Activity-Based Incremental Travel Demand Model (ABIT)

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Model introduction

ABIT has two major components:
• Base year demand: generates travel plans for every person
• Incremental update: modifies previously generated plans
Development started November 2021

Properties of ABIT:
• Agent-based, activity-based
• 7-day model
• Open source, written in JAVA

Data source:
• German mobility panel (MOP)
Base year travel demand
**Motivation**

From trip-based models to activity-based models: MITO $\rightarrow$ ABIT

MITO: Microscopic Transport Orchestrator is a trip-based agent-based model
- JAVA open-source model developed in our group
- Four-step model at individual resolution
- Very fast (without traffic assignment): 2 minutes for 4.4 million persons and 12 million legs (Munich metropolitan area)
- Relatively simple, allowing for extensions, e.g. joint travel with partners of a social network
- Trip chains are not consistent in time and space
Base year demand generation workflow

Choose habitual mode → Generate mandatory activities → Generate discretionary activities → Generate subtours
Base year demand generation workflow

1. Choose habitual mode
2. Generate mandatory activities
   - Choose destination
   - Choose duration and time of day
   - New mandatory tour
3. Generate discretionary activities
   - Split by type
   - If stop on mandatory tour
     - Choose tour
     - Choose duration
     - Choose destination
   - If new discretionary tour
     - Choose tour
     - Choose duration
     - Choose destination
   - If stop on discretionary tour
     - Choose tour
     - Choose duration
     - Choose destination
4. Generate subtours
   - Choose tour mode
   - Choose destination
   - Choose duration and time of day
   - New discretionary tour
   - Choose tour mode
Habitual mode choice

- Mode that is used the most to travel to mandatory activities
  - Person attribute
  - Influences trip chaining behavior
  - Influences tour mode choice
Base year demand generation workflow

- Choose habitual mode
- Generate mandatory activities
  - Choose destination
  - Choose duration and time of day
  - New mandatory tour
- Generate discretionary activities
  - Split by type
  - If stop on mandatory tour
    - Choose tour
    - Choose duration
    - Choose destination
  - If new discretionary tour
    - Choose tour mode
    - Choose destination
    - Choose duration
    - New discretionary tour
- Generate subtours
  - Choose duration
  - Choose destination
  - Chose subtour mode
  - Choose tour mode
Scheduling

- Joint choice of activity start and activity duration
- Weighted sampling
Base year demand generation workflow

Choose habitual mode

Generate mandatory activities

Choose destination

Choose duration and time of day

New mandatory tour

Generate discretionary activities

Split by type

If stop on mandatory tour

Choose tour

Choose duration

Choose destination

If new discretionary tour

Choose destination

Choose tour

Choose duration and time of day

If stop on discretionary tour

Choose tour

Choose duration

Choose destination

New discretionary tour

Choose destination

Choose tour mode

Choose destination

Choose tour mode

Choose tour mode

Generate subtours

Choose duration

Choose destination

Choose subtour mode
Destination choice models

Tour stop destinations based on a logit model:

- Utility depends on cost from previous activity, cost to following activity and destination attractiveness
- Locations close to the origin or the main tour activity are more likely to be selected as stops
Preliminary results

- Operational, uncalibrated model is available now
- Runtime: 1 h 55 min with 4.4 million persons, without traffic assignment (0.0014 s/person)
  - 68 million activities (9.6 million activities per day – 2.2 per person)
  - 121 million legs (17 million legs per day – 3.9 per person)
Incremental update of travel demand
Travel behavior may differ a lot from day to day (Raux et al. 2016), but it does not change dramatically from year to year (McCarthy 1982, Kitamura 1987).

Life events, such as household relocation, graduation from school, change of job, birth of a child, etc., may change travel behavior fundamentally.

But for most agents, such changes are rare, and travel behavior changes marginally if at all.

By contrast, transport models tend to recreate travel behavior from scratch every time the model runs! Habitual behavior and attitudes are typically ignored in transport models.
Traditionally, successive transport model runs are independent:

- No memory, random variations that might be unrealistic
“Broken” travel times

In this integrated LU/T model, the transport models is run every 15, 5 or 2 years.

- Transport model should run every year to avoid jumps in travel time.
- Long run times of transport models typically prohibit frequent runs.

Frequency of transport models:
- a) every 15 years
- b) every 5 years
- c) every 2 years

Graph showing average commute time (min) versus year from 2020 to 2040.
Idea

State of practice

Synthetic population 2011 → Travel demand 2011 → Assignment 2011

Synthetic population 2012 → Travel demand 2012 → Assignment 2012

Synthetic population 2013 → Travel demand 2013 → Assignment 2013

Synthetic population 2050 → Travel demand 2050 → Assignment 2050
State of practice

Practice at TUM

ABIT Model

Idea
Idea

- For most agents, copy weekly travel demand generated by ABIT from previous year.
- For agents who experienced a major life event (birth of child, change of job, etc.), adjust travel behavior.
- Also, recalculate travel demand for agents where population, employment or travel times changed substantially within their common activity space.
- In the MATSim assignment, remove trips that were dropped, add new trips and keep everything else unchanged. Given the small changes, MATSim should reach an equilibrium again within a few iterations.
German mobility panel

- weeklong travel diaries
- households asked to participate three years in a row
- Data of the last 9 years include 4,043 households and 6,508 persons
- Activities: work, education, shopping or errands, leisure or hobby, pick-up or drop-off, recreational round trips and other
- Modes: walk, bicycle, car driver, car passenger and public transport (city bus, long-distance bus, light rail, subway, regional and long-distance trains)

### Dataset

<table>
<thead>
<tr>
<th>Kohorte</th>
<th>2016</th>
<th>2017</th>
<th>2018</th>
<th>2019</th>
<th>2020</th>
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Quelle: Deutsches Mobilitätspanel
Life events considered

1. Change in employment status of a person,
2. Change in household size,
3. Birth of a new child,
4. Change in household car ownership and
5. Household relocation.

The number of weekly trips by purpose and mode were compared between people with and without such life events.

<table>
<thead>
<tr>
<th>Number of Life Events</th>
<th>Persons</th>
<th>Proportion</th>
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<tr>
<td>0</td>
<td>7782</td>
<td>76.8%</td>
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<tr>
<td>1</td>
<td>1781</td>
<td>17.6%</td>
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<td>2</td>
<td>464</td>
<td>4.6%</td>
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<tr>
<td>3</td>
<td>97</td>
<td>1.0%</td>
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<tr>
<td>4</td>
<td>13</td>
<td>0.1%</td>
</tr>
<tr>
<td>5</td>
<td>2</td>
<td>0.0%</td>
</tr>
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</table>

Ignored so far due to uncertainty how multiple life events might interact
Change in employment status

Change in work trips
Change in employment status

Change in weekly work trips
Change in employment status

Change in education trips
Change in employment status

Change in shopping trips

Change in Weekly Shopping/Errands Trips

- Employed (N = 3816) Weighted Mean = -0.26
- Employed to Unemployed (N = 312) Weighted Mean = 0.33
- Unemployed (N = 3966) Weighted Mean = -0.193
- Unemployed to Employed (N = 230) Weighted Mean = -0.861
Change in employment status

Change in escort trips
### TABLE 2: Weighted average change in weekly number of trips by purpose and life event.

<table>
<thead>
<tr>
<th>Car ownership</th>
<th>Work trips</th>
<th>Education trips</th>
<th>Shopping/ errand trips</th>
<th>Leisure/hobby trips</th>
<th>Pickup/ drop-off trips</th>
<th>Other trips</th>
<th>Recreational round trips</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zero</td>
<td>0.082</td>
<td>-0.108</td>
<td>-0.169</td>
<td>-0.175</td>
<td>0.026</td>
<td>0.265</td>
<td>0.014</td>
</tr>
<tr>
<td>Remained same</td>
<td>-0.035</td>
<td>-0.044</td>
<td>-0.236</td>
<td>-0.299</td>
<td>-0.022</td>
<td>0.175</td>
<td>0.011</td>
</tr>
<tr>
<td>Increased</td>
<td>-0.155</td>
<td>-0.063</td>
<td>0.011</td>
<td>0.072</td>
<td>-0.086</td>
<td>0.106</td>
<td>-0.216</td>
</tr>
<tr>
<td>Decreased</td>
<td>-0.329</td>
<td>-0.328</td>
<td>-0.734</td>
<td>-0.239</td>
<td>-0.21</td>
<td>0.092</td>
<td>0.052</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Household size</th>
<th>Work trips</th>
<th>Education trips</th>
<th>Shopping/ errand trips</th>
<th>Leisure/hobby trips</th>
<th>Pickup/ drop-off trips</th>
<th>Other trips</th>
<th>Recreational round trips</th>
</tr>
</thead>
<tbody>
<tr>
<td>No change</td>
<td>-0.015</td>
<td>-0.054</td>
<td>-0.225</td>
<td>-0.278</td>
<td>-0.014</td>
<td>0.19</td>
<td>0.012</td>
</tr>
<tr>
<td>Increased</td>
<td>-0.077</td>
<td>-0.062</td>
<td>-0.428</td>
<td>-0.146</td>
<td>0.702</td>
<td>0.12</td>
<td>-0.206</td>
</tr>
<tr>
<td>Decreased</td>
<td>-0.021</td>
<td>-0.052</td>
<td>-0.478</td>
<td>0.097</td>
<td>0.023</td>
<td>0.129</td>
<td>0.019</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Child birth</th>
<th>Work trips</th>
<th>Education trips</th>
<th>Shopping/ errand trips</th>
<th>Leisure/hobby trips</th>
<th>Pickup/ drop-off trips</th>
<th>Other trips</th>
<th>Recreational round trips</th>
</tr>
</thead>
<tbody>
<tr>
<td>Child born</td>
<td>-0.067</td>
<td>-0.191</td>
<td>-0.297</td>
<td>-0.437</td>
<td>-0.288</td>
<td>-0.146</td>
<td>-0.002</td>
</tr>
<tr>
<td>No child born</td>
<td>-0.015</td>
<td>-0.054</td>
<td>-0.225</td>
<td>-0.278</td>
<td>-0.014</td>
<td>0.19</td>
<td>0.012</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Household move</th>
<th>Work trips</th>
<th>Education trips</th>
<th>Shopping/ errand trips</th>
<th>Leisure/hobby trips</th>
<th>Pickup/ drop-off trips</th>
<th>Other trips</th>
<th>Recreational round trips</th>
</tr>
</thead>
<tbody>
<tr>
<td>Relocation</td>
<td>0.089</td>
<td>-0.122</td>
<td>-0.047</td>
<td>-0.356</td>
<td>-0.063</td>
<td>0.328</td>
<td>-0.47</td>
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<tr>
<td>No relocation</td>
<td>-0.015</td>
<td>-0.054</td>
<td>-0.225</td>
<td>-0.278</td>
<td>-0.014</td>
<td>0.19</td>
<td>0.012</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Employment status</th>
<th>Work trips</th>
<th>Education trips</th>
<th>Shopping/ errand trips</th>
<th>Leisure/hobby trips</th>
<th>Pickup/ drop-off trips</th>
<th>Other trips</th>
<th>Recreational round trips</th>
</tr>
</thead>
<tbody>
<tr>
<td>Employed</td>
<td>-0.057</td>
<td>-0.012</td>
<td>-0.26</td>
<td>-0.193</td>
<td>-0.033</td>
<td>0.161</td>
<td>0.005</td>
</tr>
<tr>
<td>Employed to unemployed</td>
<td>-1.806</td>
<td>0.445</td>
<td>0.33</td>
<td>0.003</td>
<td>0.101</td>
<td>0.524</td>
<td>-0.118</td>
</tr>
<tr>
<td>Unemployed</td>
<td>0.022</td>
<td>-0.093</td>
<td>-0.193</td>
<td>-0.354</td>
<td>0.004</td>
<td>0.216</td>
<td>0.018</td>
</tr>
<tr>
<td>Unemployed to employed</td>
<td>1.738</td>
<td>-0.838</td>
<td>-0.861</td>
<td>-0.554</td>
<td>-0.087</td>
<td>0.122</td>
<td>-0.02</td>
</tr>
</tbody>
</table>

| Total*            | -0.039     | -0.083          | -0.223                 | -0.29               | -0.027                 | 0.185       | -0.001                   |

* Includes total population with and without life event as shown in Table 1.
It is hypothesized that the incremental model requires smaller constants than traditional activity-based models that recreate travel behavior from scratch.

It is further hypothesized that the incremental runs much faster than traditional activity-based models, as most activities and travel choices are copied from the previous year.

There are still ‘unexplainable’ changes in travel behavior that would still require some random effect in agent-base models. However, the more elements we are able to move from random effect to explainable effects with empirical evidence, the more meaningful the policy sensitivities in transport models will become.
Thank you

For more information, visit our ABIT wiki:
https://wiki.tum.de/display/msmmodels/abit

Download the code
https://github.com/msmobility/abit

Acknowledgment

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