CEE 123 Transport Systems 3: Planning & Forecasting

Spring 2025: Michael G. McNally (mmcnally-at-uci-dot-edu) [15450]

Homework #8 -- Trip Assignment Modeling [S O L U T I O N S]

The following problems deal with a hypothetical, 4-zone region (this data was used in prior homework assignments). Table 1 summarizes activity system and **HBW** trip generation data (Ps and As) for 2010, and estimates of activity system variables for 2020. Use the Table 2 base Trip Distribution in all problems.

Table 1. Base and Future HBW Trips and Demographic Data Summary

	HBW		HH(i)		C(i)		W(i)		E(j)		I(i)
	P(i)	A(j)	Households		Cars		Workers		Empl.		Inc.
Zone	'10	'10	'10	'20	'10	'20	'10	'20	'10	'20	both
1	825	710	321	330	447	460	390	395	300	300	Low
2	775	800	402	470	360	420	345	480	360	450	Med
3	910	970	330	300	396	375	582	570	600	690	High
4	865	895	375	420	450	465	399	450	456	455	Med
Tot	3375	3375	1428	1520	1653	1720	1716	1895	1716	1895	N/A

Table 2. Base Travel Time and Trip Distribution Matrix

From\To	1	2	3	4	From\To	1	2	3	4	P(i)
1	5	16	13	18	1	250	125	375	75	825
2	16	7	20	12	2	100	400	50	225	775
3	13	20	2	9	3	205	60	225	420	910
4	18	12	9	3	4	155	215	320	175	865
					A(j)	710	800	970	895	3375

Table 7b. Base Network: Minimum Path Skims and Paths (HW 7)

From\To	1	2	3	4
1	-	16 [1-5-2]	13 [1-3]	18 [1-6-4]
2	16 [2-5-1]	-	20 [2-6-3]	12 [2-4]
3	13 [3-1]	20 [3-6-2]	-	9 [3-4]
4	18 [4-6-1]	12 [4-2]	9 [4-3]	-

Problem 8. Trip Assignment (20 points)

Assign total AM-peak vehicle demand to the network based on minimum time paths and All-or-Nothing (AON) Assignment. Use estimated HBW O-D vehicle trip matrix from Problem 6 and the HBO and NHB matrices provided in Table 8. Show all work, including an **assignment table** and a **network map** of assigned link volumes (use *desire lines* and/or annotated links).

Table 8a. AM-peak Vehicle-trip O-D Matrix

	HBW					HBO					NHB				
Fr\To	1	2	3	4	O(i)	1	2	3	4	O(i)	1	2	3	4	O(i)
1	69	34	102	20	225	30	18	53	9	110	5	5	18	2	30
2	27	109	14	61	211	12	54	7	27	100	6	50	8	6	70
3	56	16	61	115	248	44	15	56	95	210	16	9	42	13	80
4	42	59	87	48	236	29	48	69	34	180	2	6	11	1	20
Tot	194	218	265	244	920	115	135	185	165	600	29	70	79	22	200

8b. All Purpose, AM-peak OD Matrix

Fr/To	1	2	3	4	O(i)
1	104	57	173	31	365
2	45	213	29	94	381
3	116	40	159	223	538
4	73	113	167	83	436
D(j)	338	423	528	431	1720

Solution:
The AM-peak OD matrix for HBW, rom Problem 6, is combined with the provided HBO and NHB matrices to form the Combined Purpose, AM-peak OD matrix of vehicle trips for trip assignment. Only interzonal OD-pairs of the matrix are loaded, using the minimum paths found in Problem 7. Note that, for this simple network, most (if not all) links are used by one and only one OD-pair (NOT the usual case). Table 8c is the Assignment Table (see Problem 10 for network graphic).

Table 8c. Assignment Table: A-O-N Loading of AM Combined OD Vehicle-trips

	O/D Pair											Link Chars		
Lnks	12	13	14	21	23	24	31	32	34	41	42	43	Vol	ta	ta*
1-3		173											173	13	30.5
1-5	57												57	11	11.2
1-6			31										31	12	12.0
2-4						94							94	12	13.4
2-5				45									45	5	5.0
2-6					29								29	7	7.0
3-1							116						116	13	16.5
3-4									223				223	9	42.4
3-6								40					40	13	13.1
4-2											113		113	12	14.9
4-3												167	167	9	19.5
4-6										73			73	6	6.3
5-1				45									45	11	11.1
5-2	57												57	5	5.1
5-6													0	6	6.0
6-1										73			73	12	12.5
6-2								40					40	7	7.0
6-3					29								29	13	13.0
6-4			31										31	6	6.0
6-5													0	6	6.0

* t recomputed with BPR LPF (see Problem 9 below)

Problem 9. Trip Assignment: Updating (10 points)

After trip assignment, **re-compute** link travel times using the BPR Link Performance Function. Assume the default values of alpha (0.15) and beta (4.0) and link capacities of 100 vehicles per hour for the 2-hour AM-peak period. **Tabulate** these results (you may append to the table in Problem 8). **Explain** how these adjusted link travel times would be used to find the UE solution. The FHWA LPF is:

$t_a = t_a^0 [1+\text{alpha}(x_a/c_a)^{\text{beta}}]$

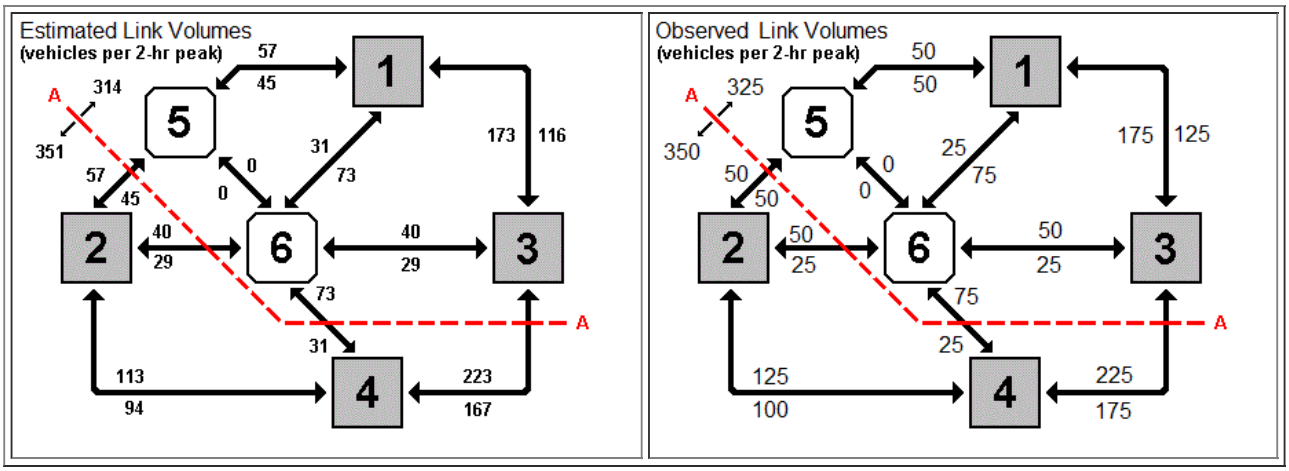
where:

t_a = travel time on link a (minutes)
t_a^0 = free flow travel time on link a (minutes)
x_a = volume of link a (vph)
c_a = capacity of link a (vph)

Solution:
Using period capcities of 100 vph, the results are provided in the last column of Table 8c; note that several links changed significantly (links 1-3, 2-4, 3-1, 3-4, 4-2, and 4-3. Iterative assignment is needed, using either Frank-Wolfe or MSA to find a User Equilibrium solution. The times in Table 8c are used to find new skims with which the OD table is reassigned to the network. The resulting volumes would be combined with the prior iteration's volumes (via MSA or Frank-Wolfe), the link times would be updated, and the process continued.

Problem 10. Trip Assignment: Performance (5 points)

Compare estimated link volumes to observed counts in Figure 10 using a screen line drawn from the upper left to the lower right of the network, crossing links (2-5), (2-6), (4-6), and (4-3). **Tabulate** the volumes by direction crossing the screenline, **compute** percent deviations, and **depict** the results graphically.



Solutions:
Links 2-5, 2-6, 4-6, and 4-3 lead away from zones 2 and 4, with a total screenline volume of 314 vehicles in the AM-peak (all purposes). Total screenline volume in the opposite direction (toward zones 2 and 4) is 351 vehicles in the AM-peak (all purposes). Graphical results are shown below.

Table 10. Screenline Analysis

Screenline	Toward TAZs 2 & 4 — Estimated	Toward TAZs 2 & 4 — Observed	Toward TAZs 2 & 4 — Dev(%)	Away from TAZ 2 & 4 — Estimated	Away from TAZ 2 & 4 — Observed	Away from TAZ 2 & 4 — Dev(%)
A - A	351	350	0.3%	314	325	-3.4%
B - B	not used					

Problem 11. Trip Assignment: Performance (10 points)

Summary statistics help describe the overall flow pattern at the end of the full modeling process. Using final link volumes and re-computed travel times for the base network, **compute** the average travel speeds for the 2010 base year. Link results will allow you to compute total vehicle-hours traveled (VHT) and total vehicle-miles traveled (VMT) for total travel in the AM-peak period. Be sure to estimate VHT and VMT for (unassigned) intrazonal trips. **Compare** these results with Problem 4 (in HW 7).

Solutions:
Multiplying the AoN link volumes by the adjusted link travel times and summing gives the total travel time in the system (27,808 veh-min). This does not reflect intrazonal trips. Summary stats include VHT=464 veh-hrs and VMT=7,318 veh-miles (these numbers include ONLY interzonal trips), thus an average speed of 15.8 mph (based on AON assignment). These results are really NOT comparable to HW7-Prob4 since these results pertain to the AM-peak only, while the prior results were for all trips in a 24-hour period.

1	S'25	HW8 [S&M2]							
2	A-node	B-node	Length		Volume	Time	Update	VHT	VMT
3			d		x	t(0)	t(x)	x*t(x)/60	d*x
4			(miles)		(vph)	(min.)	(min.)	veh-hr	veh-miles
5	1	3	6.5		173	13	30.47	87.85	1124.50
6	1	5	5.5		57	11	11.17	10.62	313.50
7	1	6	6.0		31	12	12.02	6.21	186.00
8	2	4	6.0		94	12	13.41	21.00	564.00
9	2	5	2.5		45	5	5.03	3.77	112.50
10	2	6	3.5		29	7	7.01	3.39	101.50
11	3	1	6.5		116	13	16.53	31.96	754.00
12	3	4	4.5		223	9	42.39	157.53	1003.50
13	3	6	6.5		40	13	13.05	8.70	260.00
14	4	2	6.0		113	12	14.93	28.13	678.00
15	4	3	4.5		167	9	19.50	54.28	751.50
16	4	6	3.0		73	6	6.26	7.61	219.00
17	5	1	5.5		45	11	11.07	8.30	247.50
18	5	2	2.5		57	5	5.08	4.83	142.50
19	5	6	3.0		0	6	6.00	0.00	0.00
20	6	1	6.0		73	12	12.51	15.22	438.00
21	6	2	3.5		40	7	7.03	4.68	140.00
22	6	3	6.5		29	13	13.01	6.29	188.50
23	6	4	3.0		31	6	6.01	3.10	93.00
24	6	5	3.0		0	6	6.00	0.00	0.00
25	Cap.=	100					Total =	463.46	7317.50
26					t=t(0)[1+0.15(x/c)^4]			Speed =	15.79

Problem 12. Trip Assignment: Develop a Network Alternative (5 points)
Given observed 2020 loads on the base network, propose and define an alternative transport system design.

Solutions will vary

Problem 13. Trip Assignment: User Equilibrium Algorithm (5 points)
Provide the numbered algorithm steps (or flowchart) for the User Equilibrium Algorithm for Trip Assignment.

Step 0. Initialization.
Initial load: Perform an all-or-nothing assignment based on $\{t_a^0\}$ to obtain a set of initial flows $\{x_a^0\}$ for all links a.
Set n=1. Initial Update: Set $t_a^n = t_a(x_a^{n-1})$, for all links a

Step 1. Loading.
Perform an all-or-nothing assignment based on $\{t_a^n\}$ to obtain a set of auxiliary flows $\{F_a^n\}$ for all links a

Step 2. Averaging.
Set: xan = (1-phi$_n$)x$_{an-1}$ + phi$_n$ F$_{an}$ for all links a, where 0 < phi$_n$ < 1

Step 3. Updating.
Set: $t_{an+1} = t_a(x_{an})$ for all links a

Step 4. Convergence Test.
If a convergence criterion (e.g., relative gap) is met, then STOP. Otherwise, set n=n+1 and GOTO Step 1

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