Understanding Household Priorities when Scheduling Activities

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INTRODUCTION
The idea of understanding activity patterns of individuals and how activities are scheduled during any given day has been the focus of the travel demand studies for decades and has resulted in various lines of research in the field. One particular line of the research is using constrained optimization frameworks to analyze activity-scheduling behavior, such as Household Activity Pattern Program (HAPP) (1), an activity-based travel demand model posed as a multi-objective optimization model that optimally schedules household activities throughout the day. However, there are at least 2 major confounding issues with these types of models:

1. Specification of the objective function(s)
2. Specification of time window constraints

Calibration Challenges (2):
- Infinite set of alternatives
- Non interpretable utility coefficients
- Household Specific methodologies

OBJECTIVES
Reformulate and Calibrate the Household Activity Pattern Problem
Address following questions:
- What do individuals and households value the most when they schedule their activities?
- Is there any similarities in the way individuals belong to the same cluster of patterns - value different utilities?
- What is the proper metric to measure and compare the utility terms of an activity pattern?
- How to account for the utility of different activity types and household characteristics in activity scheduling?

DATA DESCRIPTION
Data:
- California Household Travel Survey Data, 2000-2001 (4)
Sample size: 8684 activity patterns, generated by segmenting the length of day, starting from 5:00 to 23:00, into 10-minute intervals, clustered into 8 distinct groups (3).
Activity categories:
- In home (H), Work (W), School (S), Maintenance (M), Recreational/Shopping (R), Personal (P), Pick-up/Drop-off (K) and Other (O) activities.
Data sampling criteria for calibration (50 individuals from each of the 8 clusters):
- Out-of-home activities between 2 and 5
- Activity duration longer than 10 minutes
- Travel time shorter than 60 minutes

Input parameters for each individual:
- Cluster membership
- Activity duration
- Estimated travel time matrices

METHODOLOGY
Original HAPP as PDPTW

\[ \min Z = \sum_{i=1}^{m} \left( d_i + d_i' \right) \]

\[ \text{st.} \quad A(X,T,a,b,s,t) \leq 0 \]

\[ X = [0,1], T \geq 0 \]

Cluster Households

Goal Programming

\[ \min Z = \sum_{i=1}^{m} \left( d_i + d_i' \right) \]

\[ \text{st.} \quad U_i(X,T) + d_i - d_i' = \tau_i \quad i = 1, 2, ..., m \]

\[ d_i, d_i' \geq 0 \]

\[ i = 1, 2, ..., m \]

\[ A(X,T,a,b,s,t) \leq 0 \]

\[ X = [0,1], T \geq 0 \]

Utility Table

\[ U_i = \sum_{j=1}^{m} \left[ f_{ij} - T_{ij} \right] \]

\[ \text{2} \text{ Arrival time deviation from the cluster mean per flexible activities} \]

\[ U_i = \sum_{j=1}^{m} \left[ f_{ij} - T_{ij} \right] \]

\[ \text{3} \text{ Arrival time deviation from the cluster mean per pickup activities} \]

\[ U_i = \sum_{j=1}^{m} \left[ f_{ij} - T_{ij} \right] \]

\[ \text{4} \text{ Travel time budget deviation from cluster mean} \]

\[ U_i = \sum_{j=1}^{m} \left[ T_{ij} - T_{ij} \right] \]

\[ \text{5} \text{ Out-of-home time spent deviation} \]

\[ U_i = \sum_{j=1}^{m} \left[ (T_{ij} - T_{ij}) - T_{ij} \right] \]

\[ \text{6} \text{ Waiting time dissatisfaction before starting an activity} \]

\[ U_i = \sum_{j=1}^{m} \left[ (T_{ij} - T_{ij}) + S_{ij} + T_{ij} \right] \]

\[ \text{All objectives have some units & scale: COMPARABLE} \]

UTILITIES \( U(X,T) \)

RESULTS
We compare the calibrated and non-calibrated approach using edit distance as an error measure, 1 edit distance unit is equivalent to 10 minutes:
- Overall improvement in the sample using calibration: 7.4%
- Clusters with the largest improvement: cluster 1 and 8
- Clusters with the lowest improvement: cluster 7
- Low importance is observed for the waiting time and the travel time budget goals.
- Clusters with maximum priority for waiting: cluster 1, (waiting time before performing is not important in scheduling unless it is a mandatory activity - cluster 1; cluster 5 and cluster 7).

CONCLUSIONS
- Under the goal programming approach comparisons among priorities can be made.
- Different utilities were associated to activities based on their type:
- Individuals in different clusters set different priorities for different goals.
- The travel time and the waiting time goals are higher in clusters where a long work activity is present in the representative pattern of the cluster.
- The solutions obtained are sensitive to the priorities.
- Individuals do tend to behave as other do given the differences in cluster behavior and the sensitivity of the priorities.

FUTURE WORK
- Introduce new goals that can better capture the utility of performing an activity depending on the time of day, activity type and the sequence.
- Accommodate bimodal distributions when defining time windows to perform activities.
- Test the methodology on new datasets.

SELECTED REFERENCES

AKNOWLEDGEMENTS
This research was supported, in part, by grants from the University of California ITS Multi-Center Research Program and Initiative on Sustainable Transportation, the Rakhihi- Gharebagh de Coodaahms Fellowship and the Fundación Cajal Madrid Fellowship. Their support is gratefully acknowledged.