National Conference
on
Urban Mobility- Challenges, Solutions and Prospects

A Quantitative Comparison of Dynamic Traffic Assignment Modelling Packages for Heterogeneous Traffic Composition

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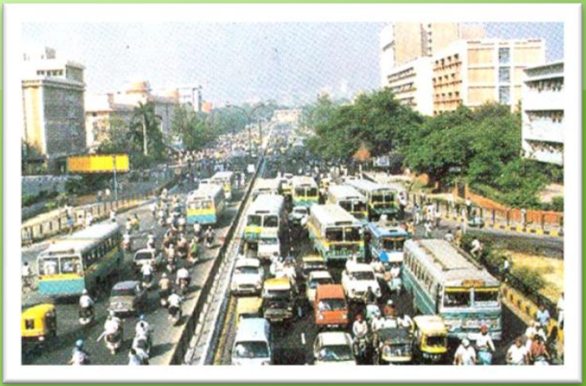
Outline

- Introduction
  - DTA packages
- Model calibration
- Simulation of IIT network
- Observations

Introduction

Indian / heterogeneous traffic conditions



- Indian traffic condition is
  - highly heterogeneous.
  - highly chaotic

- A typical mix of Indian urban traffic consists of
  - passenger cars,
  - two-wheelers (bicycle and motorbikes),
  - three-wheelers (auto-rickshaws – small, big, for goods),
  - light commercial vehicles (small sized trucks),
  - buses, and
  - Trucks

- The creeping phenomenon at the intersections, due to the high percentage of two wheelers, increases the capacity of the section near the signalized intersection significantly.

- Most unsignalized intersections in India are uncontrolled without stop or yield signs. The critical gap and critical wait parameters in such scenarios are highly variable (leads to a new concept of forced merges!)

Dynamic Traffic Assignment

- DTA is increasingly used in transportation planning and traffic management applications
- Simulation based DTA models can be classified as macroscopic, mesoscopic and microscopic depending on its representation of
  - vehicular flow
  - network characteristics
  - driver behavior
  - vehicle performance
- Mesoscopic traffic flow models provide computationally faster solutions by modelling traffic dynamics at levels that vary between disaggregate vehicle level to aggregate stream level
- They use aggregate speed-flow relations but often have the capability to extract individual vehicle trajectories from the macro-level models

DTA and ITS

- Replica of network
- DTA can be used for
  - Offline and
  - Online application

DTA simulation packages used

- Embedded with mesoscopic traffic models.
- Commercial packages:
  - Dynameq (Mahut et al., 2004),
  - AIMSUN (Barceló, 2004) and
  - DYNASMART (R.Jayakrishnan et al., 1994).

Motivation

- Many of the DTA simulation based models are developed for homogeneous traffic conditions.
- So adaptability of models in Indian traffic conditions needs to be verified.
- All packages considered here have varying capability to model multiple vehicle classes

AIMSUN 7

DYNASMART 1.3.0

Dynameq 2.0.1

Network loading

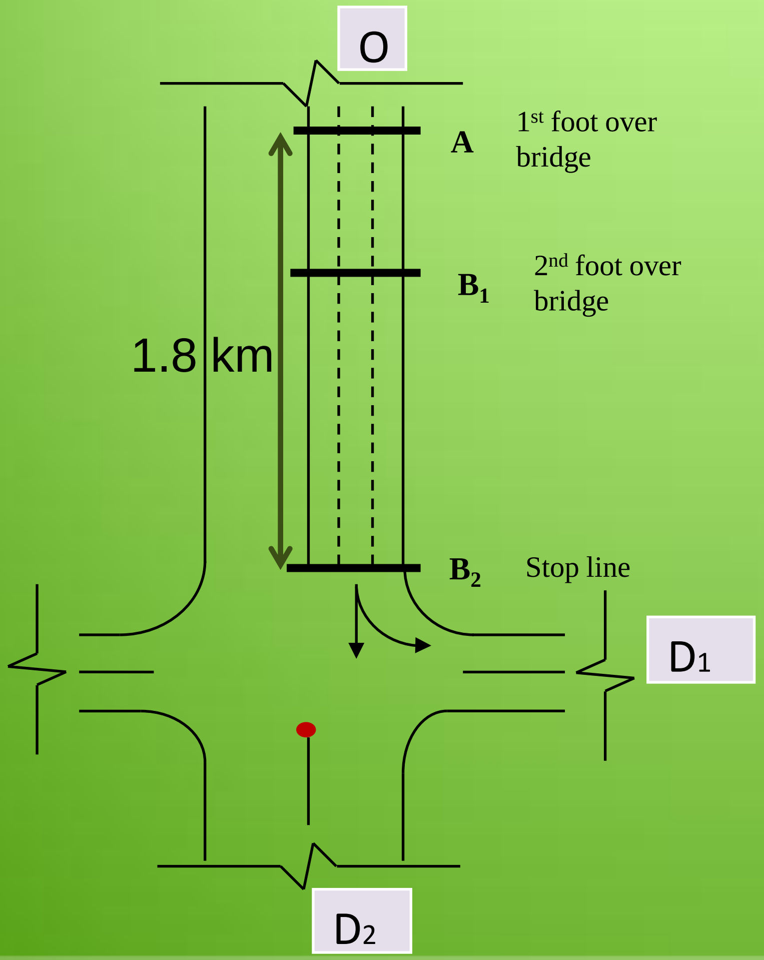
	Dynameq	AIMSUN	DYNASMART
Link	Simplified car following model	Simplified car following model	Aggregate speed density relationship – modified Greenshield
Node	Probability of accepting gap – function of gap and waiting $P = \min[\max(g/G - 0.5, w/W - 0.5, 0.0), 1]$	Multiple rules – explicit parameters	Implicit rules – no parameters
Vehicle classes	User defined (effective length, reaction time)	User defined (min / max speed, vehicle dimensions, min. clearance)	Pre-defined Trucks, buses and passenger cars

Traffic Assignment

	Dynameq	AIMSUN	DYNASMART
Convergence Criteria	$\mathrm{RGap}^{\alpha,\mathrm{n}} = \dfrac{\sum_{i \in I} \sum_{k \in k_i} h_k^{\tau}(n) s_k^{\tau}(n) - \sum_{i \in I} g_i^{\tau} u_i^{\tau}(n)}{\sum_{i \in I} g_i^{\tau} u_i^{\tau}(n)}$		$\left\| r_{ihk}^{\tau,t+1} - r_{ihk}^{\tau,t} \right\| \leq \varepsilon$

Model calibration

Study Section



O - Origin
D_1 - Destination1
D_2 - Destination 2
A - 1st foot over bridge
B_2 - stop line
A, B_1, and B_2 are the camera locations for data collection

Model calibration

PCU values and vehicle characteristics

Type	Length (ft)	Width (ft)	Min clearance (ft)	Reaction time	Effective length	PCU values
2 wheeler	5.9	2	0.33	0.9	6.23	0.75
3 wheeler	8.5	4.6	0.65	1	9.15	1.2
Car	13.12	5.25	0.98	1.2	14.1	1
Truck	24.6	8.2	0.98	2.5	25.58	2.2
LCV	16.4	6.23	0.98	2.5	17.38	1.2

Origin Destination matrix

- The OD matrix is defined for each vehicle type.
- The assignment interval for the OD matrix is fixed as 15 minutes.
- Count for entry and exit and travel time is taken for 1 minute interval.
- The i^{th} 15 minute OD matrix is computed using the flow proportions of through vehicles and left-turning vehicles at intersection during time interval (t_i , t_{i+1}).
- t_1 is the exit time of the first vehicle entering the section in the 1st 15 minute interval.
- t_{i+1} is the time of exit of the last vehicle entering the section in the i^{th} 15 minute interval (it is assumed the last vehicle enters the section exactly at the 15th minute).

Calibrated parameters

Dynameq					
	Parameters		Default value	Range of values	Calibrated values
Node	Signalized intersection	Turning speed (mph)	Free flow speed	30-50	50
		Follow up time (s)	2.5s	0-1.8	0
Link	Free speed (mph)		44mph	30-50	30
	Effective length factor		1	1.3-0.8	**0.95**
	Reaction time factor		1	1.2-0.5	**0.64**
	Maximum capacity (pcu/hr/l)			2000-4000	**3242**
	Jam density (pcu/m/l)			300-500	423
Vehicle parameters	Reaction time and effective length for PCU.		RT = 1.25s EL = 20.50ft	RT=1.2s EL=13.2ft	

Calibrated parameters

DYNASMART					
	Parameters		Default value	Range of values	Calibrated value
Node	-				
Link	Speed limit		45mph	30-50	30
	Speed adjustment factor		0	5-15	3
	Saturation flow		1800vphpl	2000-4000	2800
	Service flow		1800vphpl	2000-4000	**2500**
	Traffic flow model=single regime	Shape term factor	1	0.3-4	0.45
		Minimum speed	10	2-20	10
		Jam density	120pcphpl	200-250	200
Vehicle parameter	Length of PCU		Length=21.12ft		

Calibrated parameters

<table>
<tr><th colspan="5">AIMSUN</th></tr>
<tr><td></td><td>Parameters</td><td>Default value</td><td>Range of values</td><td>Calibrated values</td></tr>
<tr><td>Node</td><td>Turning speed</td><td>Link speed</td><td></td><td>50</td></tr>
<tr><td rowspan="5">Link</td><td>Reserved lanes visibility distance</td><td>656.2 ft</td><td>500-700</td><td></td></tr>
<tr><td>Capacity</td><td>1800pcu/hr</td><td>1800-4000</td><td>3000</td></tr>
<tr><td>Jam density</td><td>321veh/mi</td><td>300-500</td><td>400</td></tr>
<tr><td>Reaction time factor</td><td>1</td><td>0.3-1</td><td>0.53</td></tr>
<tr><td>Maximum speed</td><td>31mi/hr</td><td>35-50</td><td>40</td></tr>
<tr><td rowspan="5">Vehicle parameter</td><td>Length of the vehicle</td><td colspan="3" rowspan="5">Given in the table 1</td></tr>
<tr><td>Maximum desired speed</td></tr>
<tr><td>Speed acceptance</td></tr>
<tr><td>Minimum distance between vehicles</td></tr>
<tr><td>Maximum give way time</td></tr>
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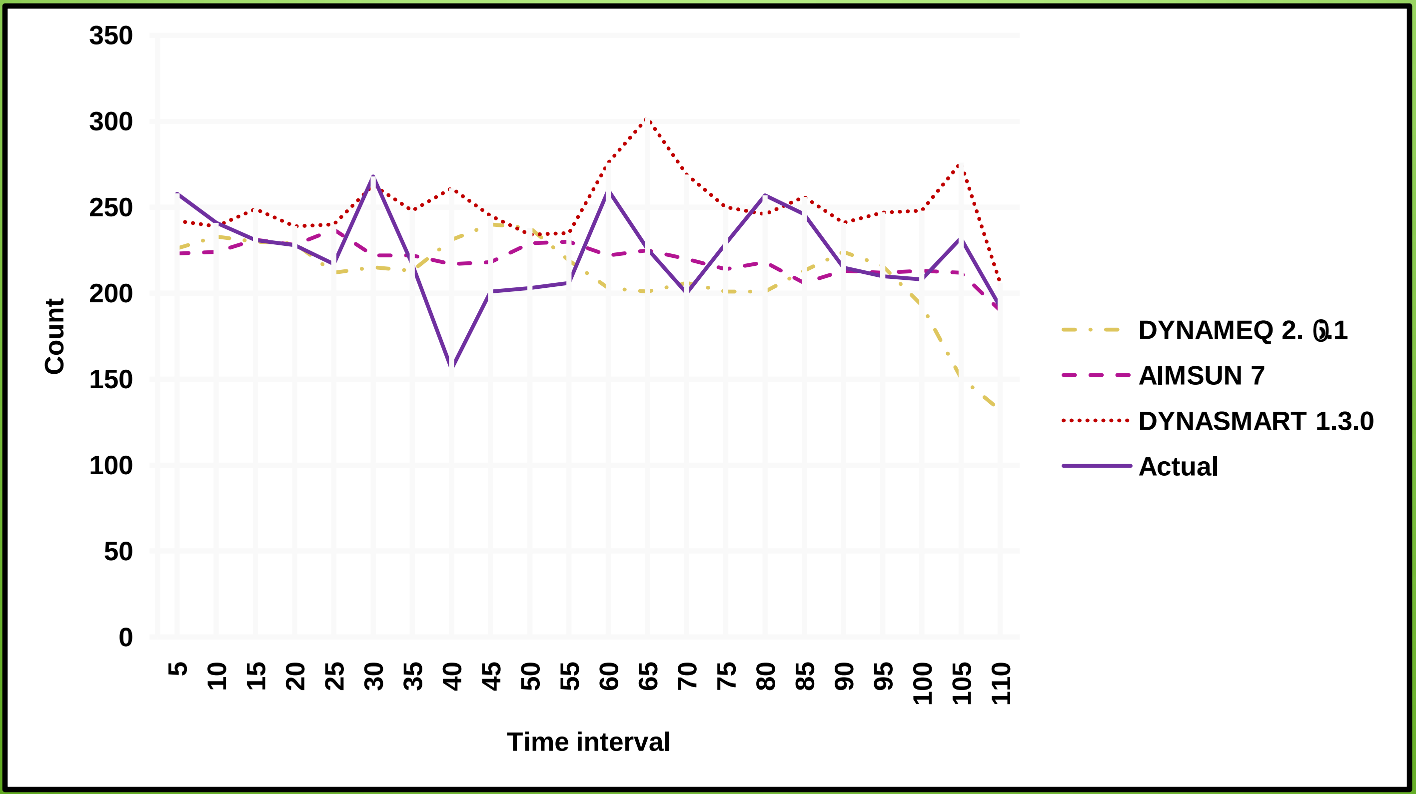
Calibrated results for travel time

Calibrated results for count



MAPE

$$1/n\left|\frac{\sum(actual - observed)}{\sum actual}\right|$$

Model	MAPE	
	Travel Time	Count
Dynameq	18.5	11.2
AIMSUN	12.11	9.4
DYNASMART	13.3	15

Dynameq

- Free flow speed is given for the link rather than vehicle types, however different vehicle characteristics can be modeled using effective length and reaction time.

- Passing a slow reacting vehicle on a link / queue and returning to same lane not possible - leads to reduction in capacity; recent version may have a fix for this?

- The whole link was divided into two segments to study the model behavior in arterial and signalized sections. The model captured the arterial section well but was less accurate at predicting vehicular movement at the intersection.

- Movement of only one vehicle at a time in a lane reduces the capacity of link drastically due to the presence of two wheelers.

DYNASMART

- The <u>different vehicle types cannot be defined</u> which is a big drawback in Indian Traffic conditions.
- The model had significant variations in the results due to different seeds used in multiple runs. However, it is not clear where this variation results from since there are no explicit stochastic parameters.
- The models do not capture common characteristics of Indian traffic conditions such as “lane” changing and overtaking.

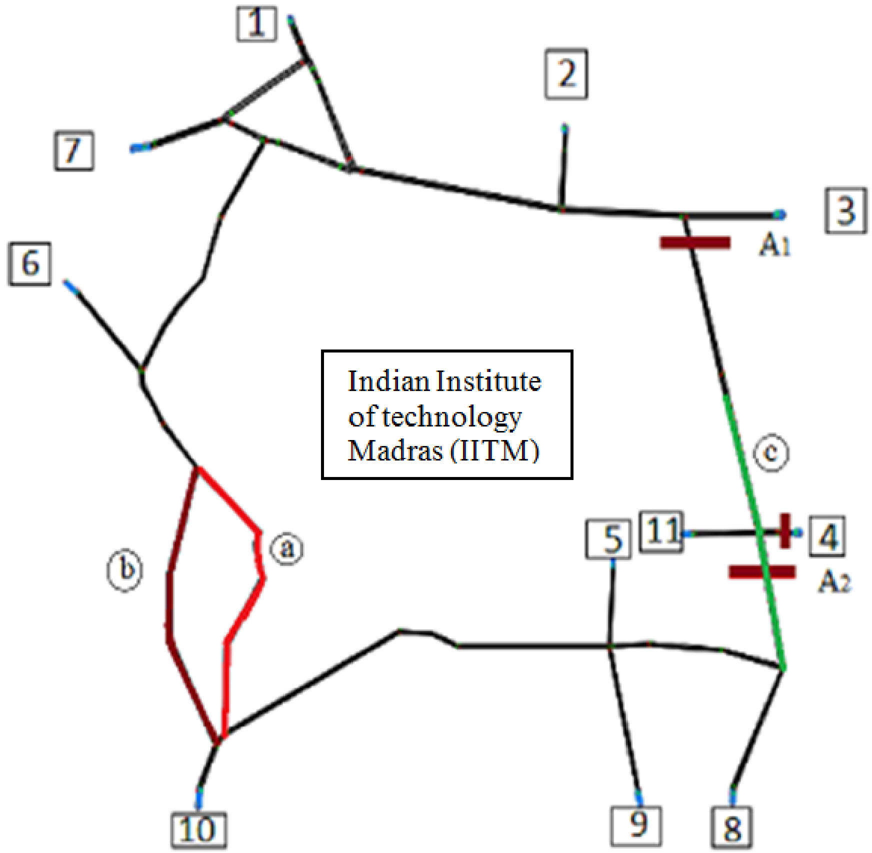
AIMSUN

- Travel time of different vehicle types matched field data, with higher travel time for three wheelers and light commercial vehicles.
- The vehicles can also be represented effectively with minimum parameters, including individual maximum desired speed.
- The calibrated result improved after activation of an option to penalize slow vehicles to travel in slow moving lane.
- When the link was divided into two sections – mid-block and intersection – the model predicted much higher delay in the mid-block as opposed to the intersection. This may be due to the advance lane changes that happen at the mid-block much before reaching the intersection

Simulation of IIT Network

Network

11 centroids, 28 nodes, and 76 links



a, b and c are 3 paths in the network

A1-A2 is the study stretch for calibration

Zones under consideration:

1. Little mount
2. Cancer institute
4. Tidel park
5. Velachery check post
8. Tharamani Periyar nagar
10. Gurunanak college

Network Performance and Convergence

Over predicts congestion

	AIMSUN	Dynameq	DYNASMART
Total travel time (hrs)	6362	6020	12660
Total distance (mi)	127368	130029	136040
Number of iterations	25	21	29
Simulation time	95s	240s	273s

Sample Path travel times

OD Pair	AIMSUN	Dynameq	DYNASMART
1-8	a.1192 (95) b.1246 (5)	c.1176	c.2700 (97) a.1560 (2.5) b.1560 (0.5)
10-2	a.706 (89) b.708 (11)	c.675	b.1860 (28) a.1620 (30.5) c.3240 (34) ab.3960 (7.5)
6-4	c.631 (98) a.754 (2)	a.825 (34) c.869 (66)	c.1260 (13) a.3180 (41) b.3540 (46)

Numbers highlighted in red are not close to equilibrium

Observations

Observations

- AIMSUN and Dynameq showed better convergence
- Relative gap given for AIMSUN and Dynameq are 1% and 2% respectively. In AIMSUN convergence for the average travel time in used paths is found to vary from 16% to 0.2%.
- In Dynameq, only one path is identified for several OD pairs by the model at equilibrium.
  - However, the path travel time from links are computed for other paths and found to be higher
- The Convergence threshold for DYNASMART was given as 50. Even though convergence criteria cannot be directly checked, the travel time on alternate paths are checked and varied from 10% to 50% in DYNASMART.

Observations

- Total travel time from DYNASMART is very high, which shows high delay in the models.
- In an independent check, DYNASMART showed higher travel time compared to Dynameq and AIMSUN in an isolated intersection.
- In DYNASMART the nodes which are at the end of short links cannot be signalized.
    - There are a very large number of short links in network model which can distort the DTA model in DYNASMART.
- The short links will be assigned a minimum length based on the free flow speed of the link which will distort the network configuration if the number of short links is very large.

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Thank you