Progress in the Development of the ADAPTS Dynamic Activity-Based 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
- Discussion / Conclusions
Introduction and Motivation
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

Before Change

After Change

B) Preplan Shop - Impulsive Eat out

Before Change

After Change
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 pattern 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

1. Intro
2. Framework
3. Activity Planning
4. Model Specification
5. Data Source
6. Model Results
7. Conclusion

Information Flow
Simulation Flow

Initialize Simulation
- Initialize World
- Synthesize Population
- Generate routines

For each timestep

Household Schedule
Household Memory
Individual Schedules
Individual Memory
Social Network

Individual Planning
Write Trip Vector
Traffic Assignment

Land Use
Institutional Constraints
Network LOS
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

```
At timestep t
    Generate new activity
        Yes -> Attribute Planning Order model
        No -> Update existing activity(s)
            No -> Set Plan Flags: (Ttime, Tloc, etc.)
            Yes ->
                \( t = Ttime \) -> Time-of-Day
                \( t = Twith \) -> Party
                \( t = Tloc \) -> Destination choice
                \( t = Tmod \) -> Mode Choice

Planned Activity Schedule
    Resolve Conflicts
        Yes -> Conflict Resolution Model
        No ->
            Execute activity -> Executed Schedule
```

Legend:
- Decision
- Logical test
- Model
- Simulated events
Framework: C# Simulation Objects

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### Activity Generator (Static)
- Generate_Activity(Entity)

### Activity Scheduler (Static)
- Schedule_Activity(Entity)

### Traffic Assignment (Static)
- Generate_Trip(Entity, Act)
- Assign_Trips(Trip[])
- Return_Location(Entity)
- Return_LOS()

### Entity (Abstract)
- Schedule[Act1, Act2,…ActM]
- Queue[Act1, Act2,…ActN]
- Serialization()
- Generate_Activity()
- Schedule_Activity()
- Update_Activity()
- Execute_Activity()

### Activity
- ID
- Type
- StartTime
- Duration
- PlanHorizons
- TravelMode
- Location
- WhoWith[P1, P2…]

### World
- Time
- ZoneList[Z1, Z2…]
- SubProblem_List[H1, H2…]
- SubProb-HH-PER_Dictionary
- RunSimulation()

### SubProblem
- SubProblemID
- HHList[H1,H2,…]
- RunSimulation()

### Zone
- ZoneID
- ZoneData

### Household
- HHID
- NumWorkers
- FamIncome
- ZONE_ID
- Vehicle List[1,2,…V]
- HHMemList[1,2…P]
- Allocate_Activity()
- Allocate_Resource()
- RunSimulation()

### Person
- PerID
- Age
- Gender
- Income
- JobStatus
- Educ. Status
- Family Type
- LongTermMemory[Z1,Z2…]
- Social_Network[P1, P2…]

### Legend
- Class
- Static Class
- Abstract Class
- Derives From
- B is a member of list in A
Completed Components of ADAPTS

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

Node 1
N = 367
Social Avg. = 0.3244
Social Std. dev. = 0.3505

Node 2
N = 125
Social Avg. = 0.4388
Social Std. dev. = 0.4341

Node 3
N = 242
Social Avg. = 0.2652
Social Std. dev. = 0.2806

Node 4
N = 25
Social Avg. = 0.6836
Social Std. dev. = 0.3767

Node 5
N = 100
Social Avg. = 0.3776
Social Std. dev. = 0.4258

AGE <= 36.5
AGE > 36.5

HHSIZE <= 1.5
HHSIZE > 1.5

Node 4 (Age < 36.5, HSIZE < 1.5)
0 0.2 0.4 0.6 0.8 1 1.2 1.4 1.6
Alpha: 2.1515
Beta: 2.5625
Min: 0
Max: 1.67

Node 5 (Age < 36.5, HSIZE > 1.5)
0 0.2 0.4 0.6 0.8 1 1.2 1.4 1.6
Alpha: 0.5522
Beta: 3.3648
Min: 0
Max: 2.71

Node 3 (Age > 36.5)
0 0.2 0.4 0.6 0.8 1 1.2 1.4 1.6
Alpha: 1.0474
Beta: 33.2423
Min: 0
Max: 9.66
Activity Generation

- 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 \( \Rightarrow \) 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
Planning Constrained Destination Choice

(a) *Shop* planned first

(b) *Shop* planned after *Social*

- **Fixed activity**
- **Planned activity**
- **Constraint from Fixed Activity**
- **Constraint from Modifiable Activity**
Destination Choice (continued)

- Choice set formed using plan-constrained prism
  - Importance sampling (on travel time, employment totals) from available zones
  - Clearly requires planning data to determine choice set

- Use variety of Competing-Destinations model:

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

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

\[ C_k = \left( \frac{1}{N_{zone} - 1} \sum_{l \neq i}^{N_z} e_{lk} e^{-\frac{d_{il}}{\gamma}} \right) \]
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 – Overall System

- Rules for adding activity to existing schedule
- 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

Case 1: Inserted Original
Case 2: Overlapped Original
Case 3: Overlap Start
Case 4: Overlap End
Case 5: Overlap End & Start
Case 6: Insert & Overlap Start
Case 7: Overlap End & Insert
Case 8: Insert/Overlap Start /End
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.

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Time
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 decisions about planning 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

- 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
Thank You!

Questions?