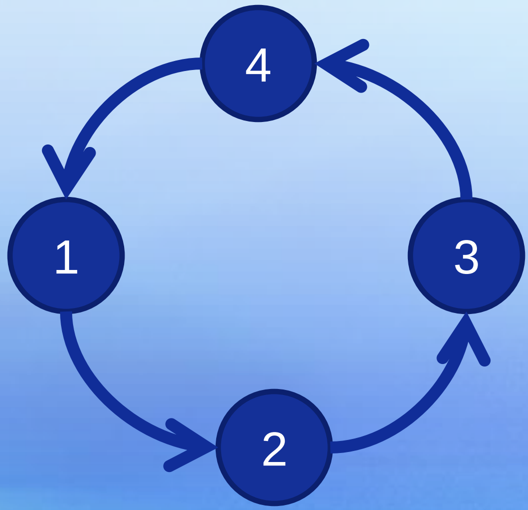
Tour Based Freight Models

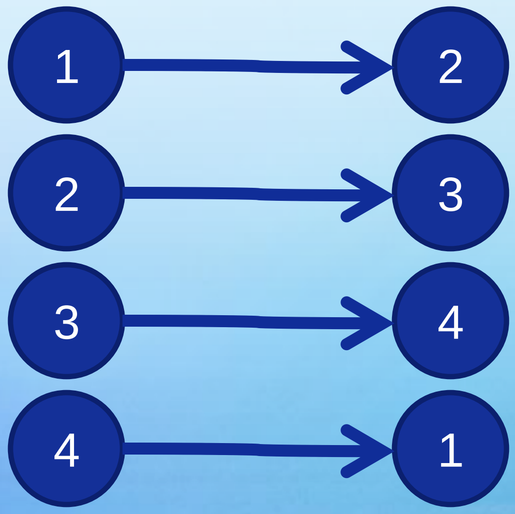
- Anupam Srivastava

Tour Based Models

- What are trips and what are tours ?



Tours



Trips

Tour Based Models

- What are trips and what are tours ?

- Trip chaining in passenger vehicles trips.

- Commercial vehicles tend to make tours composed of multiple interdependent trips. 4-Step model fails to capture this relation.

Tour Based Models – Difficulties and Benefits

- Very data intensive – usually requiring detailed ‘travel diary’-like data.
- High complexity and thus also very time intensive.
- Assumes certain decision behaviors.
- Cannot relate to directly to flow of commodities.

+ Can give detailed truck movement models.
+ Captures truer nature of vehicle movement (tour choice) decisions.
+ Useful for vehicle related policies.

Tour Based Models – Types

- Disaggregate Vs. Aggregate
  - Disaggregate
    - Vehicle routing – Wisetjindawat et. al. 2007, Donnelly 2007
    - Probabilistic discrete choice models – Stefan & Hunt 2005, Gliebe et. al. 2007, Hunt & Stefan 2007
  - Aggregate
    - Network equilibrium model – Maruyama and Harata 2005
    - Entropy maximization – Holguin-Veras 2009

Tour Based Models – Types

- Disaggregate Vs. Aggregate

	Aggregate	Disaggregate
Differences	• Tour distribution • Less Sensitive to time window	• Individual tour with time window
Pros	• Smaller data requirements • Faster computation time	• Capable of capturing the underlying decision making process behind vehicle operations
Cons	• Less reliance on behavioral assumptions	• Expensive procedures such as collecting travel diary data • Long computation times
		Source: Soyoung You, PhD Dissertation, 2012

Stefan and Hunt

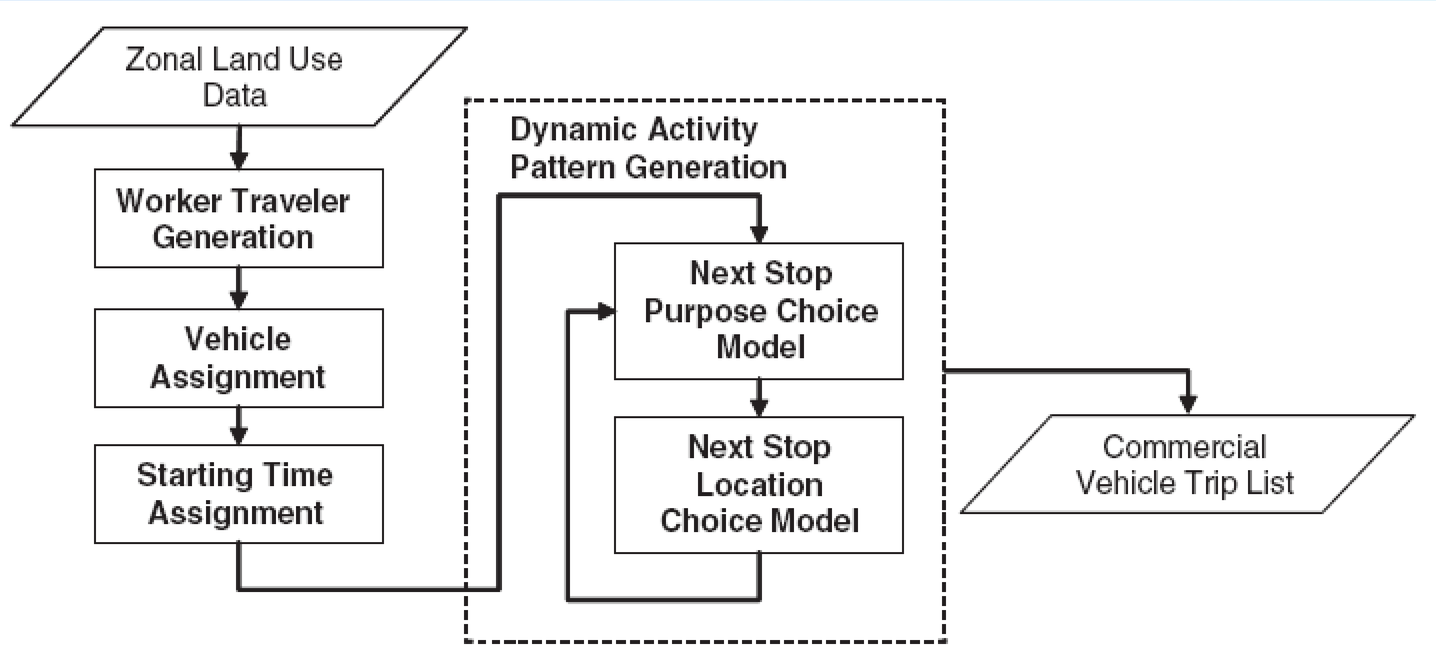
- Tour based micro-simulation of commercial vehicles for Calgary.
- Logit choice models and sampling distributions are used in Monte Carlo process to develop individual tours, including starting times, vehicle types, number of stops, and stop durations for vehicle movements observed in survey.
- Implemented for Calgary.

- More Later !

Stefan and Hunt - 2005

Gliebe et. al.

- Dynamic activity choice model.
- Disaggregate micro-simulation environment
- Implemented for Ohio



- Figliozzi
  - Vehicle routing problem to analyze impacts from congestion or technological changes.
- Donnelly - 2007
  - Commercial vehicle tour model by solving the travelling salesman problem of the empty backhaul.
- Maruyama and Harata - 2005
  - Network equilibrium analysis that accounts for trip chaining behavior.
  - Does not discuss the issues and potential applications in forecasting freight demand.

Holguin-Veras - 2009

- Entropy maximization model
- All tours are equally likely unless data shows otherwise.
- Most probable routes are the ones that can be generated in most possible ways under the aggregate restraints.
- Applied to a case study in Denver.
  - 6.61% (for formulation 2), 6.71% (for formulation 1)
- States

State	State variable
Micro state	Individual commercial vehicle journey starting and ending at a home base (tour flow) by following tour m;
Meso state	t_m : The number of commercial vehicle journeys (tour flows) following tour m;
Macro state	O_i : Total number of trips produced by node i (trip production); D_j : Total number of trips attracted to node j (trip attraction); Formulation 1: C : Total tour impedance in the commercial network; Formulation 2: C_T : Total tour travel impedance in the commercial network;

- Two variants of the formulation are offered:
  - Using only total tour impedance
  - Using total tour travel impedance and total tour handling impedance separately.

Tour-based formulation 1:

$$Min \qquad z = \sum_{m=1}^{M} (t_m \ln t_m - t_m)$$

Subject to:

$$\sum_{m=1}^{M} a_{im} t_m = O_i, \qquad \forall i \in \{1,2,\ldots,N\} \qquad (\lambda_i)$$

$$\sum_{m=1}^{M} c_m t_m = C \qquad (\beta)$$

$$t_m \geq 0, \qquad \forall m \in \{1,2,\ldots,M\}$$

Tour-based formulation 2:

$$Min \qquad z = \sum_{m=1}^{M} (t_m \ln t_m - t_m)$$

Subject to:

$$\sum_{m=1}^{M} a_{im} t_m = O_i, \qquad \forall i \in \{1,2,\ldots,N\} \qquad (\lambda_i)$$

$$\sum_{m=1}^{M} c_{T\,m} t_m = C_T \qquad (\beta_1)$$

$$\sum_{m=1}^{M} c_{H\,m} t_m = C_H \qquad (\beta_2)$$

$$t_m \geq 0, \qquad \forall m \in \{1,2,\ldots,M\}$$

Iris - 2012

- Drayage trucks tend to have more than one tour per day.
- Many tours contain repetitive patterns generating numerous similar (but not exact same) tours.
- Entropy maximization formulation using a path-based approach (instead of node-based).
- Accounts for the trip sequence in the tour. (A-B-C-D vs. A-C-B-D)

- Formulation

$$\text{Max W} = \frac{X!}{\prod_{j=1}^{J} x_j!}, \qquad x_j \geq 0, \quad \forall j \in \{1,2,3,\dots,J\}$$

$$\text{Min z} = \sum_{j=1}^{J} (x_j ln\, x_j - x_j),\ x_j \geq 0, \quad \forall j \in \{1,2,3,\dots,J\}$$

Subject to

$$\sum_{j=1}^{J} a_{ij} x_j = O_i\ , \qquad \forall i \in \{1,2,3,\dots,N\}$$

$$\sum_{j=1}^{J} b_{ij} x_j = D_i, \qquad \forall i \in \{1,2,3,\dots,N\}$$

$$\sum_{j=1}^{J} l_{kj} x_j = L_k\ , \qquad \forall k \in \{1,2,3,\dots,K\}$$

$$\sum_{j=1}^{J} c_{Tj} x_j = C_T$$

$$\sum_{j=1}^{J} c_{Hj} x_j = C_H$$