# Automatic calibration of agent-based public transit assignment path choice to count data

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## 1 Agent-based transit assignment

Schedule-based transit assignment has become rather mainstream. Reasons for this include on the one hand that certain aspects of the complexity of public transit, e.g. multi-stage trips, reliability, different vehicle sizes, are difficult to capture in more traditional flow-based models; and on the other hand that growing computational capabilities make it now possible to run schedule-based transit assignments for large scenarios.

The step from schedule-based transit assignment to agent-based transit assignment is not very large. As a tendency, the agent-based approach attaches more information to the individual traveler, for example the full daily plan rather than treating each trip separately. The approach considered here will be:

1. **Initialization:** Synthetic travelers with activity-based day plans are assumed to be given. Any missing information is now generated by a synthetic procedure. This includes generating suitable connections through the public transit network for each trip that is part of the passenger's plan.

2. **Synthetic reality** (aka **network loading):** All these plans are executed simultaneously in a simulation of the physical system ("synthetic reality") which includes a detailed simulation of the public transit system (Rieser, 2010; Rieser and Nagel, 2009). This simulation can and should include travel incidents such as boarding delays, failures because of overloading, delays because of late incoming vehicles, etc.

3. **Scoring:** Each plan is scored based on its own performance in the synthetic reality.

4. **Choice set modification:** The synthetic travelers try to construct new plans given their experience from the previous simulated day. These new plans are added to the agents' choice sets.

   Bad plans are removed from the agents' choice sets.

5. **Choice:** All other agents select between already known plans, typically with a logit model.

6. Goto (2).

That iterative loop is continued until some appropriate convergence criterion is reached. The loop describes day-to-day learning; one may, in particular for the investigation of short-term customer reactions, also include within-day or en-route learning.

## 2 Challenge: Calibration

An important challenge for the agent-based approach for the recent past has been computational: Finding an implementation that is both close to the agent-based concepts and fast enough for real world scenarios. Another challenge has been calibration. More technically: Given a set of macroscopic observations $\vec{y}$, how should the physical or behavioral microscopic rules of the agent-based simulation be modified in order to move the simulation closer to the observations?

The example considered here is a situation where one has hourly or daily passenger counts for certain or all transit lines, demand for 1% of the population from trip diaries, but no route information from the survey. The task is to find passenger connections and possibly modify the passenger demand such that the simulation matches the counts.

This topic belongs to a class of problems which are quite common in agent-based simulations. Agent-based simulations were always built around the notion of "emergence", that is, they are expected to be particularly useful where certain macroscopic properties, in our case congestion, vehicle overloading, and resulting delay patterns, cannot be derived in analytical ways from the microscopic input data (including the behavioral rules), and in consequence one needs to run the simulation in order to obtain them. However, because the connection from input data to emergent properties is by simulation, the mathematical connection is not as well established as in normal numerical modelling.

## 3 A solution approach: Cadyts

For transport simulations, but with the clear potential to be more general, the problem was addressed by G. Flötteröd and co-workers (e.g. Flötteröd, 2008; Flötteröd et al., 2011). He implemented his methodological approach into the open source software Cadyts (Flötteröd, 2009). Very intuitively, the approach uses the freedom that is left when individual decisions are modelled as random draws from a discrete choice model: decisions that are congruent with the observations become preferred over those that are not.

We have so far considered two ways to apply Cadyts to agent-based public transit assignment. In the first approach (Moyo O. and Nagel, 2012), multiple plans per public transit passenger were precalculated according to different criteria, such as least number of interchanges, least amount of walking, or some balance of the criteria. Cadyts would then select those plans most consistent with the observations.

While that approach worked well, it depended on the fixed set of precalculated transit connections. This would not allow the calibration procedure to guide the search into directions most consistent with the observations. For that reason, a second approach was investigated, with the following characteristics:

- New plans are now generated as part of the choice set modification step (Step 4). For this, a transit routing algorithm is used that randomizes the utility coefficients of in-vehicle time, walk time, wait time, and number of interchanges, before searching for a route.
- The Cadyts offset is now, in Step 3, added to the plans score rather than only used during choice. The main effect is that the Cadyts offset is also considered during plans removal (Step 4) which it is not in the original implementation where it could easily happen that plans that were good from a calibration perspective would be removed anyways.

Both approaches are applied both to a small scenario consisting of a single Berlin transit line having hourly passenger counts, and a large scenario consisting of all Berlin transit lines but having only daily passenger counts available.

The results demonstrate clearly that the approach is able to work with very large scale real world scenarios, and that it is able to deal with the inter-temporal aspects implied by hourly counts.

The next challenge will be how to make these findings useful for prediction. Our approach for this will be to extract behavioral parameters, possibly per individual, which would explain behaviorally the choices that are most consistent with the measurements.

A similar abstract was submitted to the Conference on agent-based modeling in transportation planning and operations (`http://www.cpe.vt.edu/abmconf`).

## References


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