CEE 123 Transport Systems 3: Planning & Forecasting

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

Homeworks 6 and 7 utilized data pertaining to a hypothetical five zone region. The data set included surveyed production, attractions, and activity system variables for the base year (2020), as well as estimates of activity system variables for the future year (2030).

Table 1a. Travel Times ; HBW Ps & As ; Base and Future Demographics

	-Base Travel Time-					-Base Trips-		-Base Demo-		-Future Demo-	
From\To	1	2	3	4	5	PROD	ATTR	WORK	EMPL	WORK	EMPL
1	1	3	3	6	3	0	450	0	220	0	216
2	3	1	2	6	5	0	250	0	110	0	118
3	3	2	1	5	6	300	0	140	0	250	0
4	6	6	5	1	4	0	300	0	140	0	166
5	3	5	6	4	1	700	0	360	0	472	166
Totals						1000	1000	500	470	722	666

Table 1b. Base HBW Trip Distribution

FROM\TO	1	2	4	Prod
3	125	125	50	300
5	325	125	250	700
Attr	450	250	300	1000

In HW 6, a HBW trip gravity model was calibrated and forecasts were completed for trip generation and distribution. In HW 7, adjustments produced a peak period vehicle trip matrix in OD format for all purposes.

Problem 8. Trip Assignment (20 points)

The study area network is shown below (Node 6 is an interchange, not a centroid). Links are labeled with length in miles. For the AM-peak period, assume average auto speeds of 30 mph. **Assign** total AM-peak vehicle demand. Use the estimated AM-peak Period HBW O-D vehicle trip matrix from Problem 7 and the HBO and NHB matrices in Table 8. Use *All-or-Nothing Assignment* based on shortest time paths (verify path results with skims provided in Table 1a). Show all work, and include a **network map** depicting link volumes.

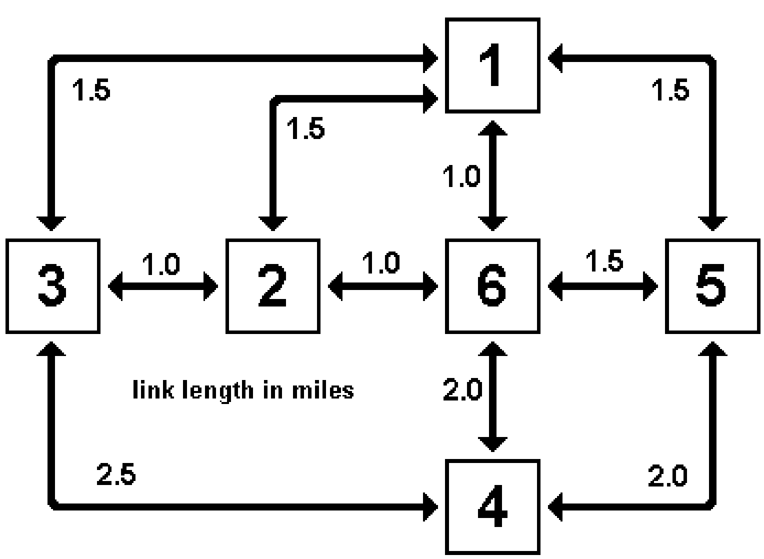


Figure 1. Transportation Network

Table 8. AM-peak Period HBO and NHB Vehicle-trip O-D Matrices [HBW results appended]

-- HBO Vehicle-trips -							-- NHB Vehicle-trips --							-- HBW Vehicle-trips --						
Fr\To	1	2	3	4	5	Tot	Fr\To	1	2	3	4	5	Tot	Fr\To	1	2	3	4	5	Tot
1	0	0	2	0	3	5	1	5	2	1	0	1	9	1	0	0	0	0	0	0
2	0	0	4	0	4	8	2	2	3	1	3	1	10	2	0	0	0	0	0	0
3	5	11	3	2	12	33	3	1	1	1	1	1	5	3	34	34	0	14	0	82
4	0	0	1	0	2	3	4	0	3	1	3	1	8	4	0	0	0	0	0	0
5	9	11	18	7	27	72	5	1	1	1	1	1	5	5	89	34	0	68	0	191
Tot	14	22	28	9	48	121	Tot	9	10	5	8	5	37	Tot	123	68	0	82	0	273

Solution:

Only interzonal OD-pairs are loaded; minimum paths are found (not shown) after converting link distances to link travel times using average automobile speed. Network skim times checked with the corresponding values in the base travel time matrix in Table 1b. Since the network is highly connected (most zones are directly connected to other zones) there are few links with more than one O-D pair assigned. Updated link travel times based on Table 8c are computed in Problem 9.

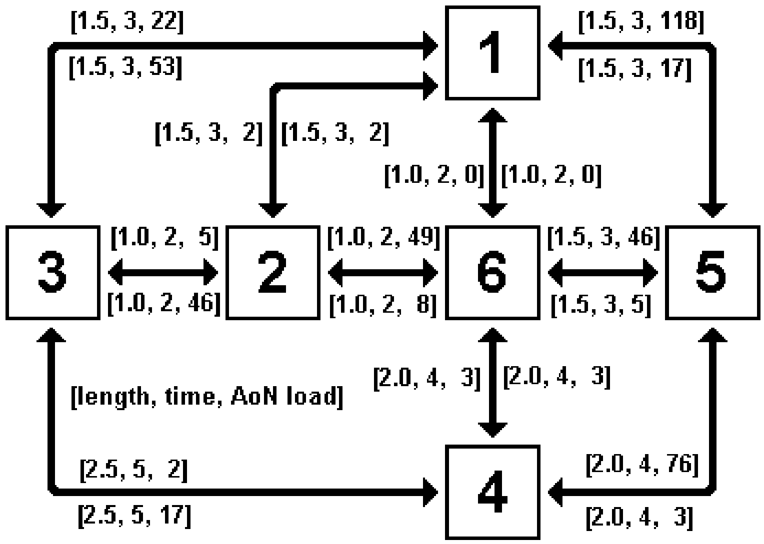
Table 8b. Combined AM-peak Vehicle-trip O-D Matrix

-- Total Vehicle-trips --						
Fr\To	1	2	3	4	5	Tot
1	5	2	3	0	4	14
2	2	3	5	3	5	18
3	40	46	4	17	13	120
4	0	3	2	3	3	11
5	99	46	19	76	28	268
Tot	146	100	33	99	53	431

Table 8c. AON Loading of Total Purpose AM-peak OD Vehicle-trip Matrix

	From 1 to:				From 2 to:				From 3 to:				From 4 to:				From 5 to:				Vol
Links	2	3	4	5	1	3	4	5	1	2	4	5	1	2	3	5	1	2	3	4	x
1-2	2																				2
1-3		3																	19		22
1-5				4								13									17
1-6			0																		0
2-1					2																2
2-3						5															5
2-6							3	5													8
3-1									40			13									53
3-2										46											46
3-4											17										17
4-3															2						2
4-5																3					3
4-6													0	3							3
5-1																	99		19		118
5-4																				76	76
5-6																		46			46
6-1													0								0
6-2														3				46			49
6-4			0				3														3
6-5								5													5

Figure 2. Link length, Base Travel Time, and AON Load for AM-peak



Problem 9. Trip Assignment: Updating [10 points]

After network assignment, **re-compute** link travel times using the FHWA/BPR Link Performance Function. **Summarize** in tabular format. Assume the default values of alpha (0.15) and beta (4.0) and link capacities of 25 vehicles per hour (or 50 vph for the 2-hour AM-peak period). The FHWA LPF is:

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

where: t_a = travel time on link a

t_a^0 = free flow travel time on link a

x_a = volume of link a

c_a = capacity of link a

a. **Explain** how these adjusted link travel times would be used to find the UE solution.
b. **Compute** at least one system-level performance measure (mean speed, VMT, etc.)

Solution:

These results are provided in Table 9b; note that, for these relatively small link volumes, few congestion effects are apparent (the figures reflect link capacities of 50 vehicles in the 2-hour AM-peak period). Total vehicle-hours traveled is 56.76 veh-hrs. For these volumes, it is unlikely that any congestion effects would arise, thus AoN may be valid for this example.

These updated link times would be used t oidentify new shortest path trees, upon which another All-or-Nothing loading would be made. A weighted combination of the two link loadings would be used to ocne again update link travl times and test for convergence. Performance measures are summarized in Question 11 below (VHT, VMT, average speed).

Table 9b. AON Loads and Updated Link Travel Times (BPR LPFs)

Links	Link Volume	Base Time	Updated Time
1-2	2	3	3.00
1-3	22	3	3.02
1-5	17	3	3.01
1-6	0	2	2.00
2-1	2	3	3.00
2-3	5	2	2.00
2-6	8	2	2.00

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----------------------------
3-1      53      3     3.57 *
3-2      46      2     2.21
3-4      17      5     5.01
----------------------------
4-3       2      5     5.00
4-5       3      4     4.00
4-6       3      4     4.00
----------------------------
5-1     118      3    16.96 *
5-4      76      4     7.20 *
5-6      46      3     3.32
----------------------------
6-1       0      2     2.00
6-2      49      2     2.28 *
6-4       3      4     4.00
6-5       5      3     3.00
----------------------------
* Significant changes;
  MinPaths may change with these volumes.
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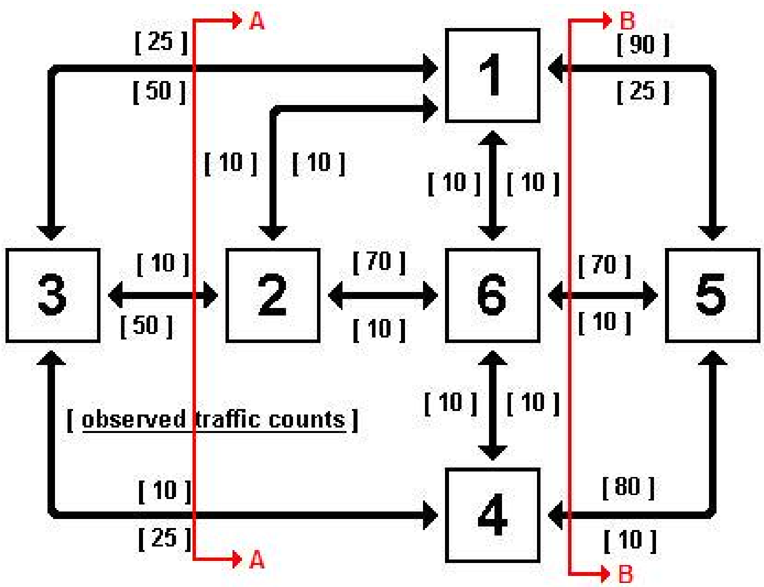
Problem 10. Trip Assignment: Screen Line Performance [10 points]
Observed traffic counts for the AM-peak period are provided below. Using observed and estimated volumes, **compute** the volumes associated with screen lines drawn to isolate residential (HB production) zones from employment (HB attraction) zones. The first screen line (A) will cut links (3,1), (3,2), and (3,4); the second screen line (B) will cut links (1,5), (6,5), and (4,5).

a. Show your screen line results **graphically** and tabulate the difference between observed and estimated directional flows across the screen lines.
b. **Select** a third screenline and repeat the analysis. **Describe** what types of flow are being measured by your screenline.

c. **Compute** the directional GEH statistics for each screen line (convert to 1-hour flows).



Solutions:

- ***Screenline A*** *(Links 3-1, 3-2, and 3-4): leading away from production zone 3 with a total screenline volume of 116 vehicles outbound in the AM-peak period and 29 inbound.*
- ***Screenline B*** *(links 1-5, 6-5, and 4-5): leading away from production zone 5 with a total screenline volume of 240 vehicles outbound in the AM-Peak period and 25 inbound.*
- ***Screenline C****. Several are possible but results are not shown.*

The flows outbound from zones 1 and 5 are close; inbound flows, generally smaller, are not close. However, all GEH values are less than 5. Other screenlines of interest might include an east-west screen line cutting off trips *through Zone 1 (since trips from and to 3 and 5 utilize this path) but these graphical results are not displayed.*

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Table 10b. Screenline Analysis
--------------------------------------------------------------------------
 AM-peak Flows   ----- West - to - East ----   ----- East - to - West ----
    Screenline   Estim  Obser  Dev(%)   GEH    Estim  Obser  Dev(%)   GEH
--------------------------------------------------------------------------
 A. 3-1,3-2,3-4    58     62   -6.5 %   0.73     14     22  -36.4 %   2.67
 B. 1-5,6-5,4-5    12     22  -45.5 %   3.43    120    120    0.0 %   0.00
--------------------------------------------------------------------------
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Problem 11. Trip Assignment: Network Performance [10 points]

Summary statistics help describe the overall flow pattern at the end of the full modeling process.

a. Using estimated link volumes and updated travel times for the base network, **compute** VHT, VMT, and the average travel speeds for the 2010 base year. Hint: Use a spreadsheet!
b. **Compare** these results with the Trip Distribution results in HW 6 Problem 3.
c. **Compute** the GEH statistic for each link (convert to 1-hour flows). **Evaluate** based on the GEH standard.

A-node	B-node	Length d (miles)	Time t(0) (min.)	Volume x (vph)	Update t(x) (min.)	Volume x(est) (vph)	Update t(x) (min.)	VHT x*t(x)/60 veh-hr	VMT d*x veh-miles	Average Speed (mph)
1	2	1.5	3	10	3.00	2	3.00	0.10	3.00	30.0
1	3	1.5	3	25	3.03	22	3.02	1.11	33.00	29.8
1	5	1.5	3	25	3.03	17	3.01	0.85	25.50	29.9
1	6	1.0	2	10	2.00	0	2.00	0.00	0.00	
2	1	1.5	3	10	3.00	2	3.00	0.10	3.00	30.0
2	3	1.0	2	10	2.00	5	2.00	0.17	5.00	30.0
2	6	1.0	2	20	2.01	8	2.00	0.27	8.00	30.0
3	1	1.5	3	50	3.45	53	3.57	3.15	79.50	25.2
3	2	1.0	2	50	2.30	46	2.21	1.70	46.00	27.1
3	4	2.5	5	25	5.05	17	5.01	1.42	42.50	29.9
4	3	2.5	5	10	5.00	2	5.00	0.17	5.00	30.0
4	5	2.0	4	10	4.00	3	4.00	0.20	6.00	30.0
4	6	2.0	4	10	4.00	3	4.00	0.20	6.00	30.0
5	1	1.5	3	90	7.72	118	16.96	33.35	177.00	5.3
5	4	2.0	4	80	7.93	76	7.20	9.12	152.00	16.7
5	6	1.5	3	70	4.73	46	3.32	2.55	69.00	27.1
6	1	1.0	2	10	2.00	0	2.00	0.00	0.00	
6	2	1.0	2	70	3.15	49	2.28	1.86	49.00	26.4
6	4	2.0	4	10	4.00	3	4.00	0.20	6.00	30.0
6	5	1.5	3	10	3.00	5	3.00	0.25	7.50	30.0
Cap.=	50						Total =	56.76	723.00	
Speed=	30			t=t(0)[1+0.15(x/c)^4]					Est. Speed =	12.74

Volume Obser (vph)	Volume Estim (vph)	GEH
5.0	1.0	3.266
12.5	11.0	0.619
12.5	8.5	1.746
5.0	0.0	4.472
5.0	1.0	3.266
5.0	2.5	1.826
10.0	4.0	3.207
25.0	26.5	0.418
25.0	23.0	0.577
12.5	8.5	1.746
5.0	1.0	3.266
5.0	1.5	2.746
5.0	1.5	2.746
45.0	59.0	2.746
40.0	38.0	0.453
35.0	23.0	3.151
5.0	0.0	4.472
35.0	24.5	2.722
5.0	1.5	2.746
5.0	2.5	1.826
Average GEH =		2.401

Intrazonal							
I	J	d	t(0)	Volume	VHT	VMT	Speed
1	1	0.50	2	5	0.1667	2.5	15.0
2	2	0.50	2	3	0.1000	1.5	15.0
3	3	0.50	2	4	0.1333	2.0	15.0
4	4	1.00	4	3	0.2000	3.0	15.0
5	6	0.75	3	28	1.4000	21.0	15.0
Intrazonal					2.0000	30.0	15
Total					58.7604	753.00	12.8

Solutions: *The tables, (a) for interzonal and (b) intrazonal and total, summarize the performance assessment. Note that the AoN assignment is not valid if only for link 5-1 which accounts for the low average speed (it's the only link with severe congestion). It was assumed that intrazonal speed was 15 mph and was uncongested.*

Problem 12. Developing Alternatives [5 points]

Given observed 2010 loads on the base network, propose and justify three alternate transportation system designs:

1. one that addresses infrastructure enhancements (e.g., new links)
2. one that addresses operational improvements (new link characteristics), and
3. one that addresses demand

Solutions: *There are many options. The greatest congestion appears around TAZ 5. Adding capacity to link 5-1 might relieve the most impacted link, but improving links through node 6 could divert traffic from 5-1 through node 6. TAZ 5 shows added population (workers by residence) and employemnt in 2010 -- if these jobs are balanced, residents might be able to live and work in the same zone. Note that the HW 7 analysis is based on base demand (this is to ensure that all students use the same OD table). Future demands would need to be loaded to fully investigate model performance.*

NOTE: Homework 6, 7, and 8 provide a useful exercise that illustrates the sequential application of the Four Step Model and serve as excellent preparation for the final exam.

Last Updated: 3 June 2024