# Progress in the Development of the Agent-based Dynamic Activity Planning and Travel Scheduling (ADAPTS) Microsimulation Model

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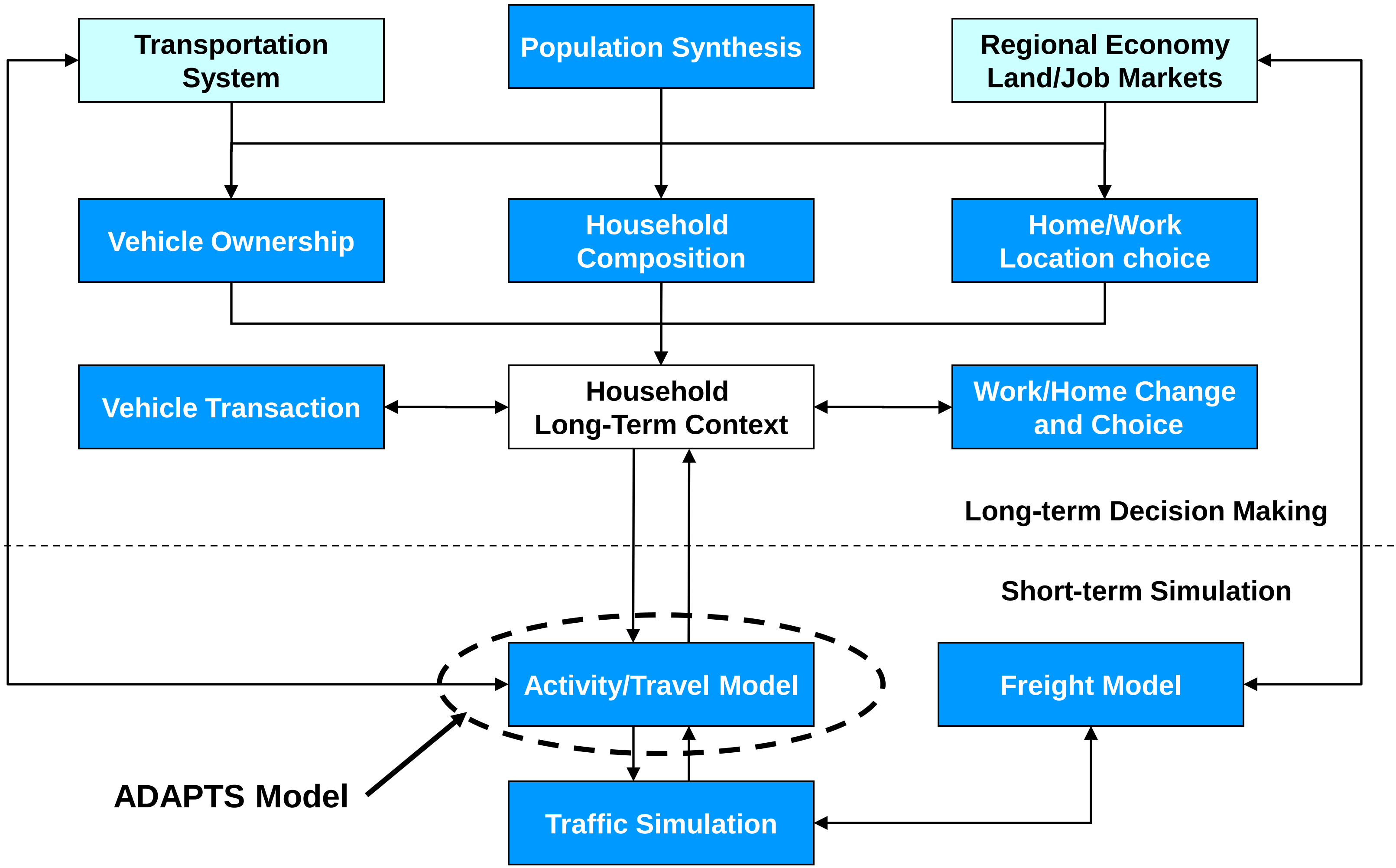
# Overview

- Introduction and Motivations
- ADAPTS Framework
- Current work on the ADAPTS model
  - Activity generation
  - Activity planning strategies
  - Attribute planning (destination choice)
  - Activity scheduling
  - Integration with Traffic Assignment
- Pricing Simulation Results
- Discussion / Conclusions

# Overall Integrated Land-Use Transportation Model Framework



# Introduction and Motivation

# Activity based modeling

- Activity-based modeling
  - Microsimulation models which develop individual activity schedules
  - Usually at the household or individual level
  - Pattern of activities and travel explicitly developed for entire population

- Advantages (from having more of a behavioral basis):
  - Can represent time very accurately
  - Represent response to policy changes very well
  - Explicitly captures trip chaining response

- Two dominant paradigms:
  - Econometric
  - Computational Process Model

- Currently lacking:
  - Representation of planning dynamics
  - Realistic activity planning
  - Integration with traffic simulation – usually done through feedback

# Issues in Activity-Based Modeling

- Preset activity priority order:
  - Activities added to schedule and attributes picked in fixed order
  - In other models: activities added in order of assumed priority
  - Does not match observations from data (Roorda et al. 2005)

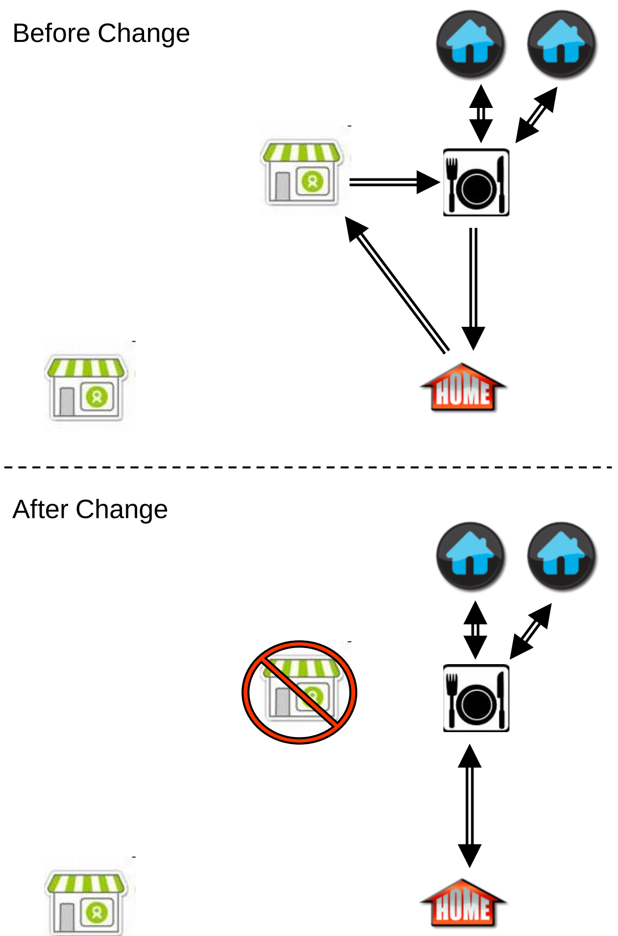
- Fixed order of attribute scheduling:
  - Ex: Party > Duration> Location > Mode > Time
  - Gives fixed dependencies in the decisions
  - Again, does not match actual scheduling process
    - seen in CHASE, OPFAST, UTRACS (our GPS survey), etc.)

- Scheduling planning dynamics
  - Order of decisions can impact subsequent decisions
  - Impulsive/unexpected events in simulation or scenarios
  - Many have entire schedule generated then executed

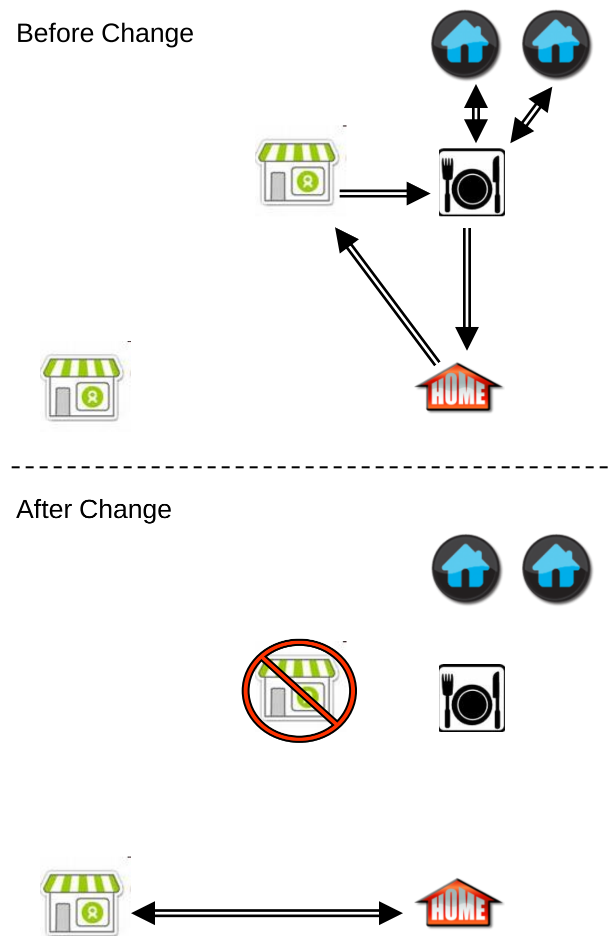
- May lead to errors modeling behavioral-based policies

# Scheduling Order Example

## A) Impulsive Shop - Preplan Eat Out




## B) Preplan Shop - Impulsive Eat out



# Motivation for ADAPTS

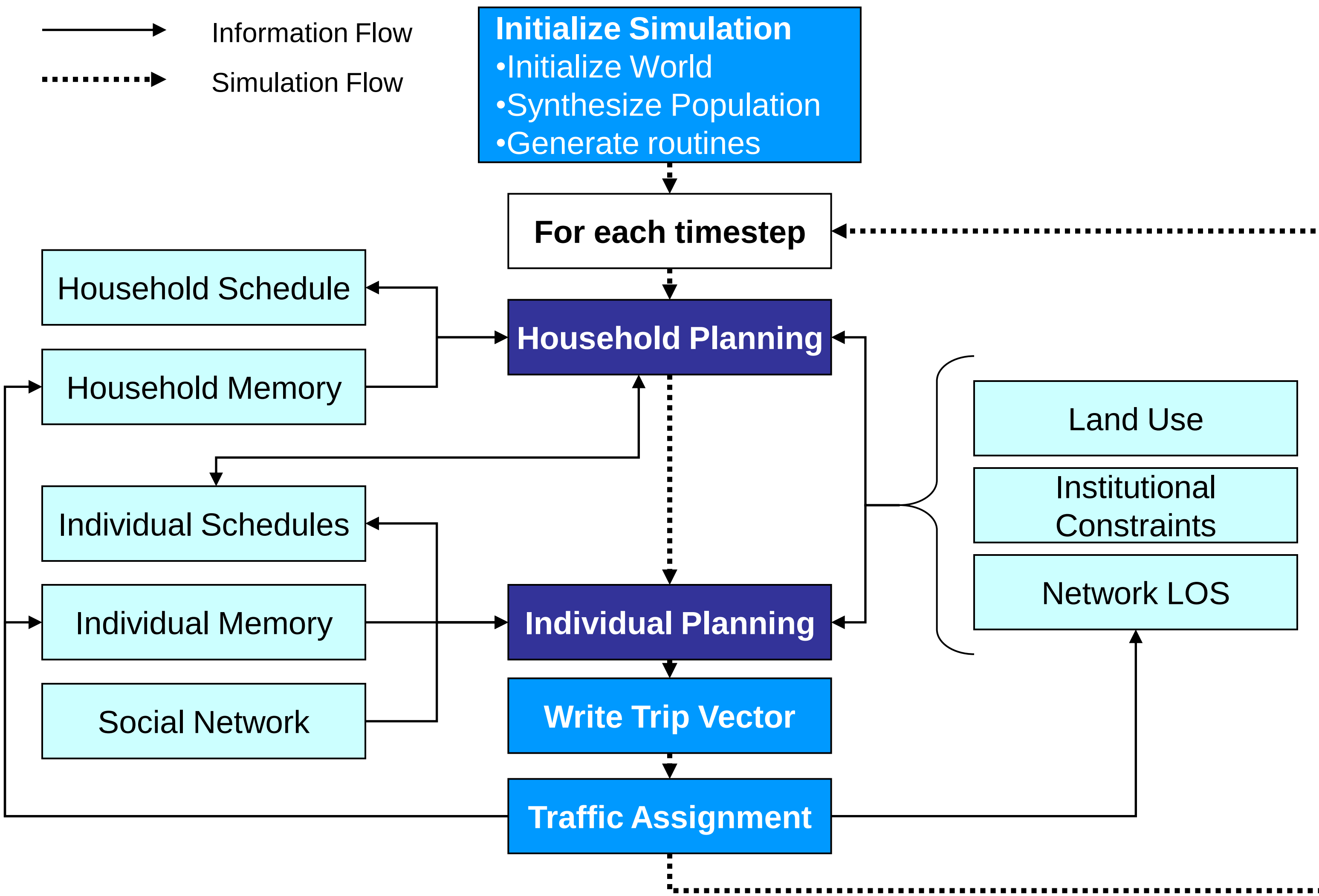
- When and how activity planning decisions are made can impact final daily activity pattern
  - In example, both situations start with same pattern
  - Small policy change creates large differences in pattern, depending only on activity planning
- ADAPTS: adds element of activity planning, to activity generation and activity scheduling
  - Simulation of planning steps
- Account for planning dynamics
  - when is each decision made in relation to other decisions, activities, schedule, etc.
- Represent macro-level changes from impacts of policies on planning dynamics at individual level

# ADAPTS Model Framework

# Framework - Introduction

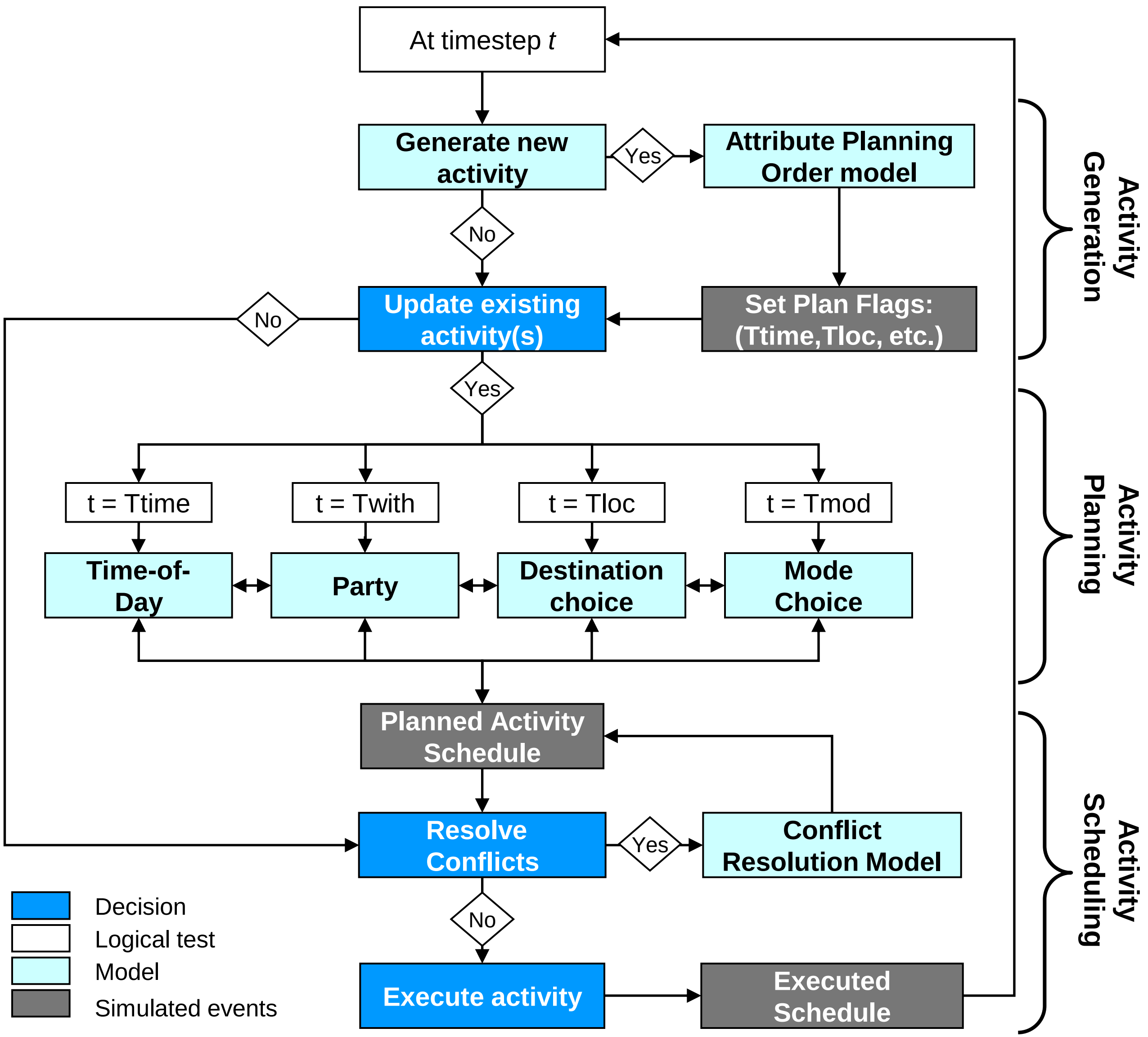
- ADAPTS scheduling process model:
  - Simulation of how activities are planned and scheduled
  - Extends concept of “planning horizon” to activity attributes
  - Time-of-day, location, mode, party composition
- Fits within overall framework of activity-based microsimulation model
  - Constraints from long-term simulation (land-use model)
  - Combined with route choice and traffic simulation
- Models being generated for Chicago region
  - Datasources: UTRACS (GPS) Survey, CMAP household travel survey, CMAP land-use database, Census 2000, CHASE, etc.

# ADAPTS Simulation Framework

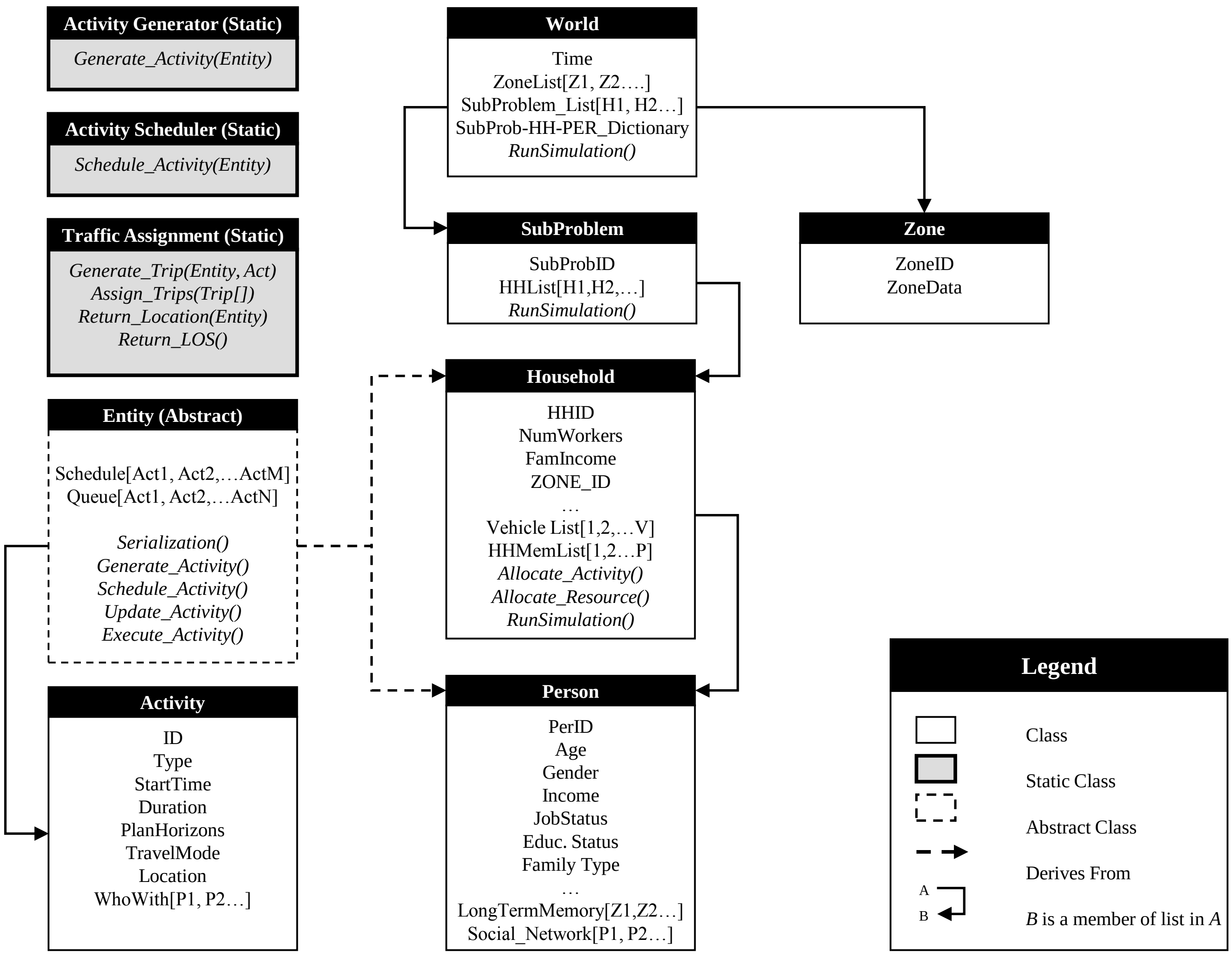


# ADAPTS Planner/Scheduler

- ADAPTS planning and scheduling framework
- Handles at each timestep:
  - Generation
  - Planning
  - Scheduling
- Generation, planning and scheduling can occur at different times for same activity
- Core of the framework is the *Attribute Plan Order Model*



# Framework:  C# Simulation Objects



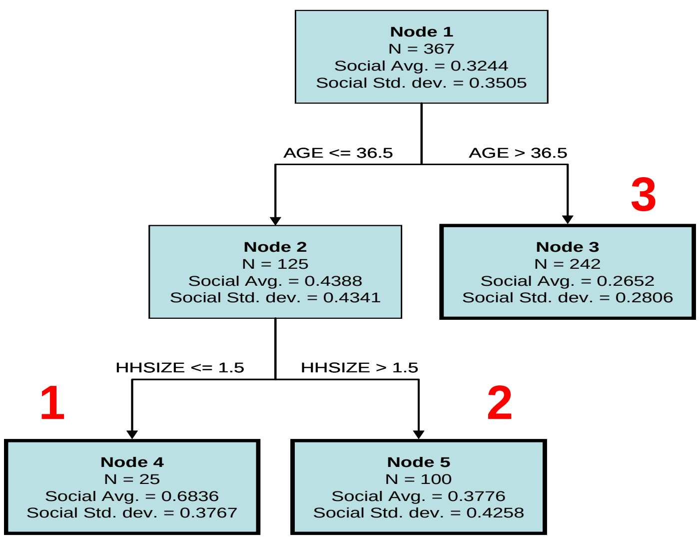
# Completed Components of ADAPTS

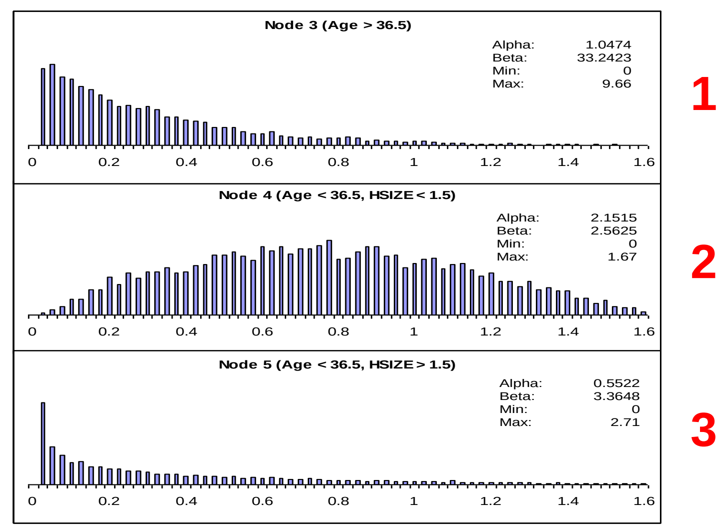
- Rest of discussion will focus on core components of ADAPTS which have been completed
  - Activity Generation (1st Stage)
  - Activity Planning Strategies
  - Attribute Planning (Destination Choice)
  - Activity Scheduling
- Demonstration of current system

# Activity Generation

# Activity Generation

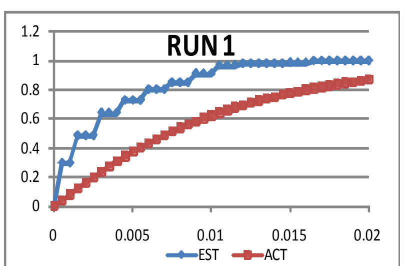
- Activity generation through set of decision trees
  - Classify HH/Person by socio-demographics
- Generation rates drawn from probability distribution fit at each node
  - Distributions estimated from 7-day CHASE data
  - Fit to Chicago 1-day survey through updating



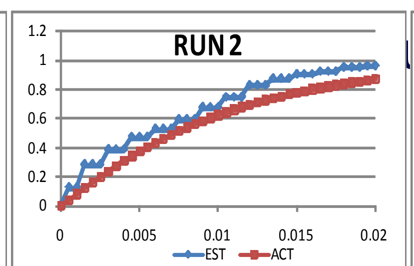



# Activity Generation: Correction Factors

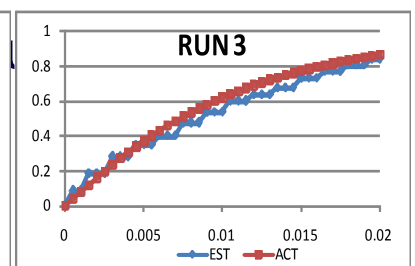
- Using observed generation rates gives incorrect results
  - Due to collisions (i.e. activity conflicts)
  - Activities split, postponed, deleted, etc.
- Unobserved planned activity generation
- Try to correct generation distributions through simulation:
  - $f_i^* = S(\lambda_i f_i)$, minimize $(f_i^* - f_i)\ \forall\ i \in$ *activity types*
  - $\lambda_i f_i$ approximates unobserved planned activity generation
  - Must be solved simultaneously



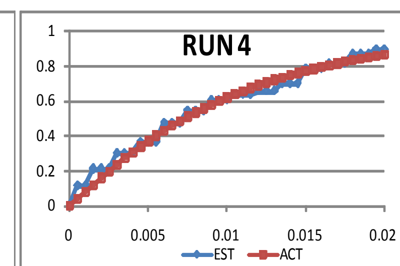

$\lambda_l = 1.0$




$\lambda_l = 1.26$



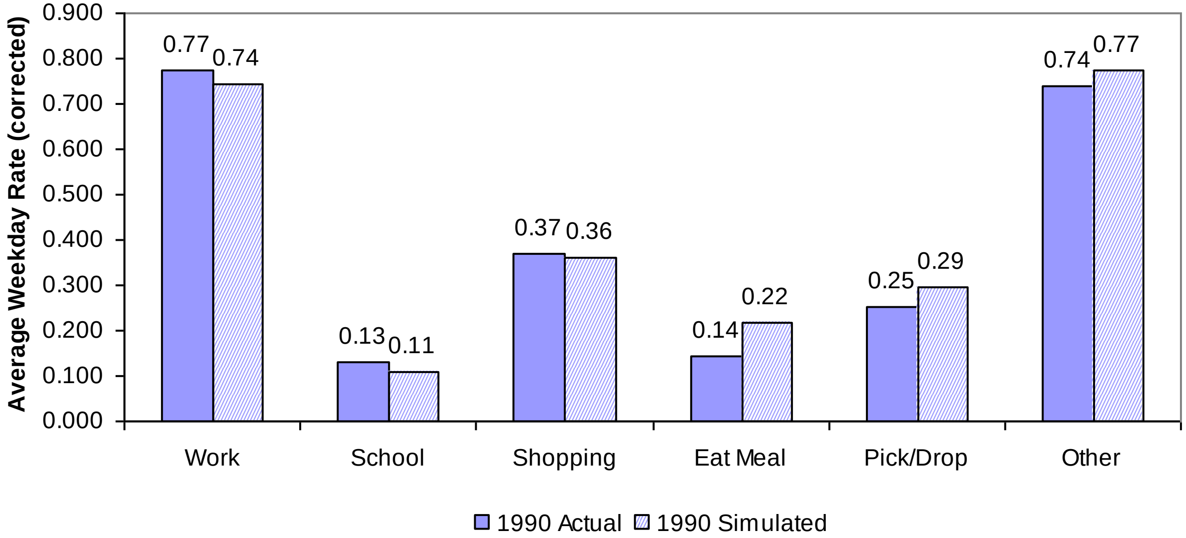

$\lambda_l = 1.53$




$\lambda_l = 1.45$

# Activity Generation: Validation

- Application to Chicago-region
  - Calibrated to 2007 data
  - Backcast validation to 1990 HHTS
  - Validated by activity-type, HH Type, etc.
- Currently updating to include generation dynamics
  - System of simultaneous hazard equations for generation

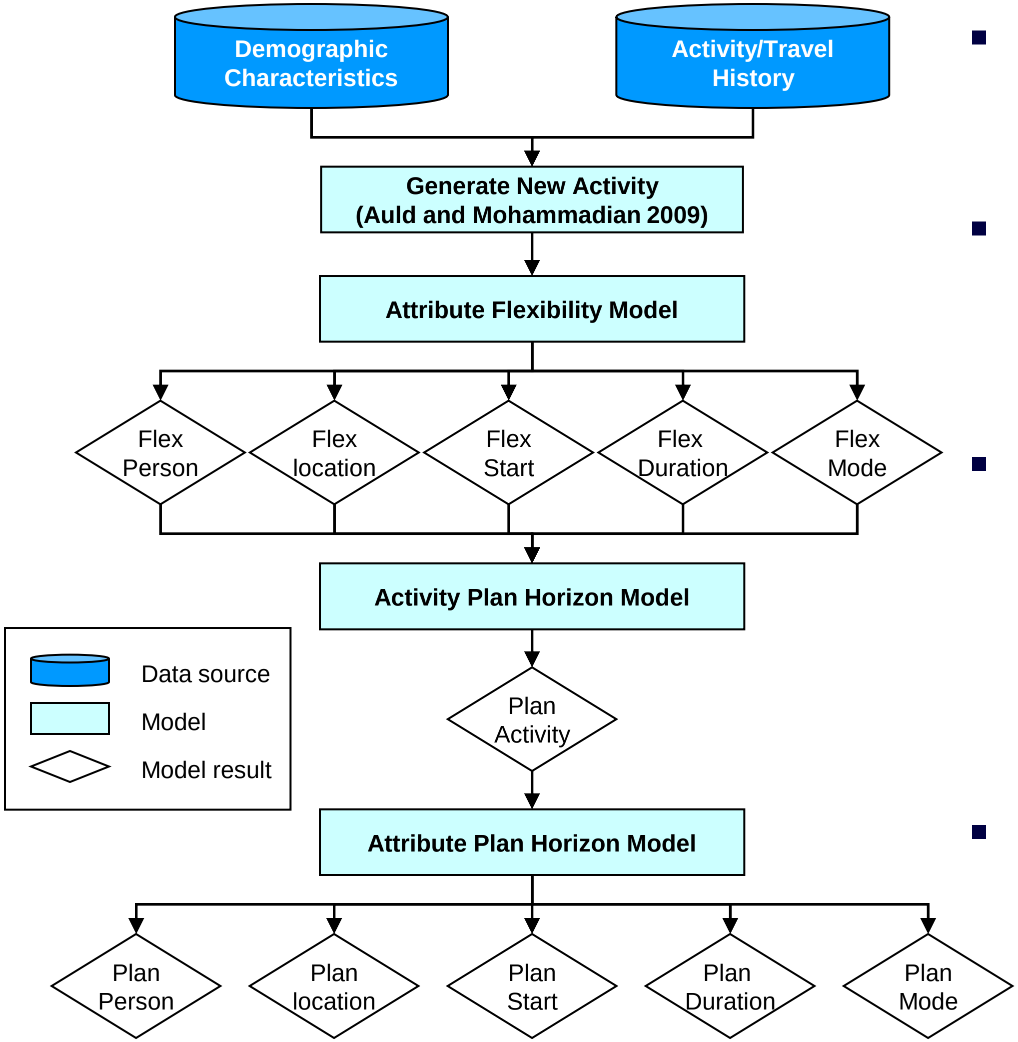


# Activity Planning Strategies

# Activity Planning in ADAPTS

- Activities generated and planned dynamically
- Conditional decision making, dependent on
  - Past history
  - Current plans
  - Situation/resource/capacity/household constraints
- Need to know when activities/attributes are planned
- Activity planning order model
  - General categories of when activity generation and attribute planning occur in the schedule

# Activity Planning Order Framework




- Assign plan horizon to each attribute
  - After activity generated
- Plan order model process
  - Assigns attribute flexibility
  - Get activity plan horizon
  - Attribute plan horizons
- Plan horizons for each attribute based on:
  - Attribute flexibilities
  - Activity plan horizon
  - General activity attributes
  - Socio-demographics, etc.
- Defines the *meta-attributes* of the activity attributes

# Planning Models Discussion

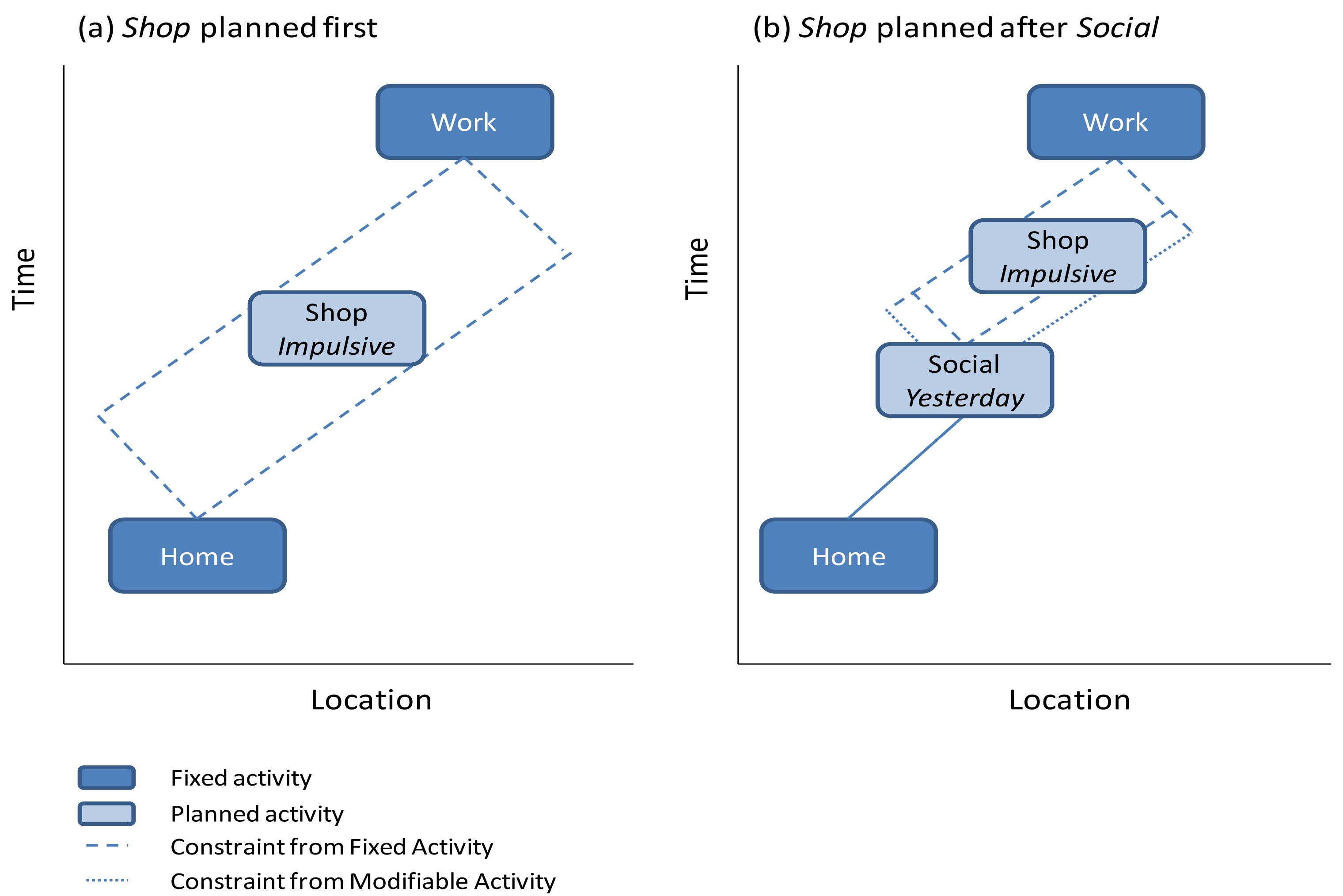
- Estimated set of ordinal/multivariate probit models
  - All models have acceptable goodness of fit
  - Significant improvement over null models
  - Generally have parameters significant at 0.05 level
- Determines how activity flexibility/plan horizon impact attribute planning
  - More expected planning/scheduling effort => more preplanning
- Includes policy sensitive variables relating to:
  - Telework and flex scheduling
  - ICT usage rates
  - Generalized travel costs
  - Endogenous scheduling variables (average frequency, duration)

# Destination Choice Modeling

# Destination Choice

- Need conditional model of destination choice
  - Represent impact of planning dynamics
  - Core focus of ADAPTS development
- Planning influences indirectly through choice set
  - No need for a full set of conditional models
- Planning constrained destination choice
  - Observe what has already been planned before choice
  - Space-time constrains based on previous plan
  - In addition to constraints from fixed activities

# Planning Constrained Destination Choice



# Destination choice: Example

- Planning constraints determine the available time
  - Assuming known values for LOS between zones
  - Conditional choice set formation using available travel time
  - Depends on plan time of each individual attribute
- Planning constraints on *Shop* Activity:
  - If *Social* timing and location known
    - Travel time available = end of *Social* to start of *Work,* calculated starting from *Social* location
  - If *Social* location known
    - Travel time available = end of *Home* to start of *Work,* calculated starting from *Social* location less travel time from *Home* to *Social*
  - If *Social* timing known
    - Travel time available = end of *Social* to start of *Work,* calculated ending at the work location (no inbound trip to *Shop* used)
    - *Shop* location choice then constrains *Social* location choice

# Destination Choice (continued)

- Choice set formed using plan-constrained prism
  - Importance sampling (on travel time, employment totals) of zones
  - Clearly requires planning data to determine choice set
- Use variety of Competing-Destinations model:

$$V_{in} = \beta_T T_{in} + \beta_I ln(I_{in}) + \beta_R R_{in} + \sum_{j}^{J} \beta_j \ln(A_{ij}) + \sum_{k}^{K} \beta_k \ln(E_{ik}) + \sum_{k}^{K} \theta_k C_k + \ln\left(\frac{1}{p(i)}\right)$$

*Where,*

$A_{ij}$ = Land use variables

$E_{ij}$ = Employment variables

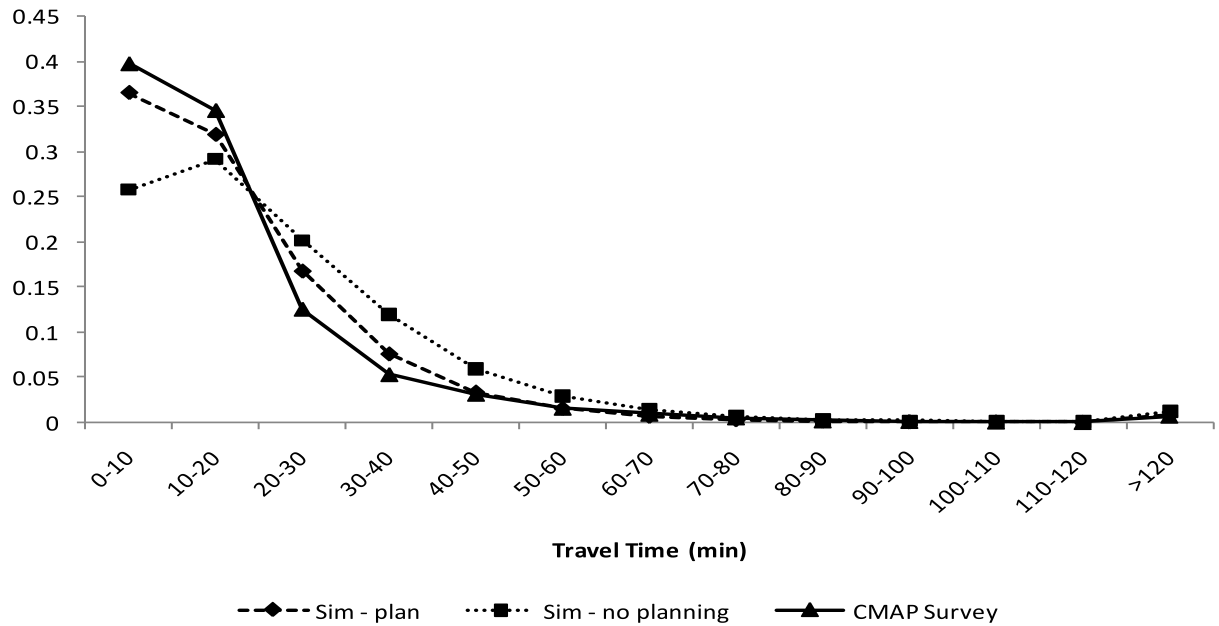
$C_k$ = Competition/Agglomeration factor

$p(i)$ = Probability of zone being selected into choice set

$$C_k = \left(\frac{1}{N_{zone} - 1} \sum_{l \neq i}^{N_z} e_{lk} \, \mathrm{e}^{\frac{-d_{il}}{\gamma}}\right)$$

# Destination Choice - Validation

- Model estimated for Chicago using 2007 HHTS data
  - Simulated planning data using plan order model
- Compared to same model with no planning constraints on choice set formation
  - Trip time distribution much closer for plan constrained model
  - Higher aggregate $R^2$ (0.602 vs 0.571) over all activities



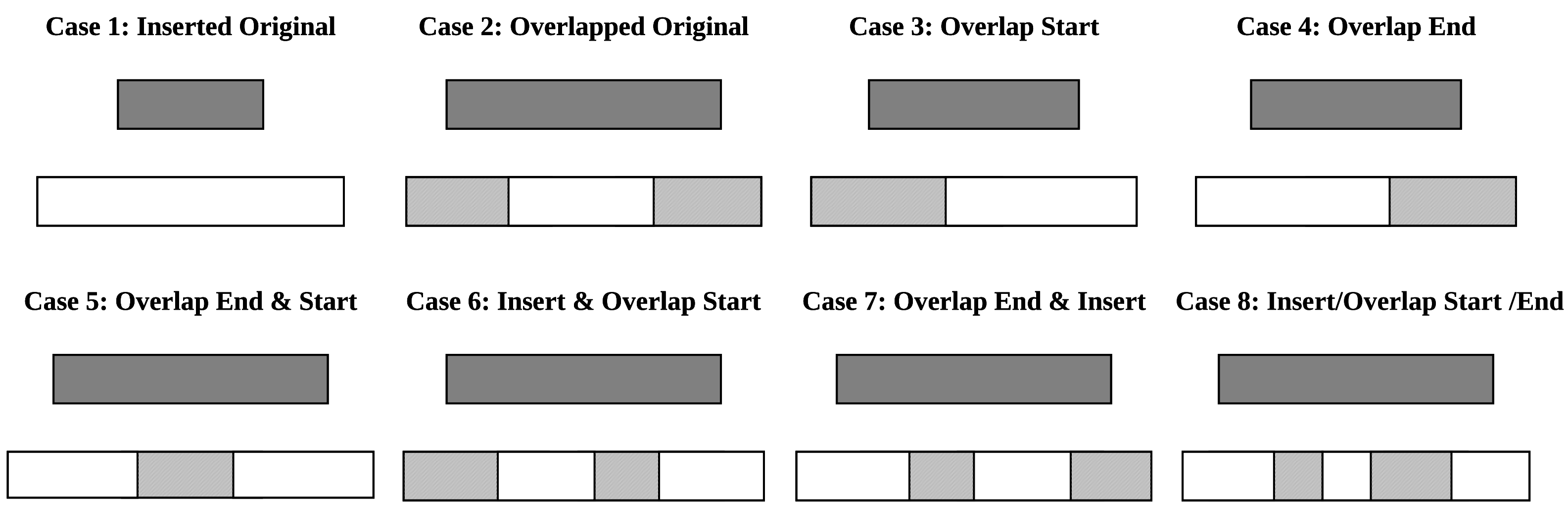
# Activity Scheduling

# Scheduling Rules - Overview

- Set of rules for scheduling randomly generated activities
- Attempts to resolve conflicts by modifying each activity
  - series of rules determine how modifications are made
  - System based on the scheduling rules found in TASHA model
- Includes results of conflict resolution model:
  - TASHA – conflict resolution based on heuristic rules
  - New rules – heuristic rules determine how conflict resolution strategy is implemented
  - Possible resolutions for two activities in conflict: delete original activity, modify original, modify conflicting, modify both
- New rules allow for the consideration of more complicated conflict types and deletion operations
- When activities can be truncated, each activity assumed to be truncated proportionally to duration

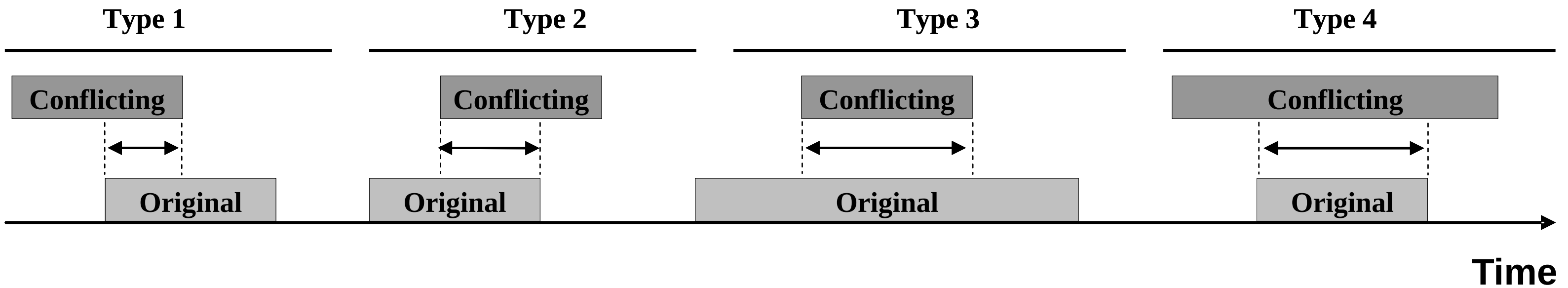
# Scheduling – Overall System

- Based on conflict resolution model
  - Resolution strategy determines rules followed
- For all situations show below:
  - Determines how schedule is modified
  - Based on available time, act. type, resolution type, etc.
  - Insert new activity or drop depending on results



# Scheduling - Conflict Resolution

- Due to dynamic nature of scheduling, conflicts naturally arise
  - Timing, location, resource
- Conflict resolution model chooses strategy for resolving conflict
  - Currently only for timing
  - Uses decision trees
  - Strategies based on demographics, constraints, schedule characteristics, etc.



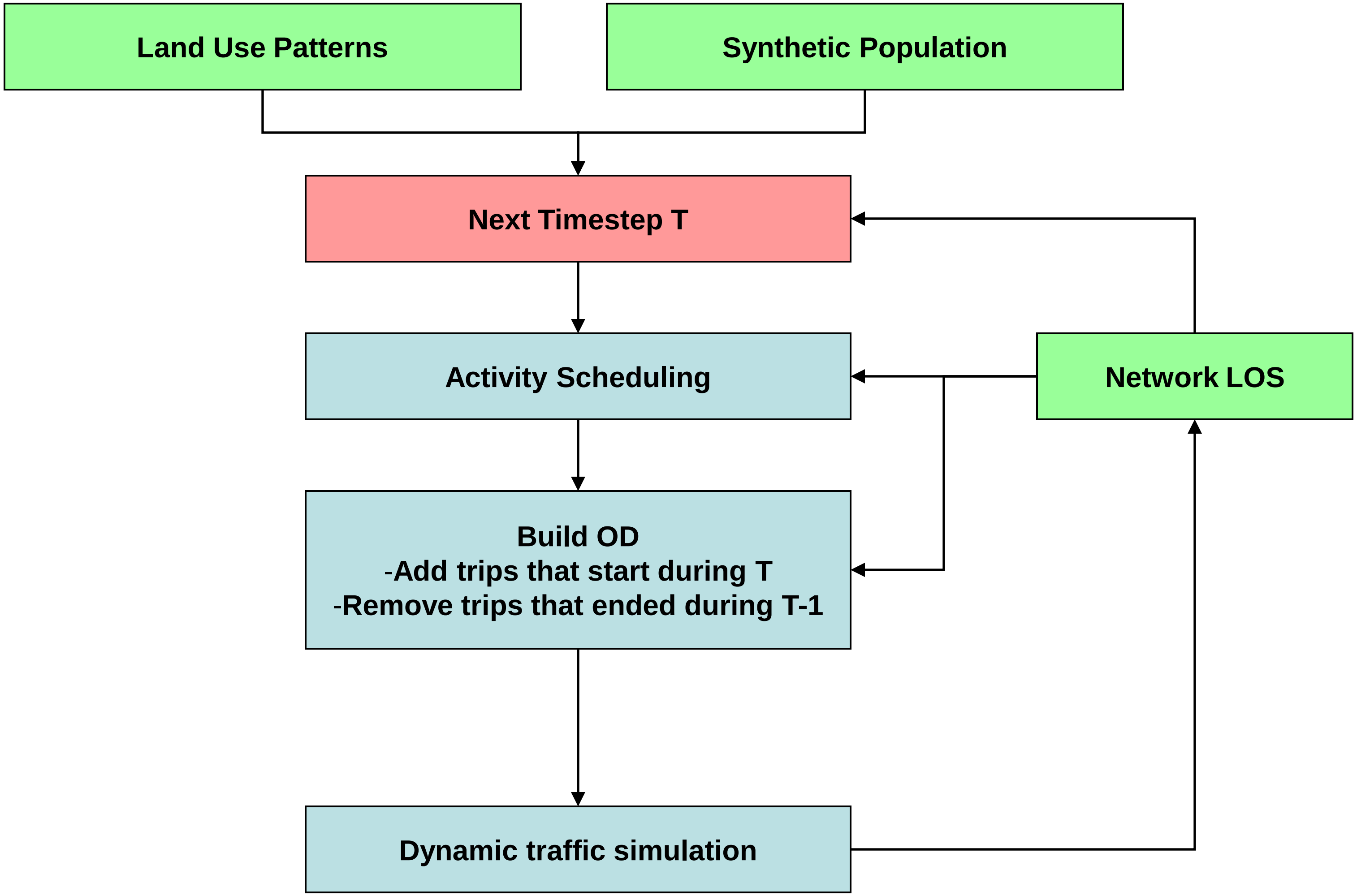
# Integration with Traffic Assignment

# Integration with Traffic Simulation

- Integration of activity planning/scheduling with traffic assignment
  - As activities are executed generate trip vector
  - Pass to dynamic traffic assignment routine
  - Return locations of each individual at end of timestep
  - Simulates 15 minutes of travel

- Currently testing a number of DTA programs
  - Needs to be able to interact with ADAPTS scheduler
  - Capable of simulating short time periods
  - Many options to test: Dynasmart, Dynamit, Vista, Transims, Aimsun, etc.

# Integration with Traffic Simulation



# Cordon Pricing Simulation Example

# Cordon Pricing Simulation

- Two small-scale ADAPTS simulations have been run for Chicago
  - Baseline scenario: using current LOS
  - Pricing scenario: cordon pricing around downtown in AM and PM peak periods
- Created to demonstrate important features of ADAPTS
  - Determine policy sensitivity
  - Demonstrate dynamic activity planning

# Simulation – Cordon Pricing

- AM and PM peak cordon pricing
  - 7-10 AM and 3-6 PM
  - All trips entering downtown (TAZ 54-128)
  - Toll of $10 to enter cordon area
    - No toll within cordon or for outbound trips

# Simulation Comparisons

**BEFORE CORDON PRICING**

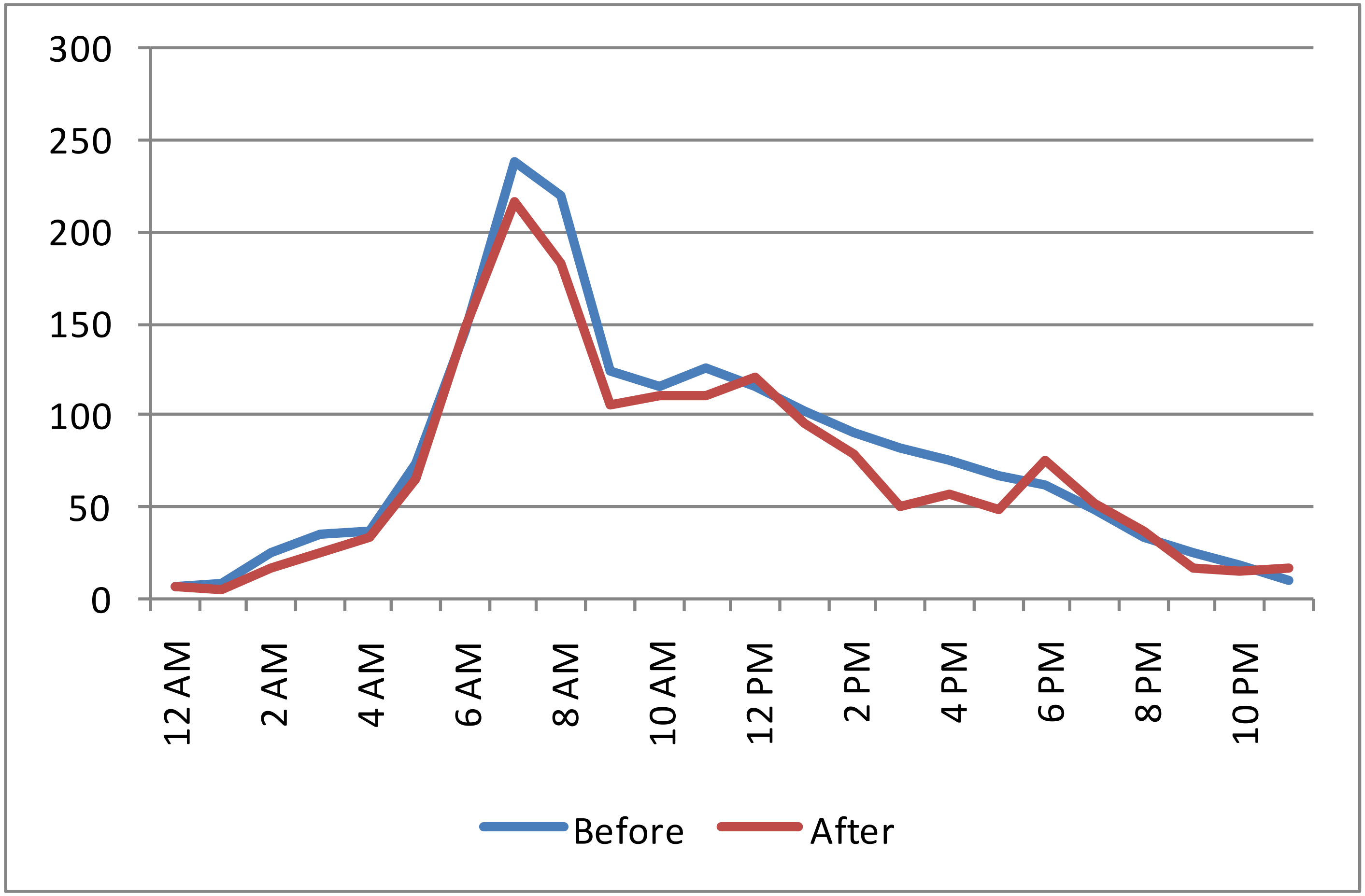
| | Mode Distribution | | | Destination Distribution |
|---|---|---|---|---|
| | Auto | Walk/Bike | Transit | |
| DOWNTOWN | 57% | 17% | 26% | 6.3% |
| COOK | 82% | 11% | 7% | 48.5% |
| DUPAGE | 93% | 5% | 2% | 15.1% |
| KANE | 94% | 6% | 1% | 8.3% |
| LAKE | 93% | 5% | 2% | 9.2% |
| MCHENRY | 94% | 6% | 0% | 5.1% |
| OTHER | 95% | 5% | 0% | 0.4% |
| WILL | 94% | 5% | 0% | 7.0% |
| **Grand Total** | **86%** | **9%** | **5%** | **100%** |

**AFTER CORDON PRICING**

| | Mode Distribution | | | Destination Distribution |
|---|---|---|---|---|
| | Auto | Walk/Bike | Transit | |
| DOWNTOWN | 51% | 16% | 33% | 5.7% |
| COOK | 82% | 12% | 6% | 49.0% |
| DUPAGE | 93% | 5% | 2% | 15.2% |
| KANE | 94% | 6% | 1% | 8.1% |
| LAKE | 93% | 5% | 1% | 9.3% |
| MCHENRY | 94% | 6% | 1% | 5.1% |
| OTHER | 94% | 6% | 0% | 0.4% |
| WILL | 95% | 4% | 0% | 7.2% |
| **Grand Total** | **86%** | **9%** | **5%** | **100%** |

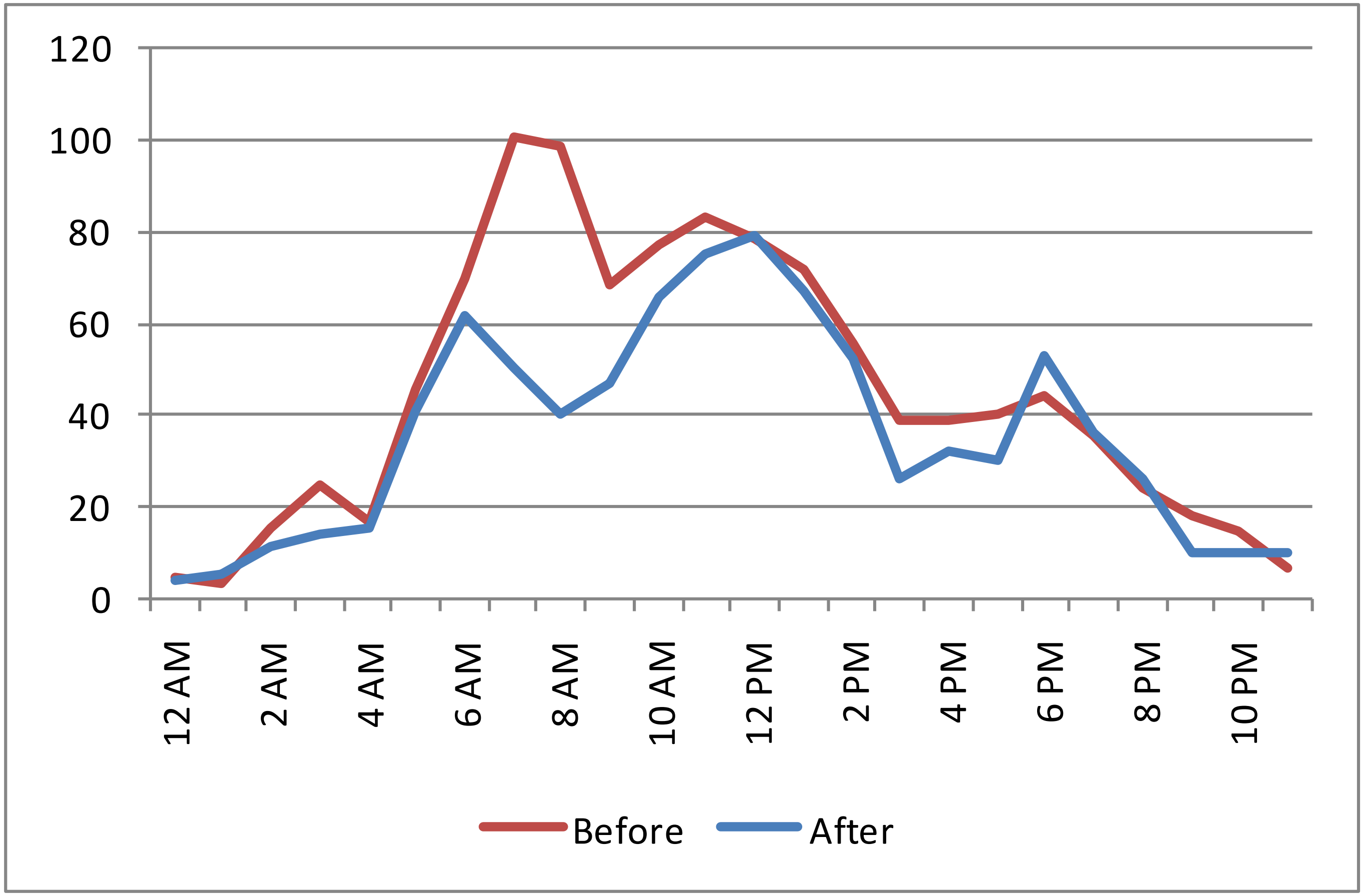
# Simulation Comparisons

- Demand by hour for all Trips to Downtown



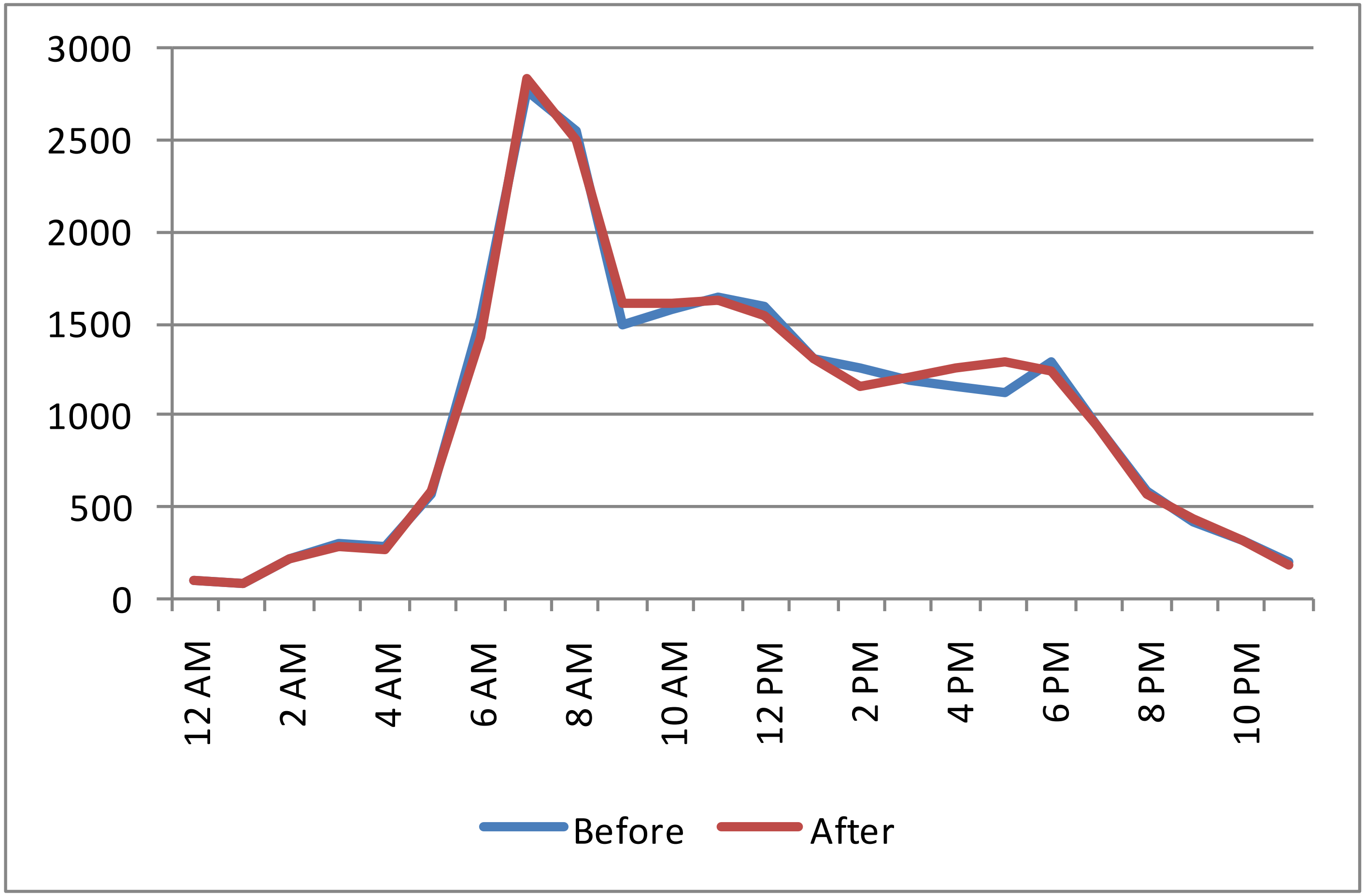
# Simulation Comparisons

- Demand by hour for Auto Mode Trips



# Simulation Comparison

- Demand for non-downtown auto trips by hour



# Simulation Discussion

- Representation of complex response to cordon pricing policy
  - Desired effect of decreased auto-demand during peak periods to downtown
  - Effects continue after pricing ends – due to trip chain effect (no autos for secondary trips)
  - Side effect of increased auto-demand overall
- Simplified models with aggregate results
  - No feedback, learning, etc. in LOS representation
  - Reevaluate when ADAPTS completed
  - Need to observe results at disaggregate geographies

# Conclusion

# Discussion and Conclusions

- ADAPTS framework represents dynamics of activity planning
  - Dynamic activity generation (when completed)
  - Conditional attribute planning (from plan order model)

- Plan order model sets when planning decisions made
  - Correlated responses give more realistic planning order
  - Linked directly to key policy variables
  - Allows conditional attribute planning
- Flexible activity scheduling with conflict resolution
  - No predetermined order of activities entering schedule

# Discussion and Conclusions

- Promising initial simulation results
  - Demonstration of trip-chaining effect
  - Demand shift due to pricing
- Future work:
  - Integration of plan horizon responses to simulation time
  - Development of rest of attribute models
  - Test impact of planning behavior changes on travel demand
  - Link to traffic simulation/assignment

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# Thank You!

## *Questions?*

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