Integration of Land Use, Travel Demand and Network Simulation Models

Case of the Atlanta Regional Commission

PARSONS BRINCKERHOFF

Principal investigators

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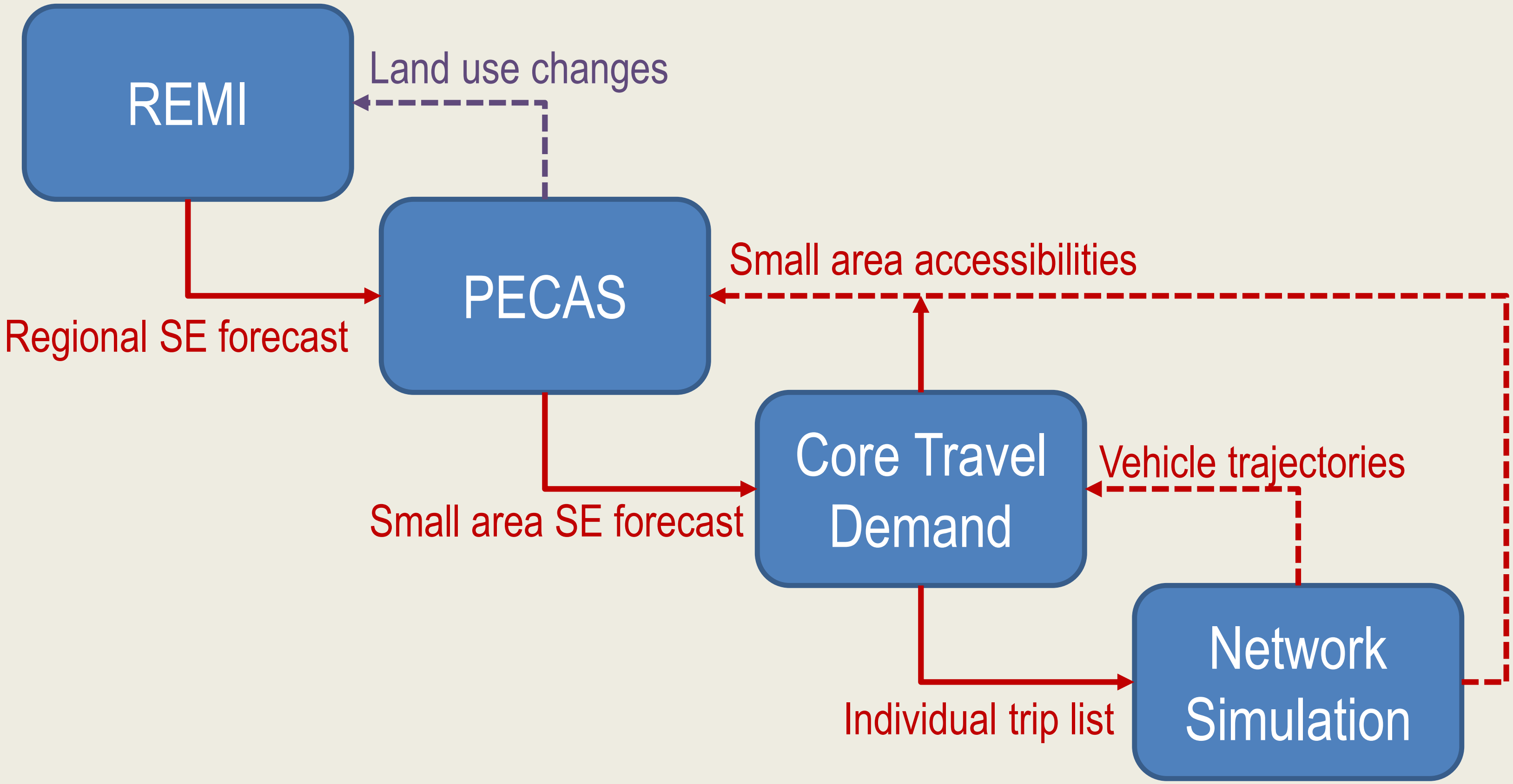
- Jim Hicks, Software Architecture
- Yi-Chan Chiu (Metropia), DTA
- Robert Tung (Metropia), DTA Network
- Guy Rousseau, ARC Modeling Manager

Atlanta Regional Commission system of integrated models



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LAND USE | TRANSPORT INTEGRATION

PECAS to ABM integration (goal)

- Small area (TAZ) land use estimates for use in destination choice models
  - Employment for ~20 industrial classifications
  - Total households
- Synthetic population control totals
  - Households by size and income (TAZ control)
  - Workers by occupation (LUZ control)

PECAS to ABM integration (reality)

- PECAS small area forecasts may be adjusted due to:
  - Consultation with local jurisdictions
  - Forecast overrides to correct for bad/incomplete base year parcel data

ABM to PECAS integration

- TAZ to TAZ Accessibilities
  - Work location mode choice logsums
  - Travel times

Principal schema of deep integration

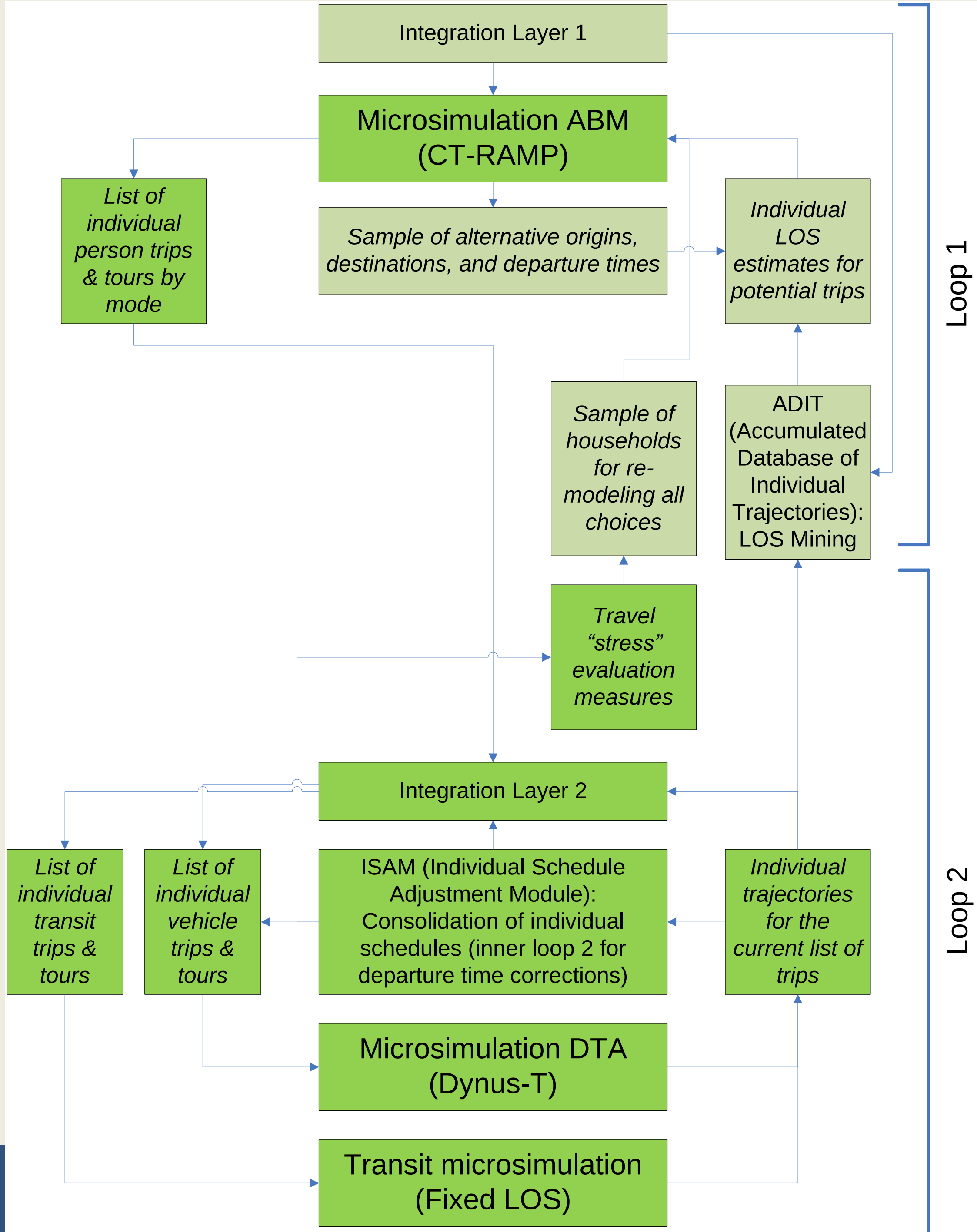
CORE DEMAND | NETWORK SIMULATION INTEGRATION

Motivation

- Improve representation of dynamically priced transport facilities
- Raise the temporal resolution of the network simulation to resolution of the core demand model (30 minutes)
- Forecast travel plans that are feasible in time and space

Integration layer components

- External loop 1 w/mining individual trajectories LOS
- Internal loop 2 w/individual Schedule Adjustment Module (iSAM)

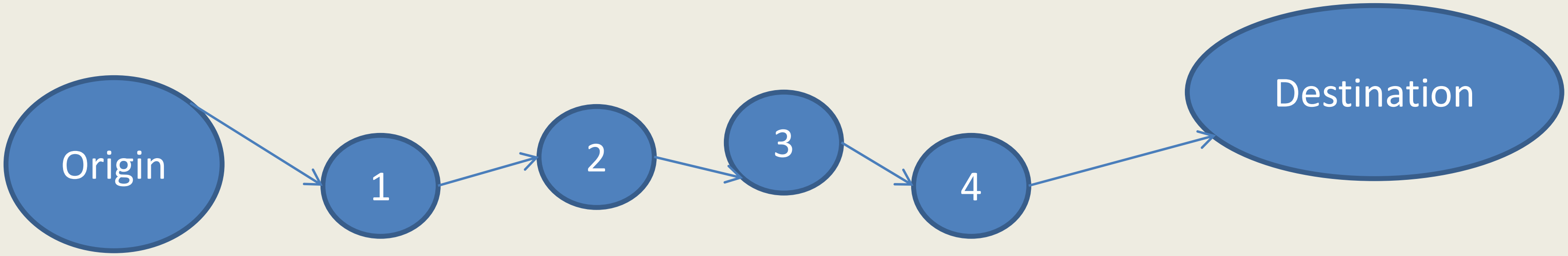


Focus on individual trajectories replacing level of service skims

EXTERNAL LOOP 1

Learning about space from individual trajectories

- One implemented trip provides individual learning experience w.r.t. multiple destinations [*Tian & Chiu, 2014*]



OD pairs covered:

OD,

O1, O2, O3, O4, 1D, 2D, 3D, 4D

12, 13, 14, 23, 24, 34

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Trajectory processing steps

- One-time (per global iteration after DTA) processing of databank (ADIT):
  - Trajectory detail file from DTA
  - Node – trajectory index for search
- On the fly search with relaxations (ABM):
  - Iterative match by index combinations
  - Trajectory evaluation by weighted discrepancy if multiple trajectories found

Sub-trajectory storage

Field	Role in the database
Global iteration	Control for LOS record priority for the next iteration
Individual person/vehicle ID	Control for LOS record priority for the next iteration
Car occupancy	Index for matching to the modeled trip
Value of time (VOT)	Index for matching to the modeled trip
Origin node	DynusT output subsequently translated into MAZ or TAZ
Destination node	DynusT output subsequently translated into MAZ or TAZ
Origin TAZ	Index for matching to the modeled trip
Destination TAZ	Index for matching to the modeled trip
Departure time	Index for matching to the modeled trip
Travel time, min	LOS measure
Free-flow time, min	LOS measure
Distance, miles	LOS measure
Toll, $	LOS measure
Toll equivalent, min	LOS measure

Current aggregation levels for trajectory search

0	Trip origMaz == Trip destMaz
1	vehicles located with same origMAZ, destMAZ, and 5 minute departure interval as trip
2	vehicles located with same origMAZ, destMAZ, and 15 minute departure interval as trip
3	vehicles located with same origTAZ, destTAZ, and 15 minute departure interval as trip
4	vehicles located with same origTAZ, destTAZ, and 60 minute departure interval as trip (benchmark similar to conventional skimming)
9	no vehicles found for aggregation levels 1-4

Coverage

Test case: Columbus (Ohio) ABM | 4.8 m vehicle trajectories

Departure Period		0	1	2	3	4	9	Total
EA	Before 6:00 am	6%	37%	11%	21%	11%	14%	100%
AM	6:00 am - 8:59 am	2%	53%	12%	20%	6%	6%	100%
MD	9:00 am - 3:59 pm	4%	48%	12%	21%	8%	7%	100%
PM	4:00 pm - 6:59 pm	1%	52%	13%	21%	7%	5%	100%
EV	7:00 pm and later	2%	35%	13%	26%	11%	13%	100%
Total		4%	46%	12%	21%	8%	8%	100%

Interim conclusions Loop 1

- 70% of trips found representative trajectories better than conventional skims
- ARC test (forthcoming):
  - 20M trips and trajectories (better chance than MORPC)
  - 5,000 TAZs instead of 20,000 MAZs (better chance than MORPC)
  - VOT and occupancy segmentation (worse chance than MORPC)
- Further expected improvement of coverage:
  - Gradual freezing of HHs, persons, and trips
  - Accumulation of trajectories from multiple global iterations
- Ways to resolve unmatched trips:
  - Use background skims (probably preferred)
  - Apply further aggregation (technically works but may produce unreasonable results)

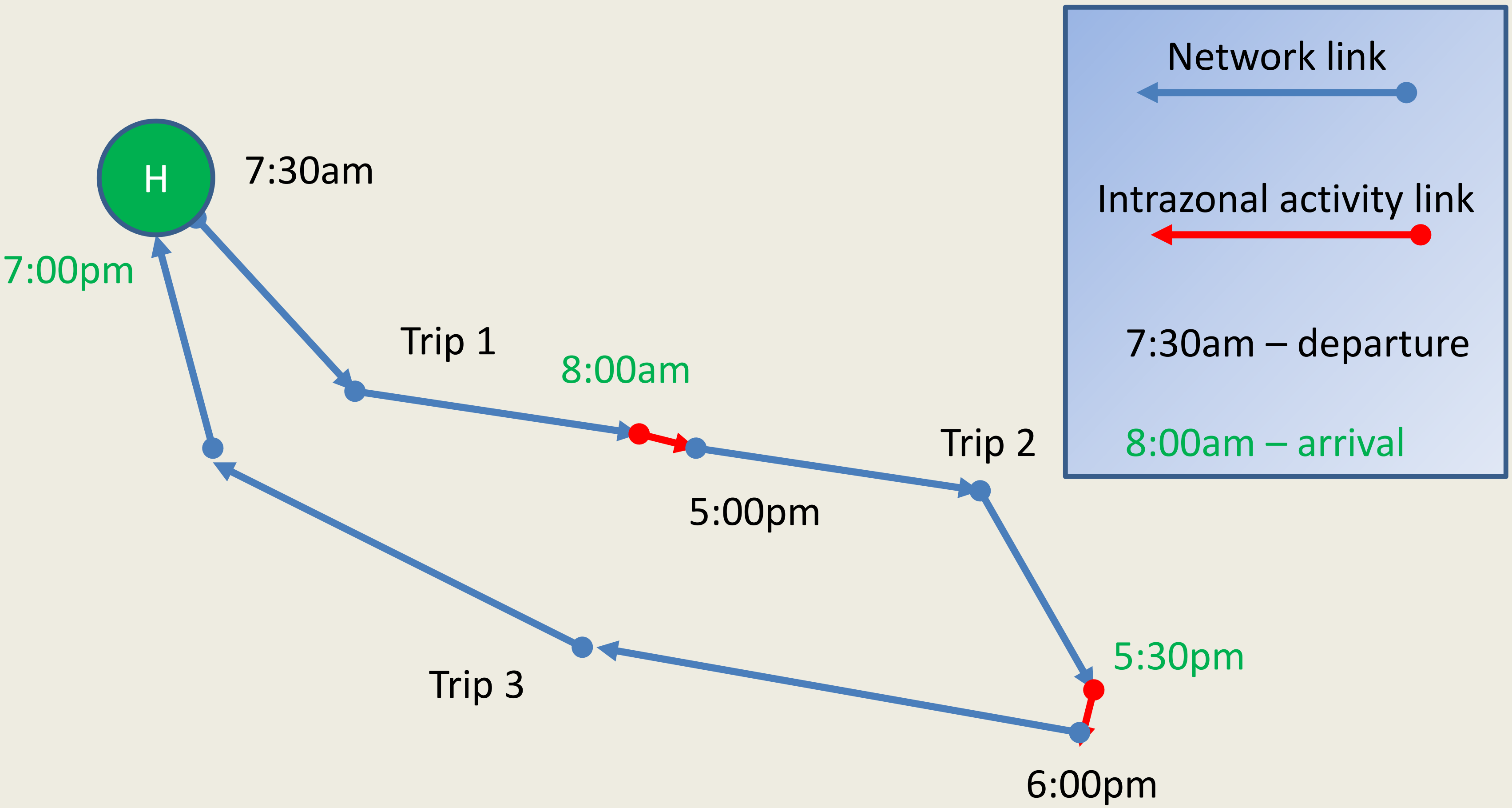
Focus on internal equilibration and individual schedule consistency

INTERNAL LOOP 2

Loading trip chains – individual schedule consistency

- Loading trips chains (Mahmassani et al, 2000-2016):
  - Cannot start next trip until the previous trip of the same individual and activity have been completed
  - Real-time simulation consideration as DTA extension
- Individual schedule consistency:
  - The same concept formulated as trips and activities cannot have time gaps or overlaps
  - Planning (scheduling) consideration as ABM extension

Loading trip chains (feasible)



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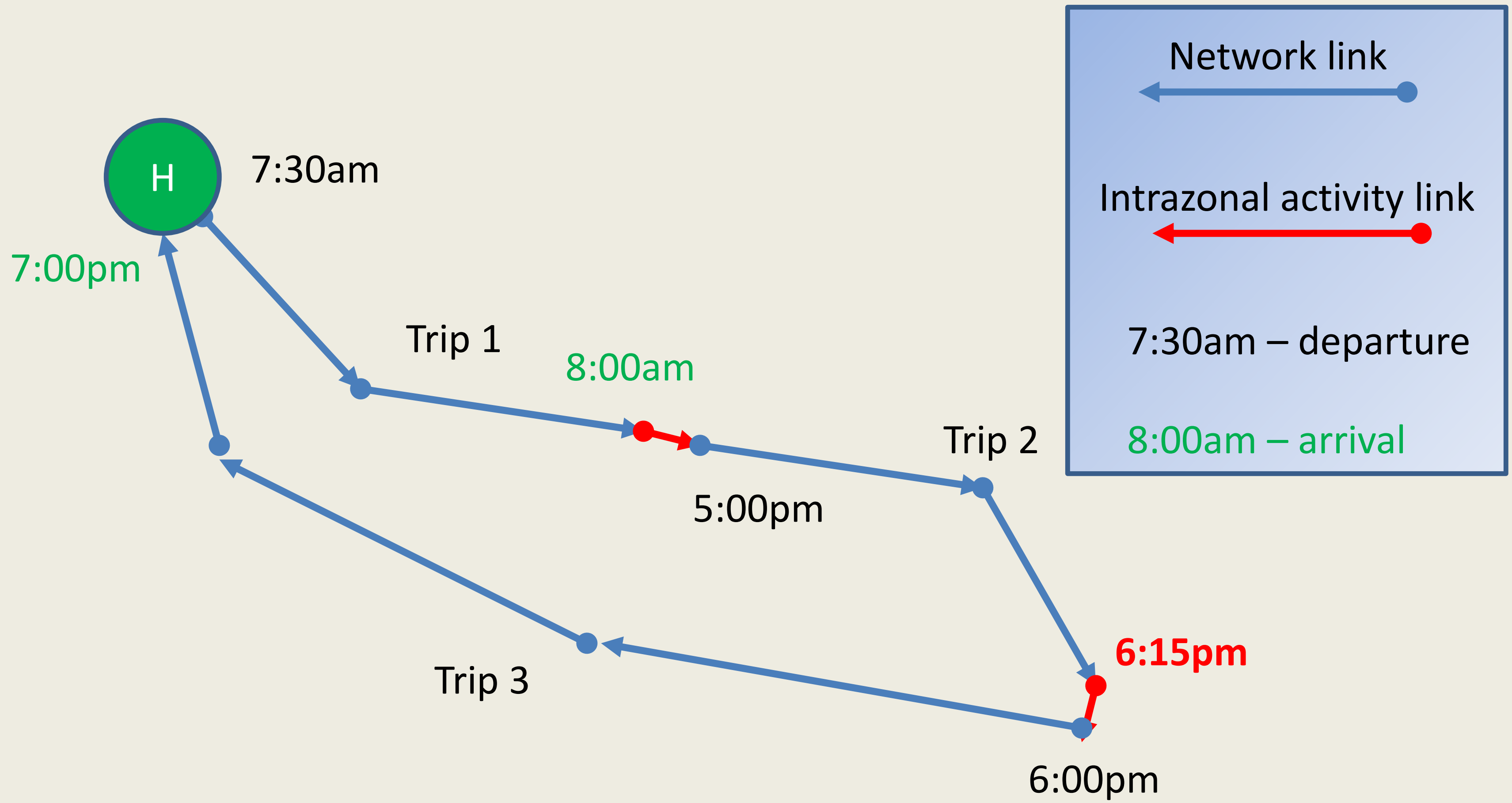
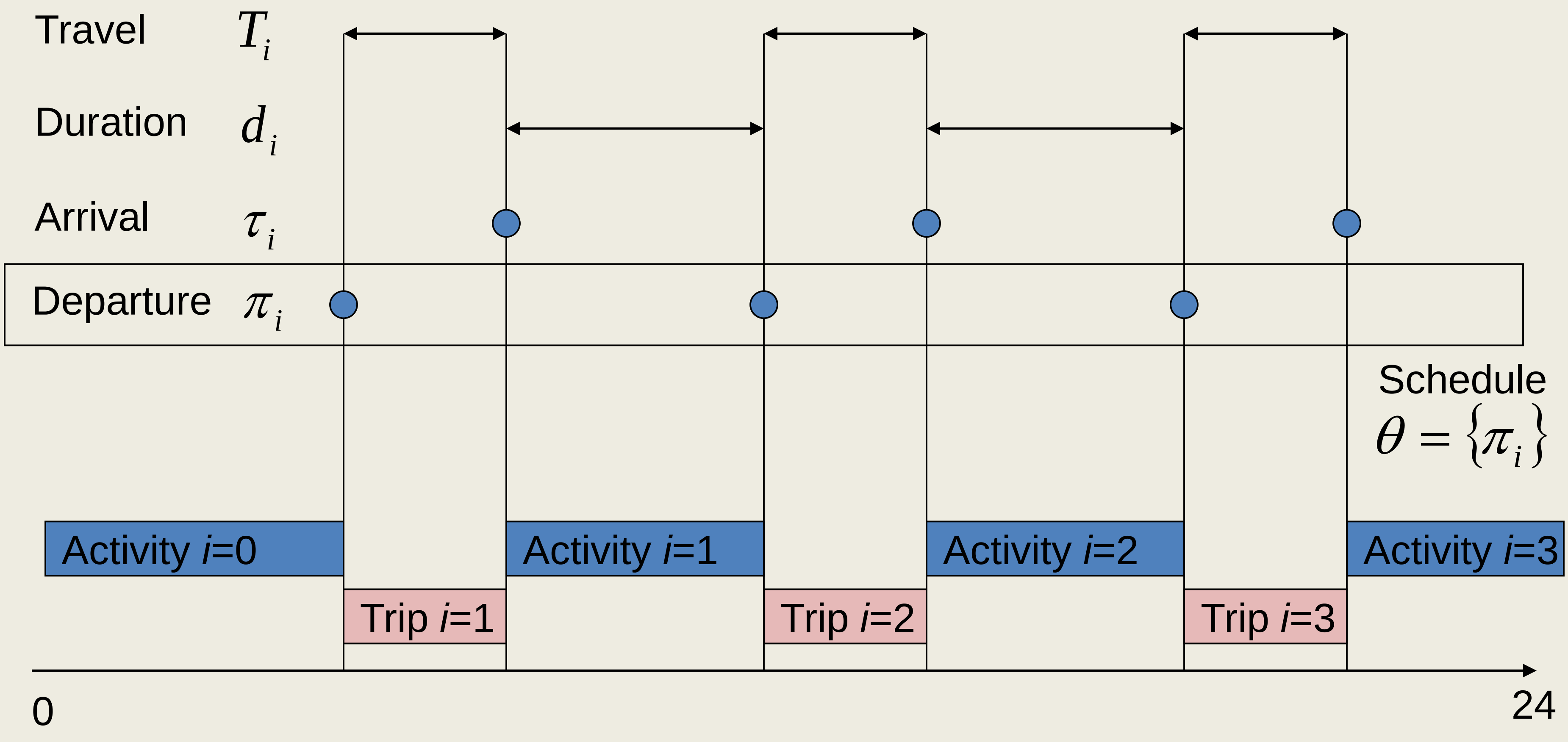
Loading trip chains (infeasible)



Individual schedule consistency



Schedule adjustment (iSAM)

- Fixed trip and tour list for each person (including joint trips)
- Adjust trip departure times to resolve infeasible schedules, given previously simulated travel times
- Simultaneous application of minimizing “schedule delays” to all trips in person’s trip chain w/intra household interactions
- Repeat network simulation and schedule adjustment until stable solution

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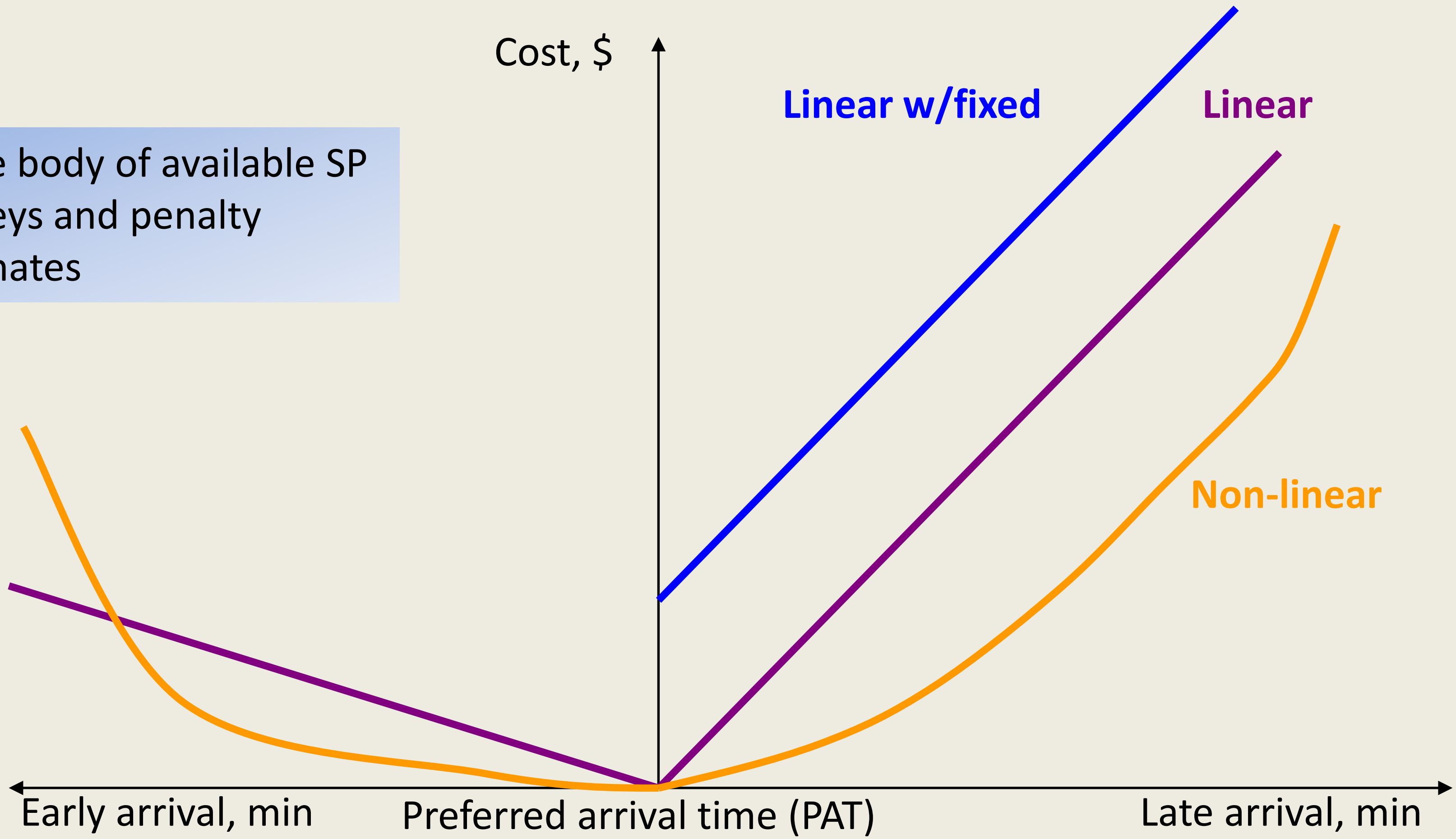
Schedule delay cost

Large body of available SP surveys and penalty estimates



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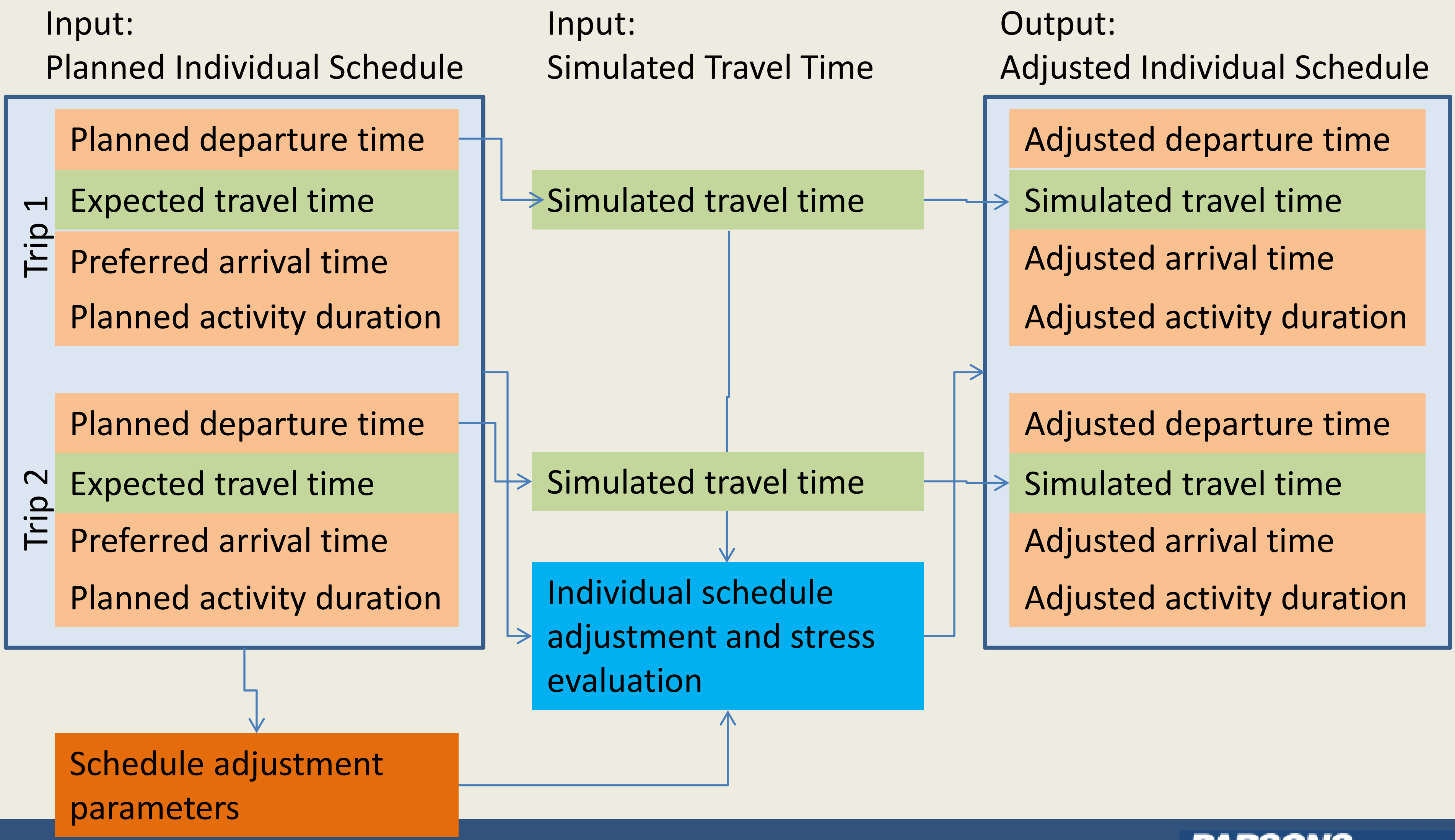
Data input and output for iSAM



iSAM metrics of convergence

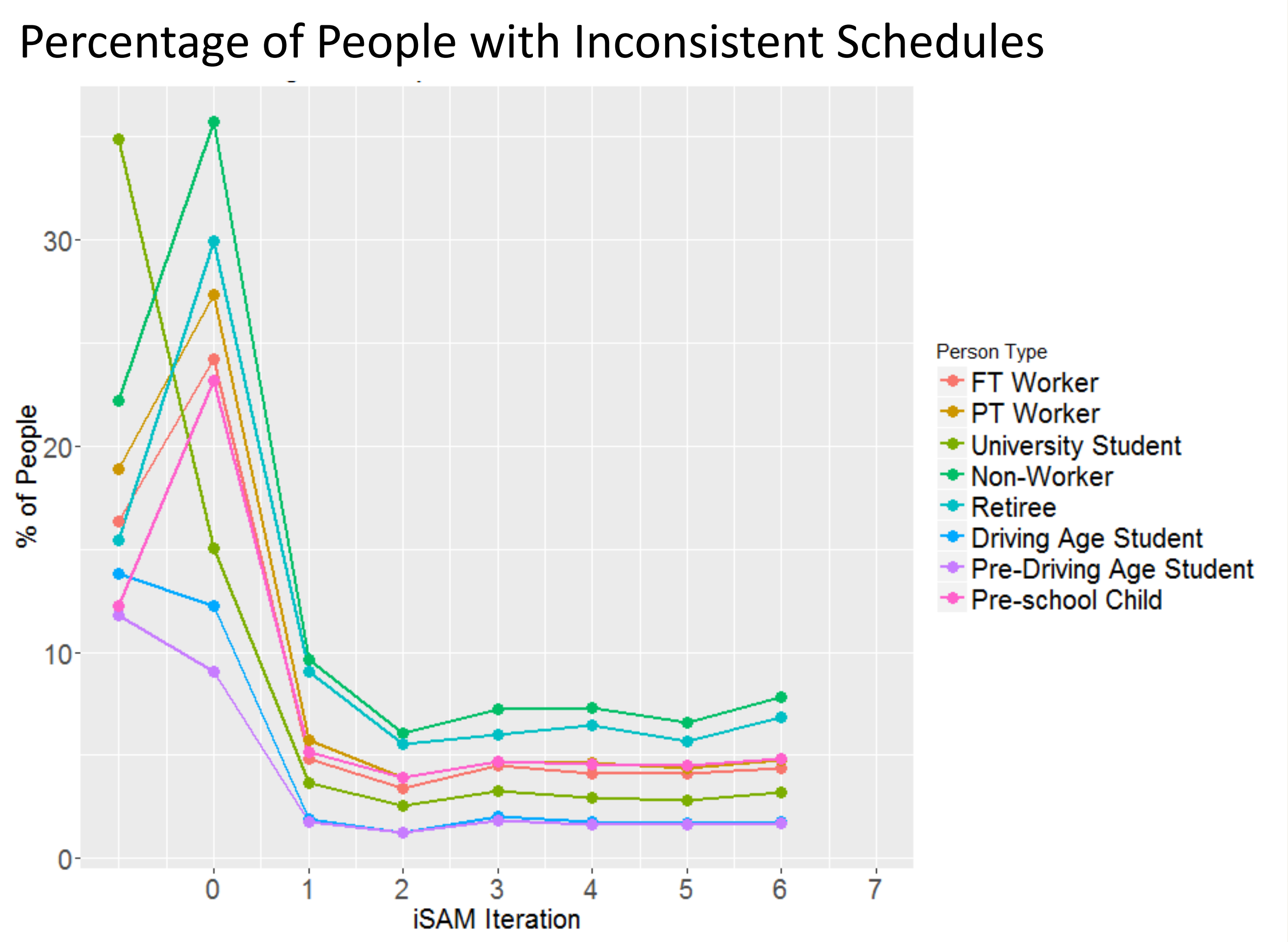
- Ensure full schedule consistency between travel times and activity durations:
  - **Number of persons with inconsistent (negative) activity duration (for at least one activity) at each iteration**
- Simulate the most realistic implementation of the given list of activities, tours, and trips by mode in terms of departure time and route choice and evaluate “stress” (behavioral gap measure) for each individual:
  - **Number of “stressed” persons and HHs at each iteration**
- Ensure stability of the simulation and convergence of departure times and routes:
  - **Number of persons with schedule corrections between two successive iterations for more that 5 min for at least one trip departure time**

Travel “stress” thresholds

Person type	Max total travel time, min	Travel time overhead	Min total out-of-home activity time for overhead, min
1=Full-time worker	240	0.5	180
2=Part-time worker	180	0.8	120
3=University student	240	0.8	120
4=Non worker U65	180	1.5	60
5=Retiree	150	1.5	60
6=Driving-age school child	150	0.4	120
7=Pre-driving-age school child	120	0.4	120
8=Preschool child	120	0.8	120

- Person is “stressed” if either the max time is reached or max overhead is reached in combination with min (or longer) activity time
- HH is “stressed” if at least one person is “stressed”

Convergence example



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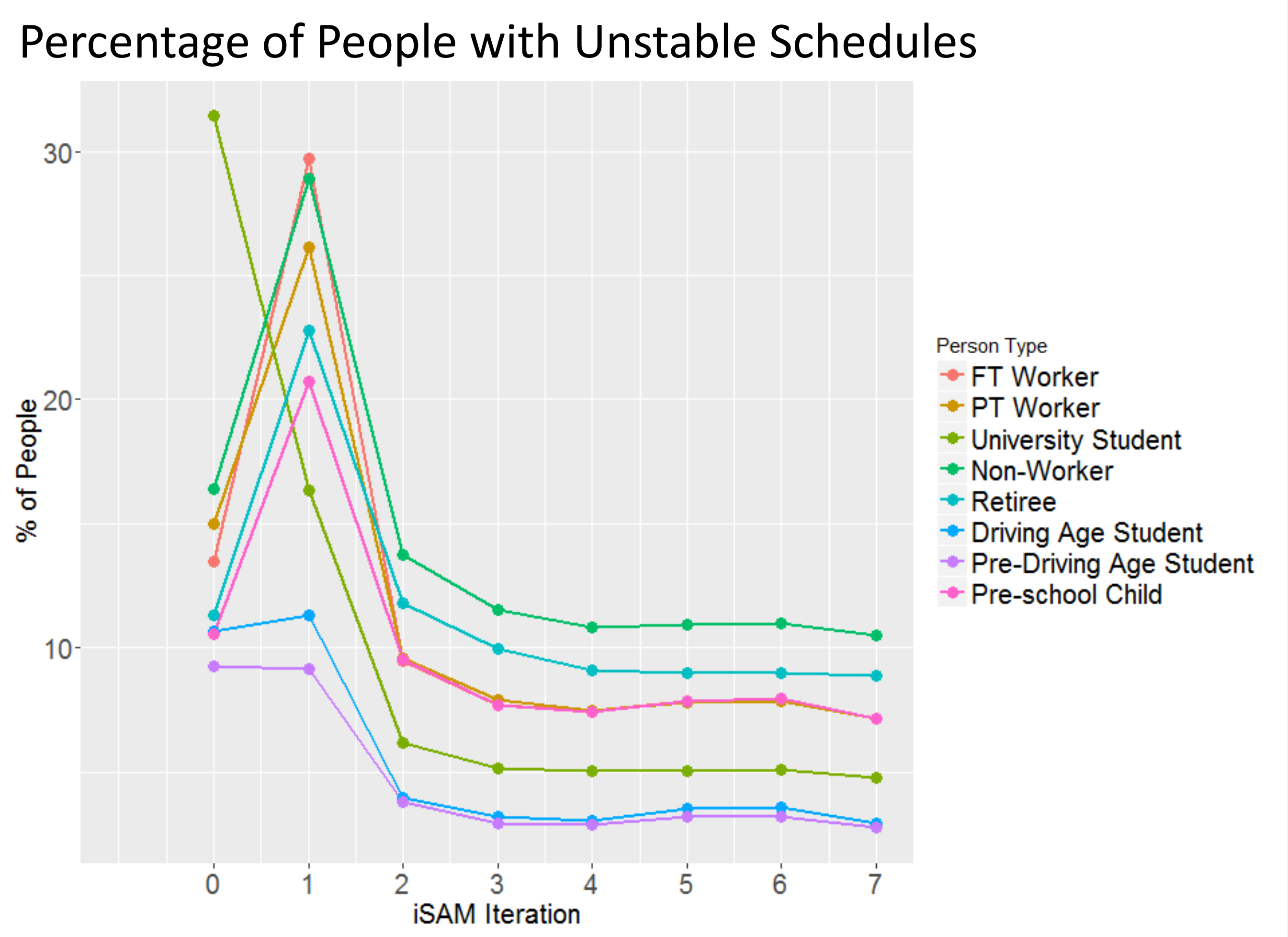

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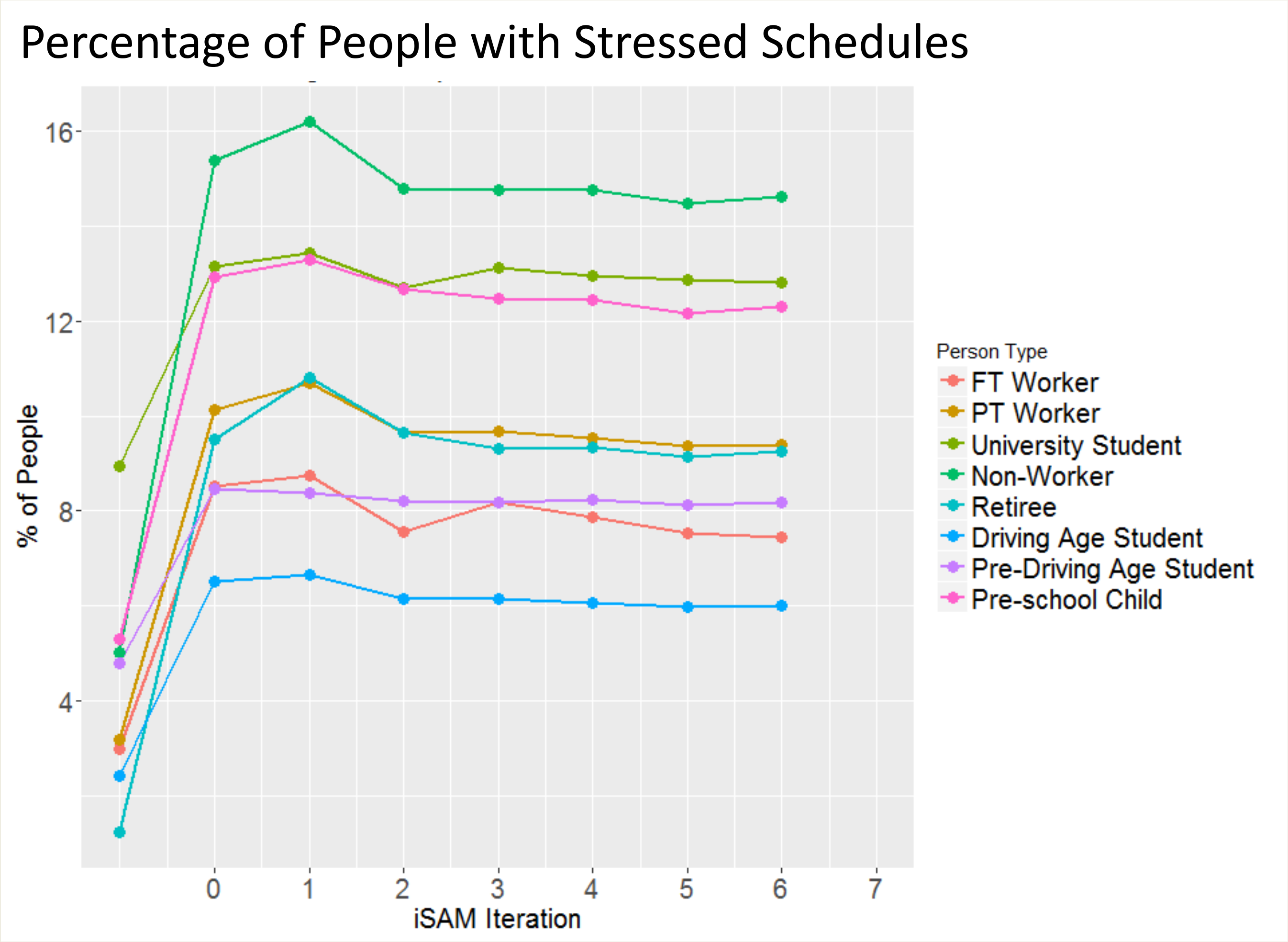

Interim conclusions Loop 2

- Behavior as expected:
  - iSAM cleans up schedule inconsistencies
  - iSAM-DTA iterative application converges to a stable schedule-route equilibrium
  - Number of “Stressed” Households does not tend to zero
    - This is rather information for Loop 1

A few other lessons learned

- Might not the persistence of “stressed” households suggest that the trip location model is too naïve?
- Value added of the travel time simulation (over SUE) is proportional to the effort spent in attributing the network
- Substantial runtime improvements needed for the model to be relevant for practical planning
- Performance as a tool for alternatives analysis still to be demonstrated