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CEMDAP: An Introduction

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Five Pillars of ABM Design

- Based on sound behavioral theory/paradigm
- Computationally feasible and tractable
  - Model estimation
  - Model implementation
- Optimal use of available data (present and future)
- ABM should be both an Activity-Based Model and an Agent-Based Model
- Sensitive to policy issues and planning applications of interest

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Behavioral Basis of ABM

- Decision hierarchies and choice processes
  - A variety of behavioral decision structures possible
  - Virtually all models assume a sequential decision structure similar to traditional four-step models for computational convenience
- Considerable evidence of simultaneity in behavioral choice mechanisms
  - Several choices made simultaneously as a lifestyle package

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Behavioral Basis of ABM

- Examples of simultaneous choice packages
  - Residential location, vehicle ownership, mode to pre-planned activities (e.g., work)
  - Activity type, activity duration, and activity timing (scheduling)
- Behavioral heterogeneity
  - Differences in choice processes across market segments
  - Identify market segments both exogenously and endogenously (latent market segments)

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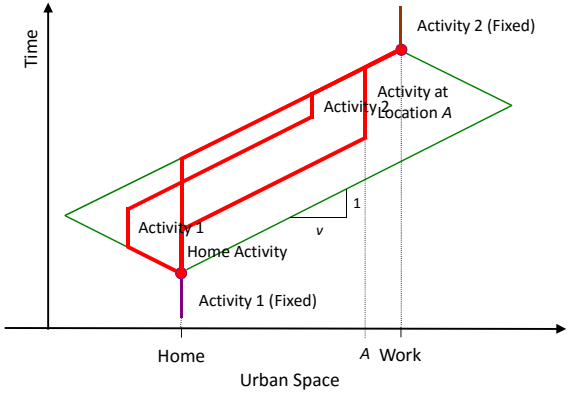
Time-Space Interactions



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Agent Interactions

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Definition of an Activity

- Disaggregate activity purpose definition
  - Challenge traditional notion of mandatory and discretionary activities/trips
  - Movie, ball game, and child's tennis lesson or soccer game often have spatial and/or temporal fixity
  - Characterize activities and trips by level of spatial and temporal fixity/constraints (besides purpose)
    - Can be accomplished using concepts of time-space geography
    - Automated method to add attributes describing degrees of freedom according to set of spatial/temporal fixity criteria to activity records in data set

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Central Role of Time Use

- Notion of time is central to activity-based modeling
  - Explicit modeling of activity durations (daily activity time allocation and individual episode duration)
  - Treat time as "continuous" and not as "discrete choice" blocks
- Activity engagement is the focus of attention
  - Travel patterns are inferred as an outcome of activity participation and time use decisions
  - Continuous treatment of time dimension allows explicit consideration of time constraints on human activities
- Reconcile activity durations with network travel durations (feedback processes)

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In Summary

- ABM should…
  - Capture the central role of activities, time, and space in a continuum
  - Explicitly recognize constraints and interactions
  - Represent simultaneity in behavioral choice processes
  - Account for heterogeneity in behavioral decision hierarchies
  - Incorporate feedback processes to facilitate integration with land use and network models
- SimAGENT does it all and more…

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SIMAGENT (SIMULATOR OF ACTIVITIES, GREENHOUSE GAS EMISSIONS, ENERGY, NETWORKS, AND TRAVEL): AN OVERVIEW

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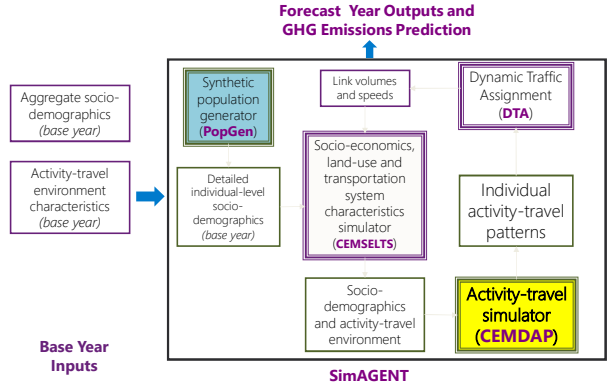
SimAGENT



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CEMDAP
A COMPREHENSIVE ECONOMETRIC MICROSIMULATOR OF DAILY ACTIVITY-TRAVEL PATTERNS

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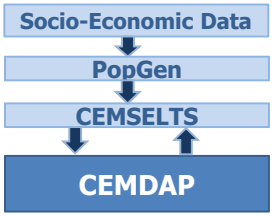
CEMDAP – The Core ABM in SimAGENT



- Simulates **activity schedule** and **travel** characteristics for each individual of the region
- Core module of SimAGENT
- 52 sub-models.
- Developed by UT Austin

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CEMDAP: A Policy Responsive Tool

- Holistic model system with closely inter-related models
- Cascading effect with secondary and tertiary changes occurring throughout the activity schedule of the day
- Changes in the activity-travel pattern of one individual in a household affect activity-travel patterns of other household members
- Also recognizes the presence of constraints in activity-travel patterns that may result in little or no change
- Enhanced sensitivity to LU, built environment and development patterns, and multi-modal transportation policies – team has pioneered the development of time-sensitive, fine-scale, accessibility measures

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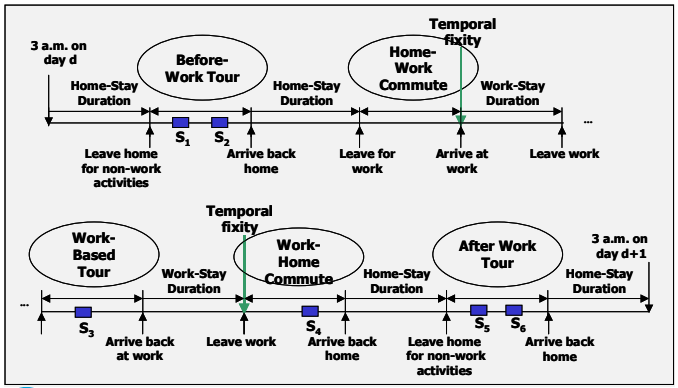
CEMDAP: A Continuous-Time ABM



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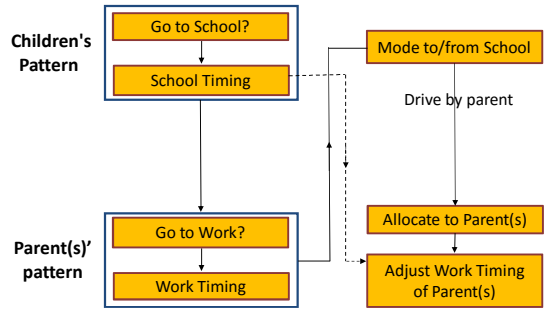
Adult-Child Interaction
An Interleaved Approach



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CEMDAP Sensitivity

- **Work Start & End times**
  - Auto IVTT & Cost
- **Determining Households with Non-zero OH Non-Work Duration**
  - Hansen Type Accessibility Measures: Retail and Service Employment Accessibility, Population Accessibility
  - Several Opportunity-based accessibility Measures
- **Non-work Independent and Joint Activity Participation Decisions**
  - Hansen Type Accessibility Measures: Retail and Service Employment Accessibility, Population Accessibility
  - Several Opportunity-based accessibility Measures
- **Number of Non-Commute Tours**
  - Several Opportunity-based accessibility Measures

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CEMDAP Sensitivity (continued)

- **Commute Mode Choice Decisions**
  - IVTT, OVTT, Cost
  - Several Opportunity-based accessibility Measures
- **Non-Commute Mode Choice Decisions**
  - Hansen Type Accessibility Measures
  - Several Opportunity-based accessibility Measures
- **Number of Stops in Tour**
  - Several Opportunity-based accessibility Measures
  - IVTT for commute tours
- **Stop Location Decisions**
  - Hansen Type Accessibility Measures: Retail and Service Employment Accessibility, Population Accessibility
  - Several Opportunity-based accessibility Measures
  - Generalized cost

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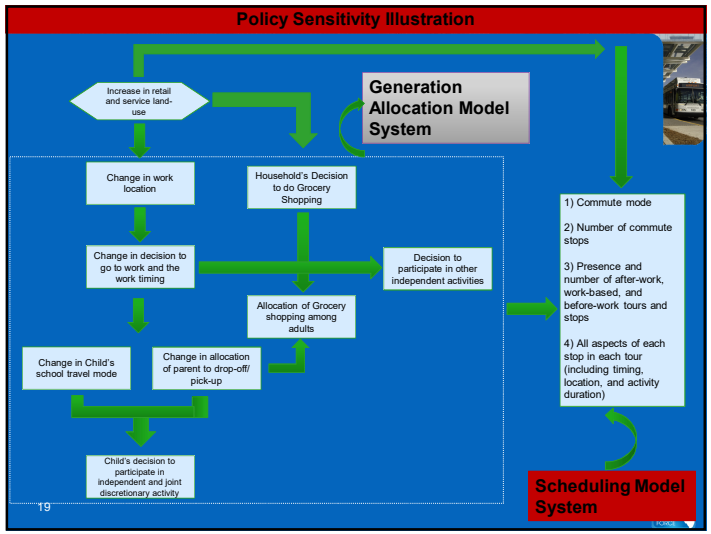
Policy Sensitivity Illustration



INNOVATION: COMPREHENSIVE REPRESENTATION OF INTRA-HOUSEHOLD INTERACTIONS

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Joint Activities and Household Interactions MDCEV Model

- Most activity based models accommodate activity type choice as a series of models for each individual in the household
- These approaches do not explicitly recognize that activity participation is a **collective decision** of household members
- **MDCEV approach** – simple and relatively inexpensive for modeling activity participation at a household level
- SimAGENT now features MDCEV modeling methodology to capture household-level activity participation

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Joint Activities and Interactions MDCEV Model

- Conventional discrete choice frameworks **need to generate mutually exclusive alternatives** → results in an explosion in the number of alternatives
- MDCEV allows us to tackle the problem by considering **activity participation as a household decision**
- MDCEV offers **substantial computational and behavioral advantages**
  - Employ one model to generate activities
  - Accommodate substitution/complementarity in activity participation and household member dimensions

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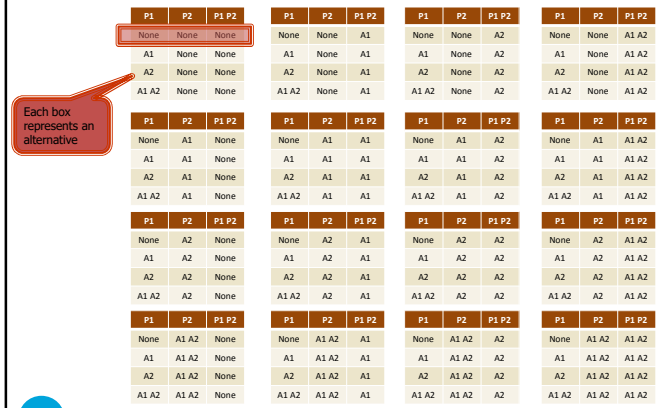
MDCEV Model



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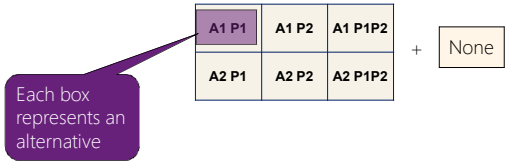
MDCEV Model



Alternatives - Total **7** alternatives versus **64** in traditional case

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Total choice set size comparison for 3 activity purposes

Household Size	Single Discrete Model (MNL)	MDCEV
1	8	3
2	512	9
3	2097152	21
4	3.52×10^{13}	45
5	9.9×10^{27}	93
Total	9.9×10^{27}	171

Once the number of activities increases, the difference will be even more stark!

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INNOVATION: HOUSEHOLD VEHICLE COMPOSITION AND DRIVER ASSIGNMENT

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Household Vehicle Fleet models

- Improves ability to forecast regional fleet mix and use
- Fundamentally important for travel demand modeling and transportation policy analysis

HOUSEHOLD'S NUMBER OF VEHICLES + ***VEHICLE TYPE CHOICE*** + MILEAGE

Determinants of :

Global Climate Change

Fuel Consumption

Green House Gas Emissions

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Household Vehicle Fleet Models

- **Currently travel models are interfaced with EPA's MOBILE6, MOVES or EMFAC for emissions analysis**
  - **Offers simplicity**
  - **Do not reflect local conditions**
  - **No basis to forecast future vehicle fleet composition changes in fuel prices, socio-economic shifts and policy decisions**

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MDCEV Model Approach

- MDCEV – Multiple Discrete Continuous Extreme Value
  - Simple closed form structure for the probability expressions
  - Allows the choice of multiple alternatives
- A disaggregate vehicle typology which is virtually impossible in traditional choice models
- MDCEV model can incorporate the notion that :
  - households own and use different vehicles for different functional purposes
  - different individuals can have different preferences.

In short, MDCEV model framework offers an elegant, theoretically consistent, and econometrically integrated approach to model vehicle ownership, vehicle type, and vehicle usage decisions, and all of them simultaneously.

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Vehicle Fleet + Primary Driver Model

- Joint estimation of the household vehicle fleet characteristics and identification of the primary driver for each of the vehicles
- Emphasis on primary driver assignment is important
  - household decisions of what body type and vintage of vehicles to own, and who the primary drivers would be for each vehicle, are not made independently
  - the assignment of a primary driver for each vehicle owned by a household can be used in SimAGENT to assign a vehicle to each trip made by the household
  - the primary driver allocation → central behavioral consideration to produce more accurate travel and emissions forecasts in activity based models

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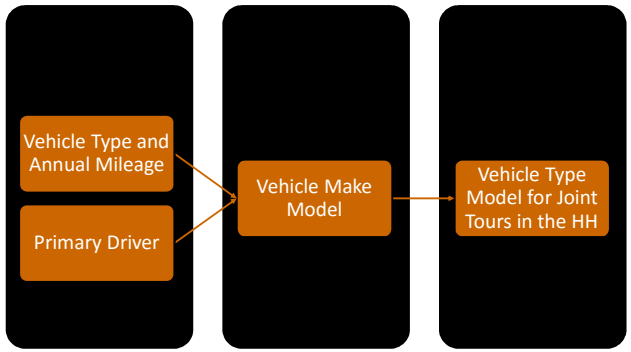

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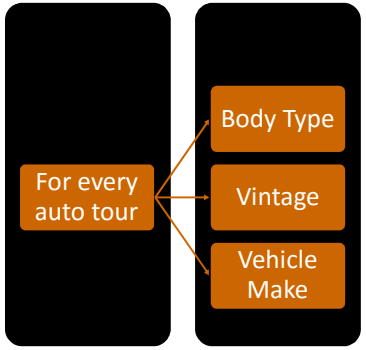

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Vehicle Fleet + Mileage Model

- MDCEV model provides aggregate forecasts of annual mileage of each of the vehicles in the household which is used by SimAGENT
- Aggregate mileage forecasts used as a quick-response tool
  - Examine the impact of a variety of land-use and transportation policies on GHG emissions and energy consumption
  - No need to run the complete SimAGENT system for each policy

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Vehicle Type Choice Simulation Component

- Vehicle type choice determines **vehicle fleet mix**; critical to energy and emissions analysis
- SimAGENT incorporates **joint vehicle type choice and primary driver allocation** model which jointly determines:
  - Multiple vehicle holdings
  - Body type (Sub-compact, Compact car, Mid-sized car, Large car, Small SUV, Mid-sized SUV, Large SUV, Van, and Pickup)
  - Age (Less than 2 years old, 2 to 3 years old, 4 to 5 years old, 6 to 9 years old, 10 to 12 years old, Older than 12 years)
  - Make/model and use (miles)
  - Primary driver of each vehicle

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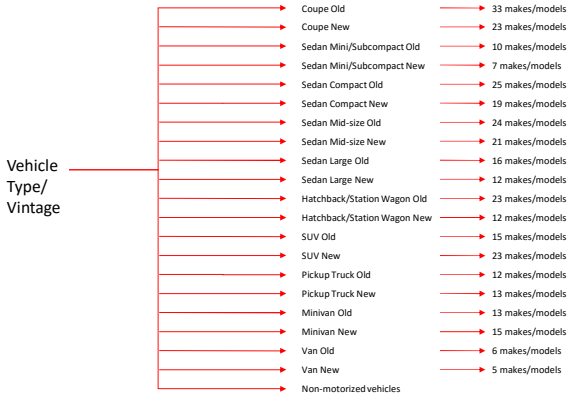
Vehicle Holdings and Use



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Computational Techniques and Integration Potential

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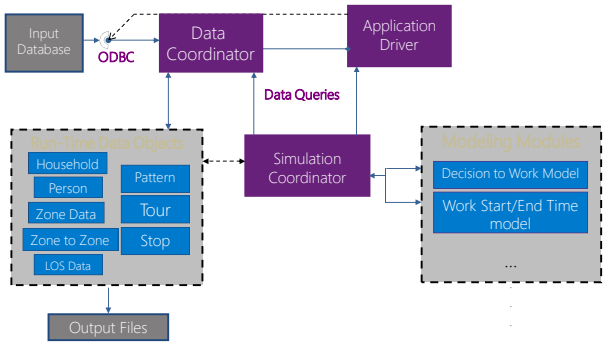
Portable & Flexible Software Architecture



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Ability to Integrate and Enhance

- Successfully interfaced with
  - Multi-period static assignment (the current four-step approach of SCAG)
  - TRANSIMS and MATSim (second by second assignment of people and vehicles on networks), and
- Continuous-time evolutionary framework facilitates real-time dynamic integration of ABM and DTA models

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- SimAGENT is successfully implemented in the LA region
- Existing SimAGENT code (CEMDAP, PopGen, CEMSELTS) is open source
- Being implemented currently in the New York region; selected based on behavioral realism and ability to accommodate CAVs
- Elements of system being used for long distance travel modeling by CDOT; UT-Austin working with CDOT

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CEMDAP: Simulation Outputs

- CEMDAP produces as output the complete activity-travel patterns for a day for every individual in the population of interest.
- There are seven output files:
  - Adults: decisions to undertake activities of different types for adults
  - Children: decisions to undertake activities of different types for children
  - Workers: pattern-level attributes of the workers' (including adult students)
  - Students: pattern-level attributes of the child students
  - Non-workers: pattern-level attributes of non-workers
  - Tours: tour-level attributes
  - Stops: stop-level attributes

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CEMDAP's Output: Adults

ADULTS.OUT	
Column No.	**Description**
1	Household identification number
2	Person identification number
3	Adult goes to work on the day
4	Adult undertakes work-related activity
5	Adult drops-off children at school
6	Adult picks-up children from school
7	Adult undertakes joint discretionary activities with children
8	Adult undertakes shopping activity
9	Adult undertakes HH/personal business activity
10	Adult undertakes social/recreational activity
11	Adult undertakes eat-out activity
12	Adult undertakes other serve passenger activity

CEMDAP's Output: Children

CHILDREN.OUT	
Column No.	**Description**
1	Household identification number
2	Person identification number
3	Child goes to school on the day
4	Child undertakes joint discretionary activities with parent
5	Child undertakes independent discretionary activities

CEMDAP's Output: Workers

WORKERS.OUT	
Column No.	**Description**
1	Household identification number
2	Person identification number
3	Work/school start time
4	Work/school end time
5	Number of before-work tours
6	Number of work-based tours
7	Number of after-work tours

CEMDAP's Output: Students

CHILDSTU.OUT	
Column No.	**Description**
1	Household identification number
2	Person identification number
3	School start time
4	School end time
5	Child gets dropped off at school by parent
6	Child gets picked up from school by parent

CEMDAP's Output: Non-workers

NONWORKERS.OUT	
Column No.	**Description**
1	Household identification number
2	Person identification number
3	Total number of tours made

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CEMDAP's Output: Tours

TOURS.OUT	
Column No.	**Description**
1	Household identification number
2	Person identification number
3	Tour identification number
4	Home/work stay duration before tour
5	Tour mode
6	Tour duration
7	Number of stops in tour

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CEMDAP's Output: Stops

STOPS.OUT	
Column No.	**Description**
1	Household identification number
2	Person identification number
3	Tour identification number
4	Stop identification number
5	Activity type
6	Start time of travel to the stop
7	Travel time to stop
8	Stop duration
9	Stop location (zone) ID
10	Origin zone ID
11	Trip distance (zone to zone)
12	Activity type at the previous stop

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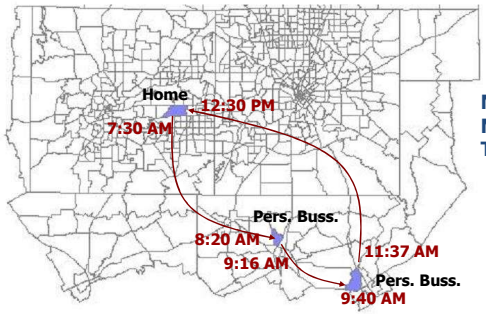
Simulation Outputs – *A Graphical Illustration*



Non-worker Multiple Stop Tour

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