve.

6. The <u>Shortest Paths</u> in a network: Revisited. *Formulate* a **minimum path** problem using the basics of the transshipment problem. *Find* the LP solution.

7. D*iscuss* how would you approach the combined problems of distributing full vehicles (the original demand matrix) and the empty-vehicle matrix utilized above (do not solve).

You **SHOULD** work **alone** on Task 1 and 7; for tasks 2-6, you may work alone or with others. If you attempt all the problems you will receive full credit. Extra credit for particularly thoughtful submissions, but less if you do not make a valid effort.