Simulating the Household Activity Scheduling Decision Process Within Urban Integrated Models

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Presentation at the Second Oregon Symposium on Integrated Land Use and Transport Modeling, Portland, Oregon, July 18-20, 2000.

Presentation Goals

- To challenge existing modelling approaches
- Provide some new directions
- Investigate new integration possibilities

Outline

- Key questions
- Introduction and background
- Activity scheduling process
  - Description
  - Modeling
- Implications for ILUTE models
- Conclusions

Key Research Questions

- What is an activity schedule? Activity scheduling *process*?
- What do we know about the underlying scheduling process?
- How can we observe it? Model it?
- Why is this important?
- How can Activity Scheduling contribute to ILUTE models?

Trips, Activities, and the Activity Scheduling Process

Background and evolution

Understanding Human Activities and Travel

Cognitive Process

⇧

Scheduling Process

⇧

Activity-Travel Pattern (Schedule)

⇧

Activities

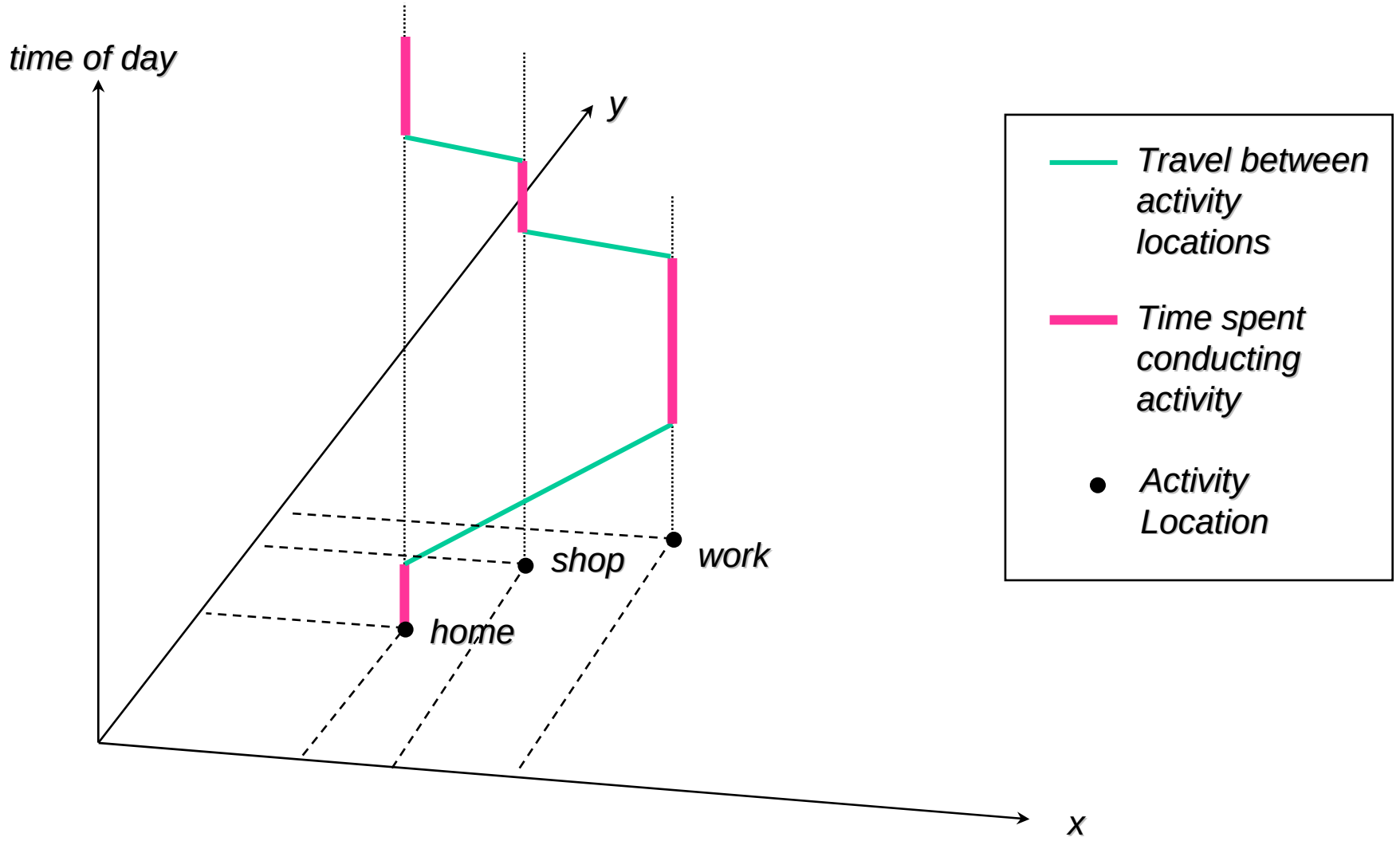
⇧

Trips

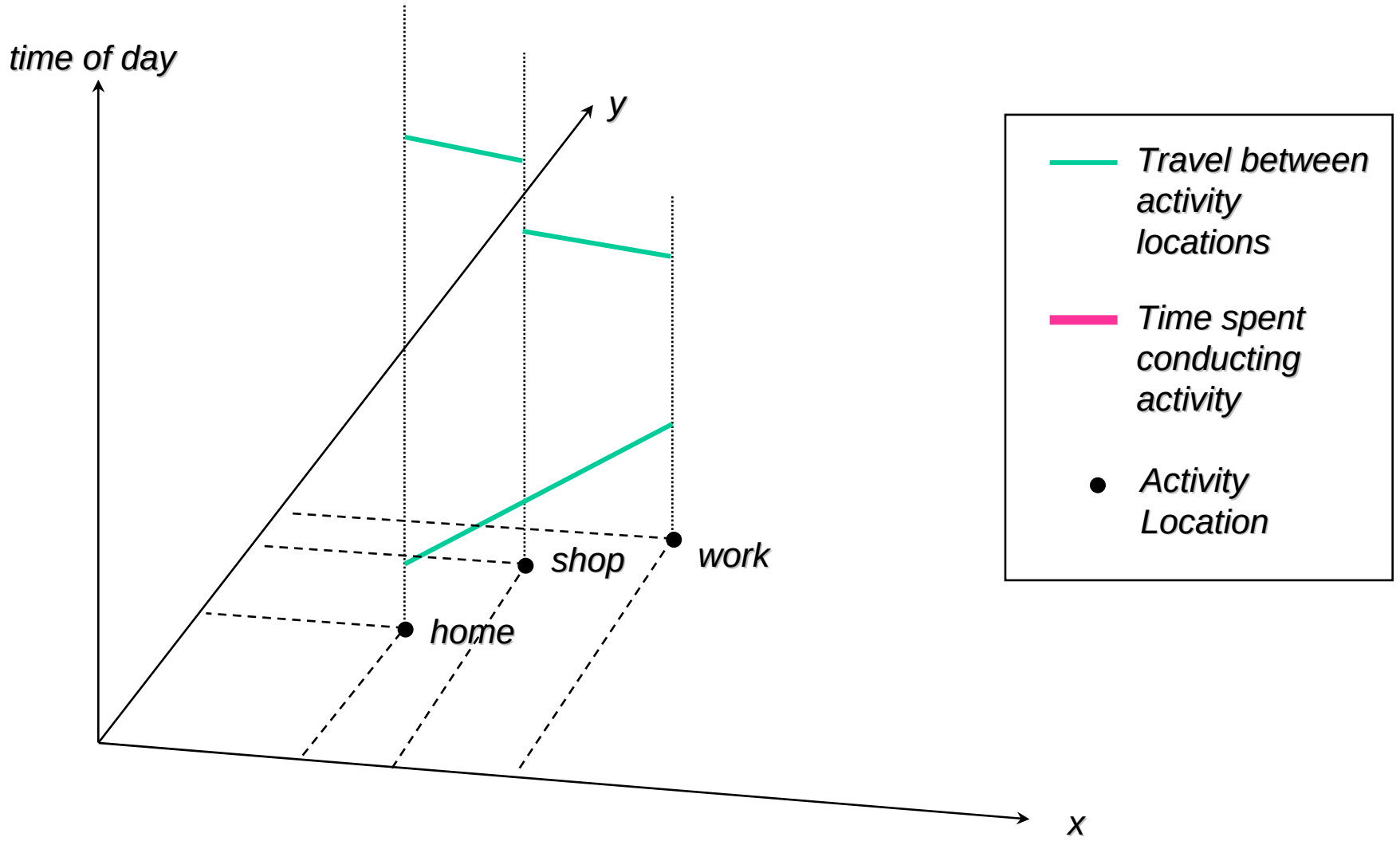
“Space-time” Prisms (Hägerstand 1970)

- Constraints in time and space viewed as the major determinant of activity patterns, including:
  - capability constraints
  - coupling constraints
  - authority constraints
- This has led to the space-time prism concept, widely viewed as more complete approach to understanding the planning, scheduling and execution of activities.

Time-Space Paths



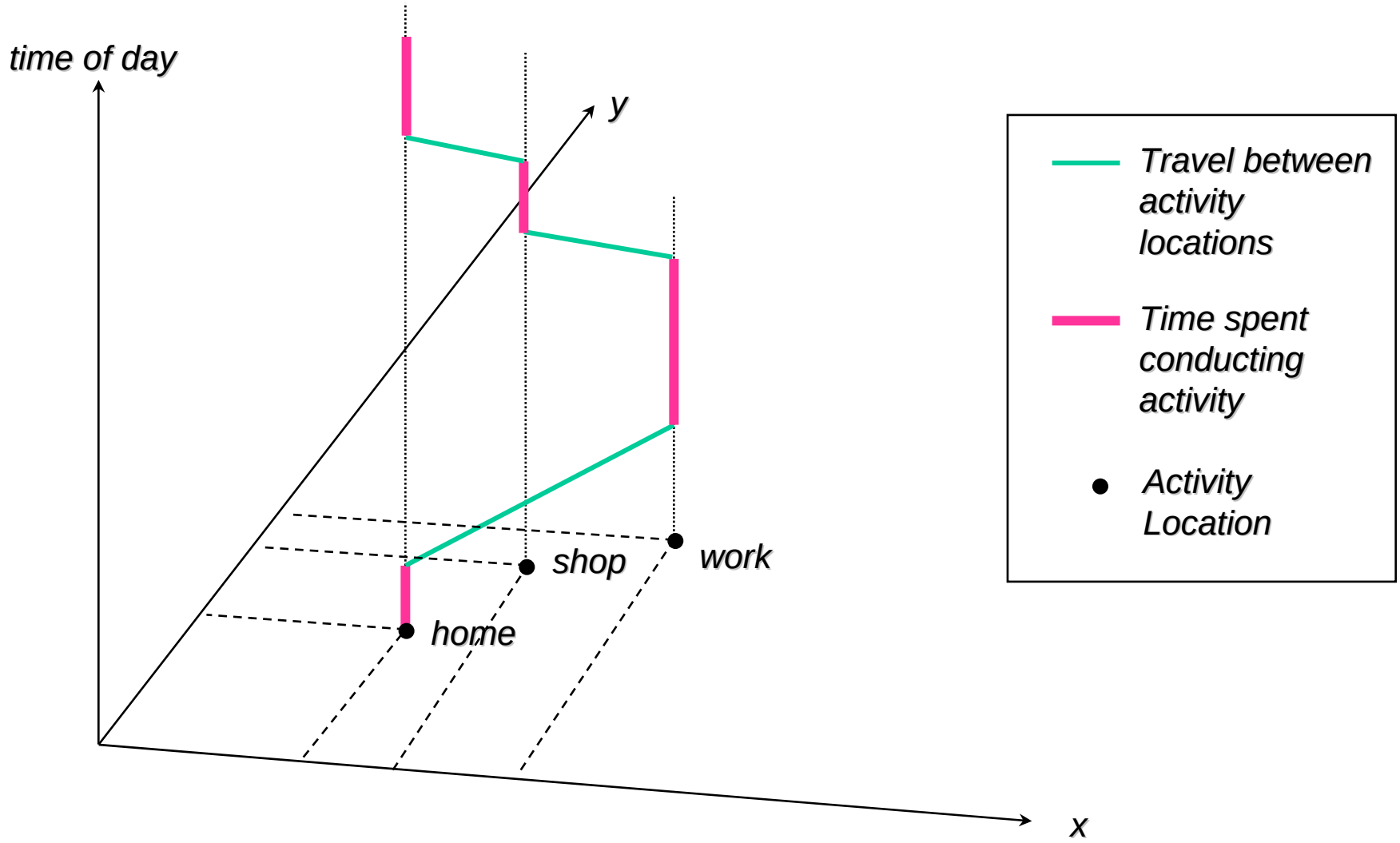
Trip-based Approach



Trip-based Approach - Major Features

- Individual trips is the unit of analysis.
- A trip is measured as a discrete event of precise duration, which is undertaken for one main trip purpose, by a specific mode
- Direction of travel and the continuity between successive trips are lost
- Time of day of travel ignored, except for the distinction between peak and off-peak periods
- Modelling proceeds in a four-step fashion

Activity-based Approach



Activity-based Approach: Major Features

- Activity approach characterized by a varied set of concepts and methods - Why?
- Basic concepts include:
  - explicit recognition that trips are *derived* from the need to participate in activities
  - activities are derived from *needs*
  - activities are governed by *opportunities* and *constraints* in time and space
  - focus on *sequences and patterns* rather than discrete events (recognizing interdependencies)
  - Emphasis on timing and duration ("Its about time")
  - focus on activity "schedules" for modelling

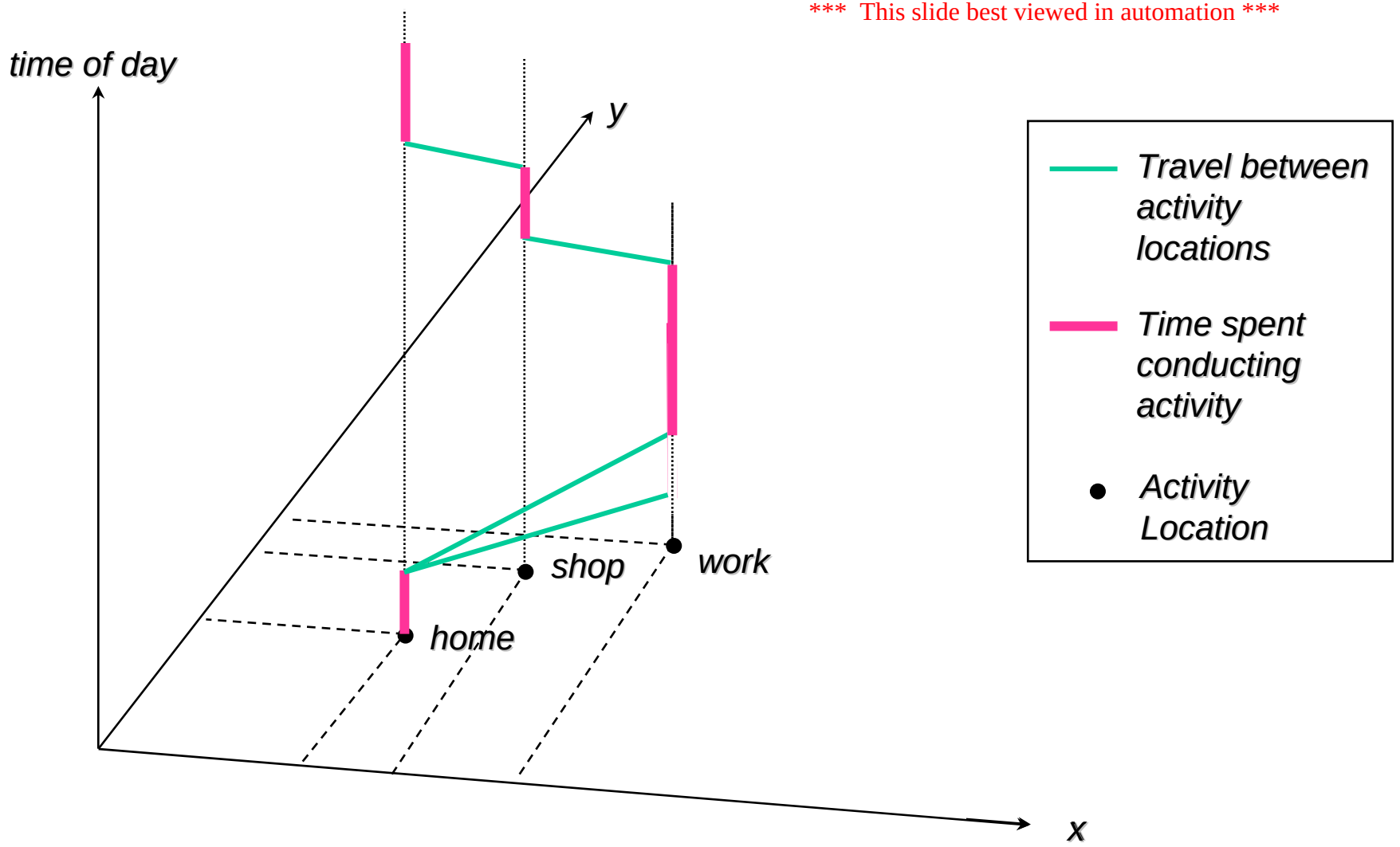
Revisting Space-time prisms - Cullen and Godson 1975

Six “phenomena” that influence activity patterns:

- activities are the result of *organized* behaviour
- there is an *action space*
- activities are *prioritized*
- *constraints* dictate when action space can be used
- activities have varying degrees of *flexibility/fixity*
- a *scheduling process* exists

A Scheduling Process Approach to Understanding Observed Time-Space Paths

*** This slide best viewed in automation ***



Scheduling Process Approach - Major Features

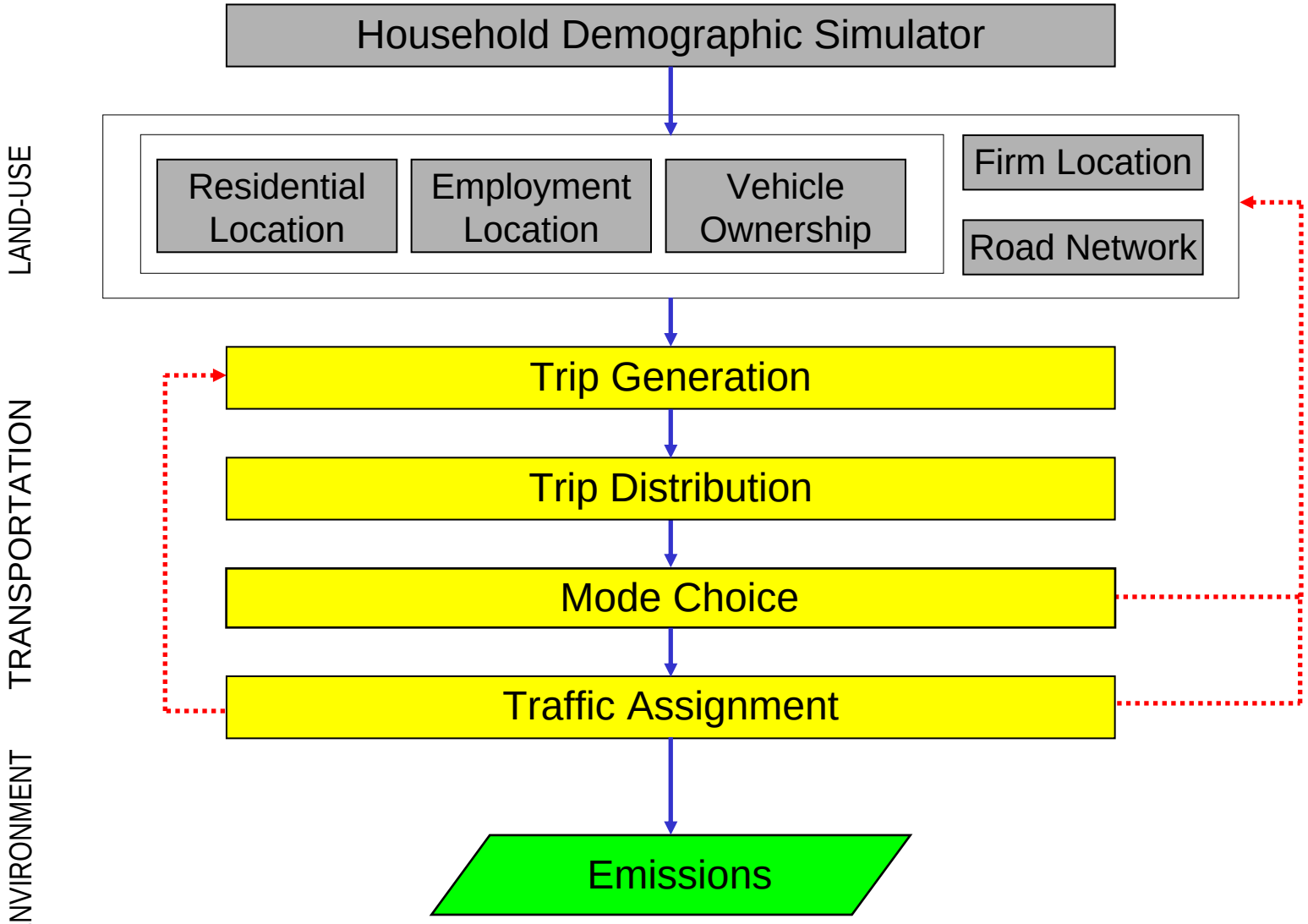
- Explicit recognition that observed activity patterns are really the result of an underlying scheduling process
- Focus on the dynamics of the process - the "planning, execution and adaptation of activities over time"
- Recognition that scheduling is largely determined by:
  - attributes of activities on a households *agenda*
  - situational attributes

Terminology Summary

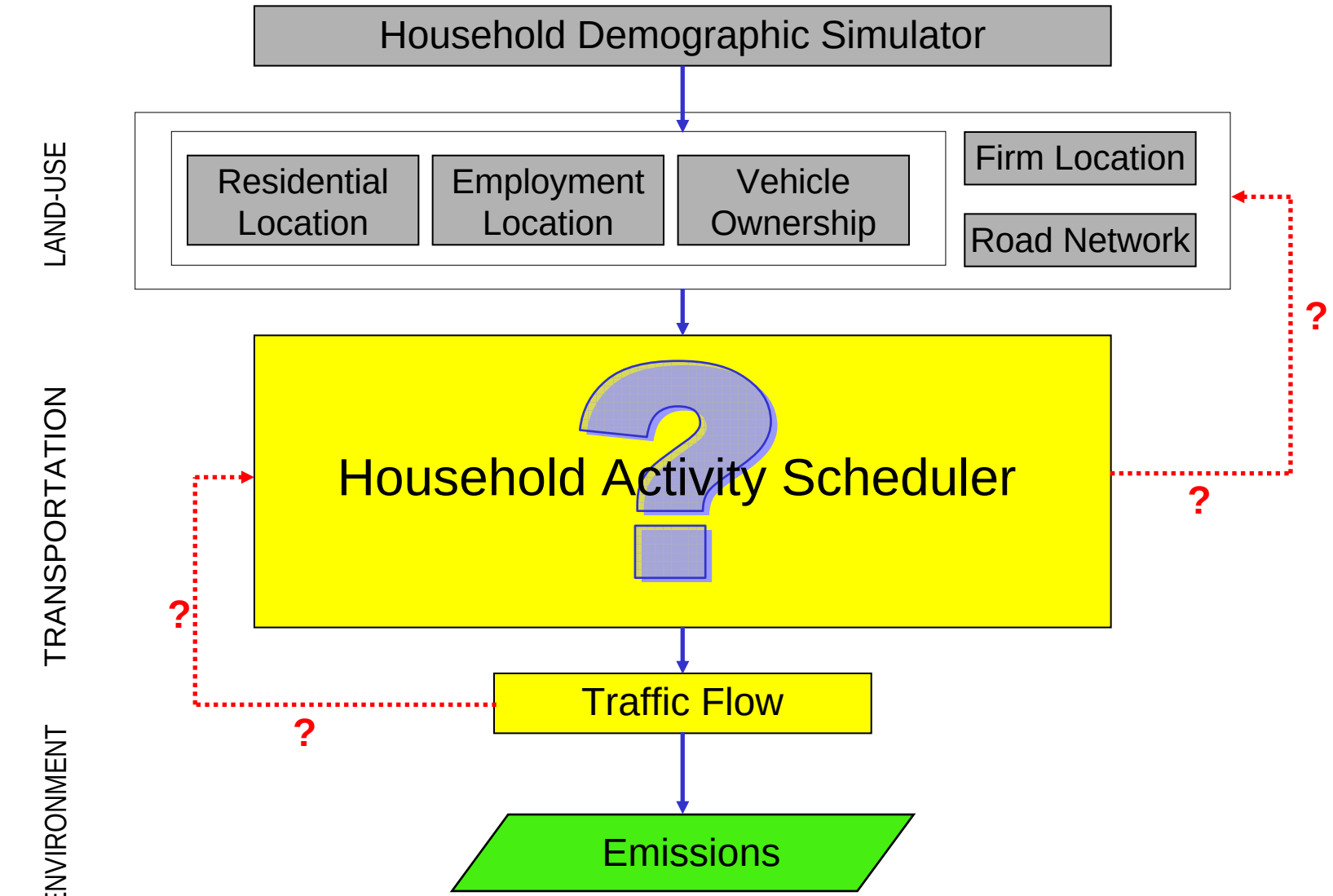
- Trips: movement over space
- Activities: the act of satisfying a unique need
- Activity Schedule: an observed sequence of activities/travel in time and space
- Activity Scheduling Process: the planning, execution and adaptation of activities and travel over time that leads to observed patterns

Role of Activity Scheduling within ILUTE models

Traditional ILUTE Modeling Framework



Emerging ILUTE Modelling Framework



What do we know about the underlying scheduling process?

Underlying Scheduling Processes

Three fold problem:

- Details unknown
- Difficult to observe
- Complex modelling task

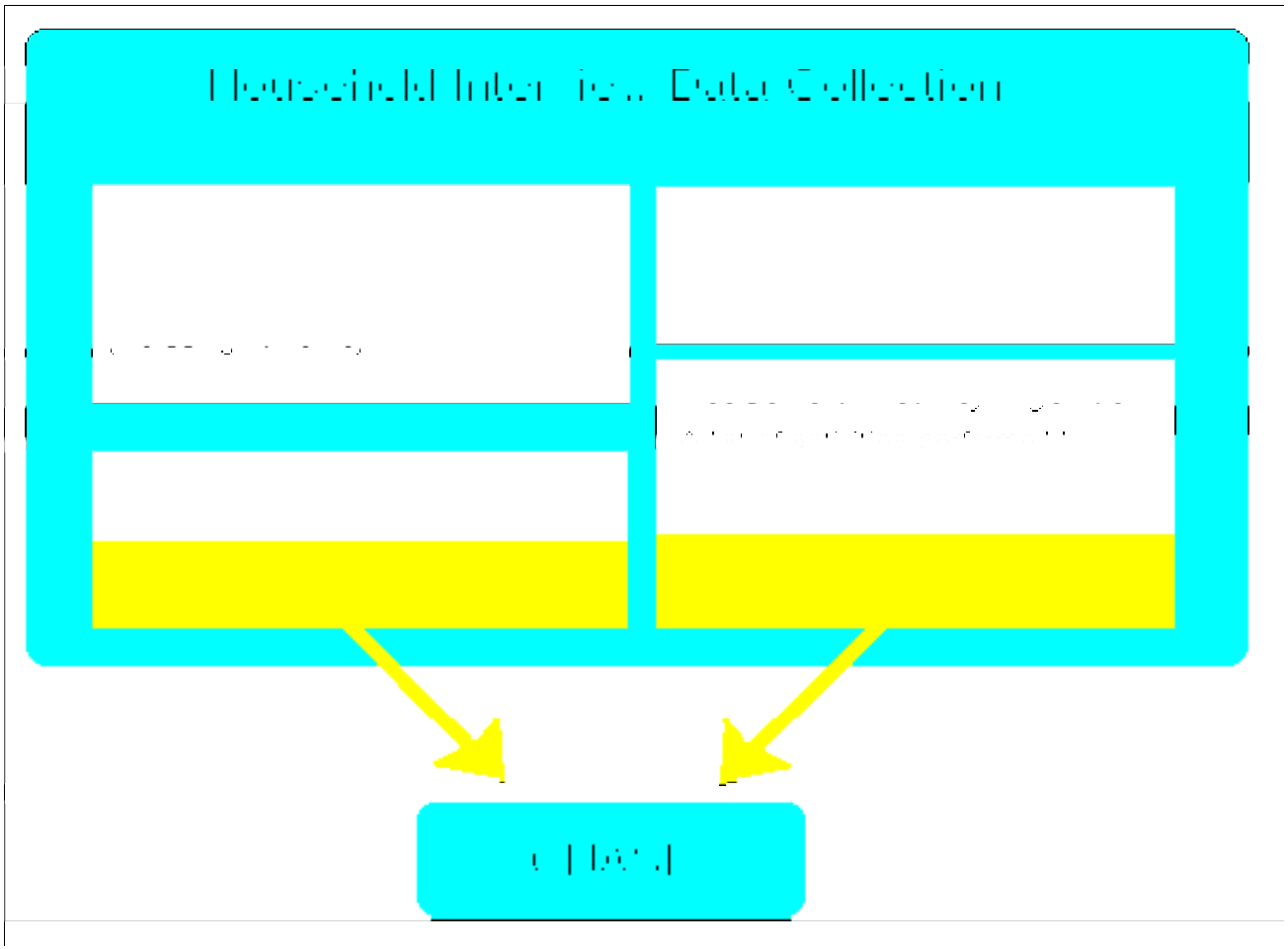
Empirical Studies

- Hayes-Roth and Hayes-Roth, 1979
  - "think aloud" experiments in a simulated urban environment
- Ettema and Timmermans, 1994
  - next day electronic scheduler with simulated activities (MAGIC), students only
- Chen and Kitamura, 2000
  - one day before-and-after study, single persons only
- Doherty 1998-present
  - weekly computerized household activity scheduler *in situ* (CHASE), mixed household types

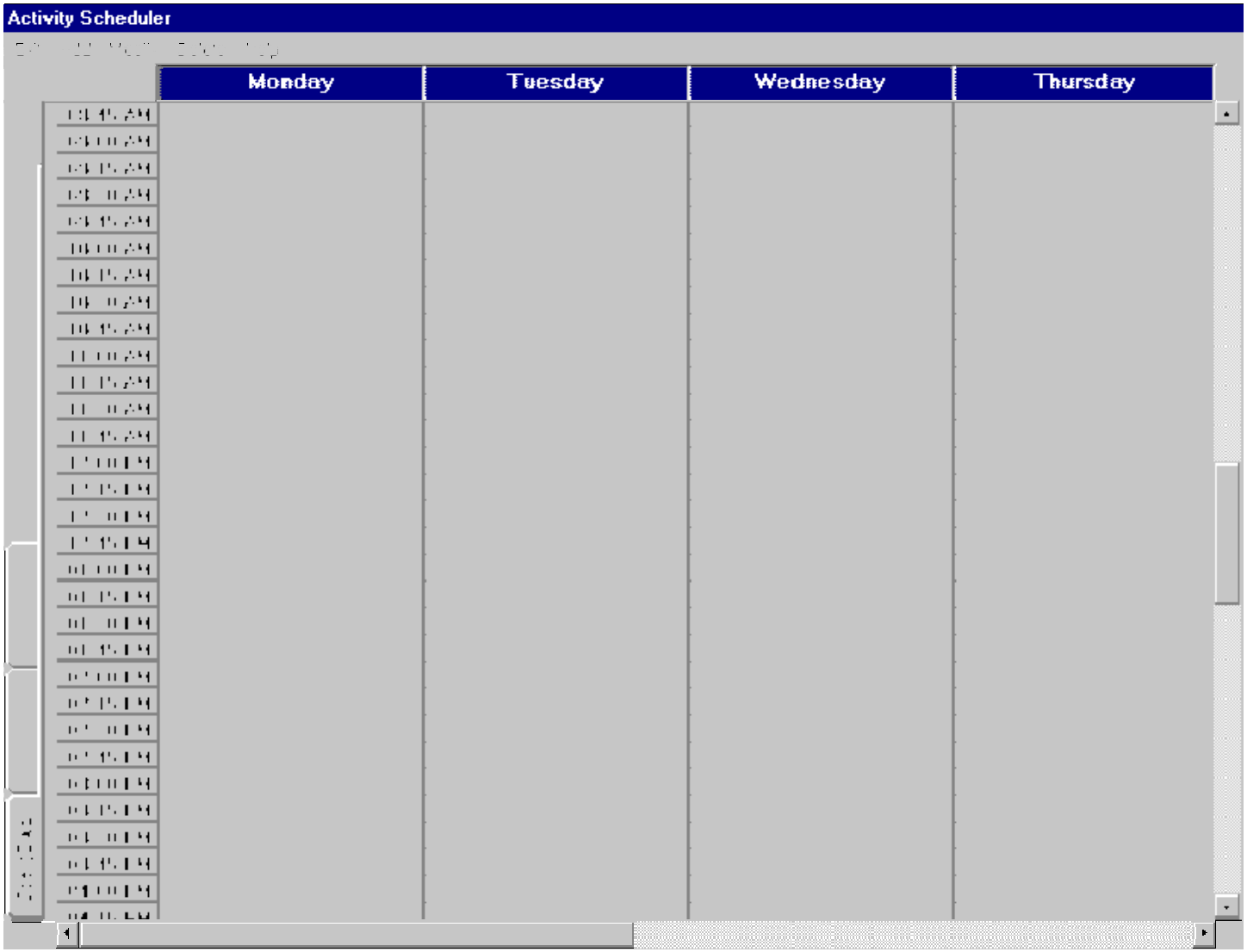
CHASE

- **C**omputerized **H**ousehold **A**ctivity **S**cheduling **E**licitor survey software
- Solved the problem of gaining insights into into underlying decision processes as they occur in reality over time
- Simultaneously records decision process AND observed patterns
- Low respondent burden
- Widely applied and developed since original creation

Upfront Interview



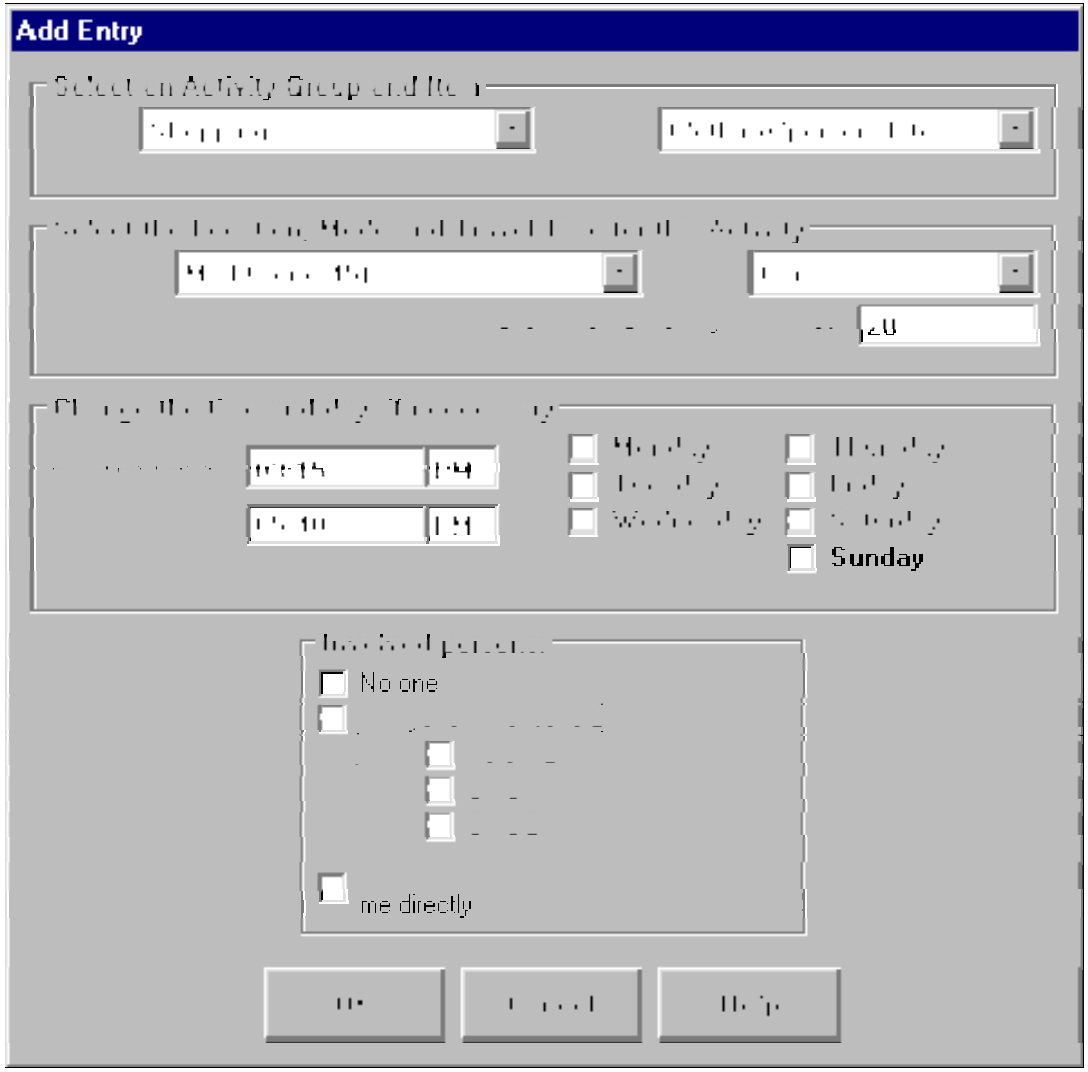
CHASE Main Screen (Blank)



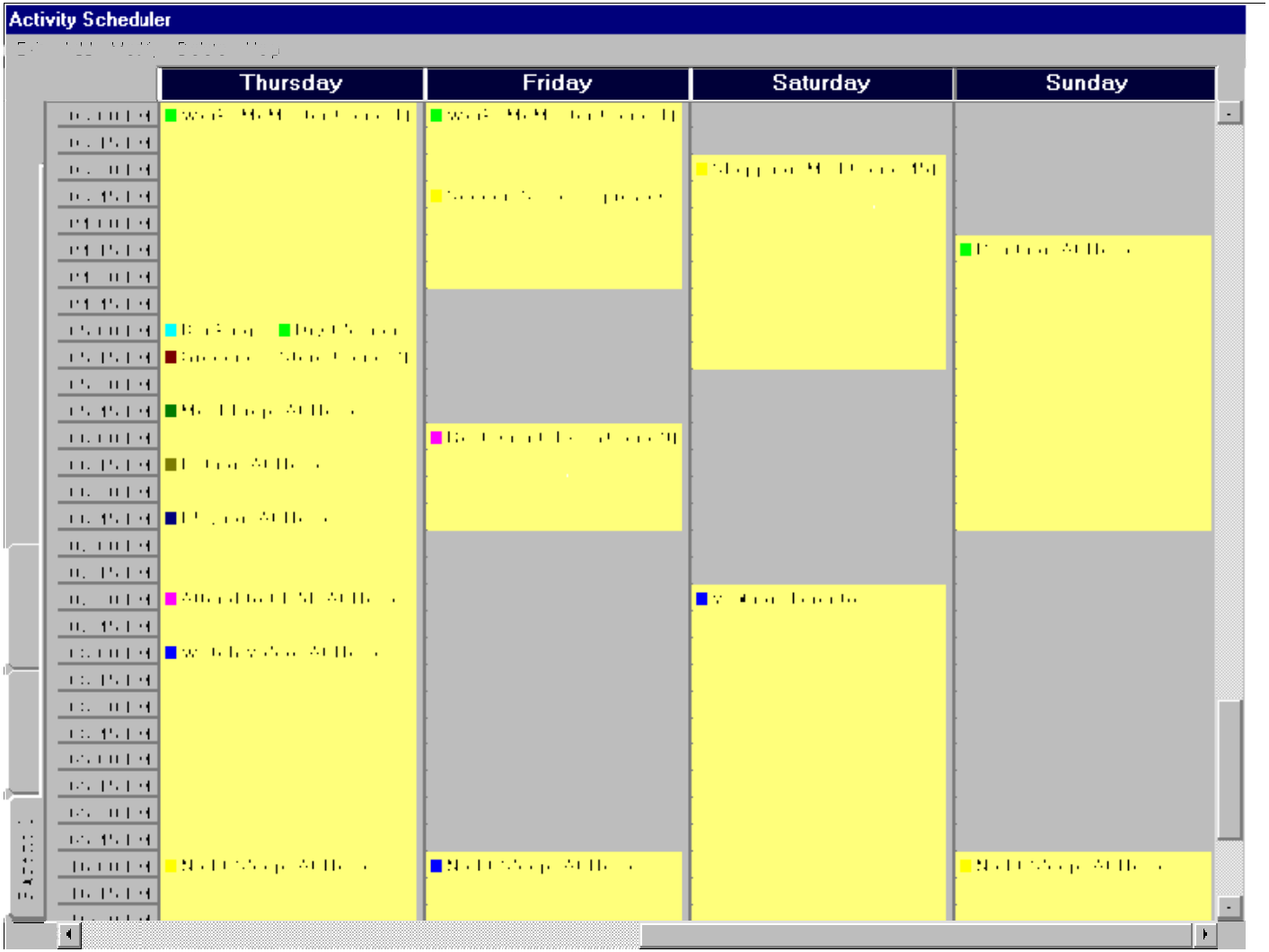
User Instructions

- Login once a day
- Add activities anywhere in your schedule
- Review and modify
- Respond to prompts

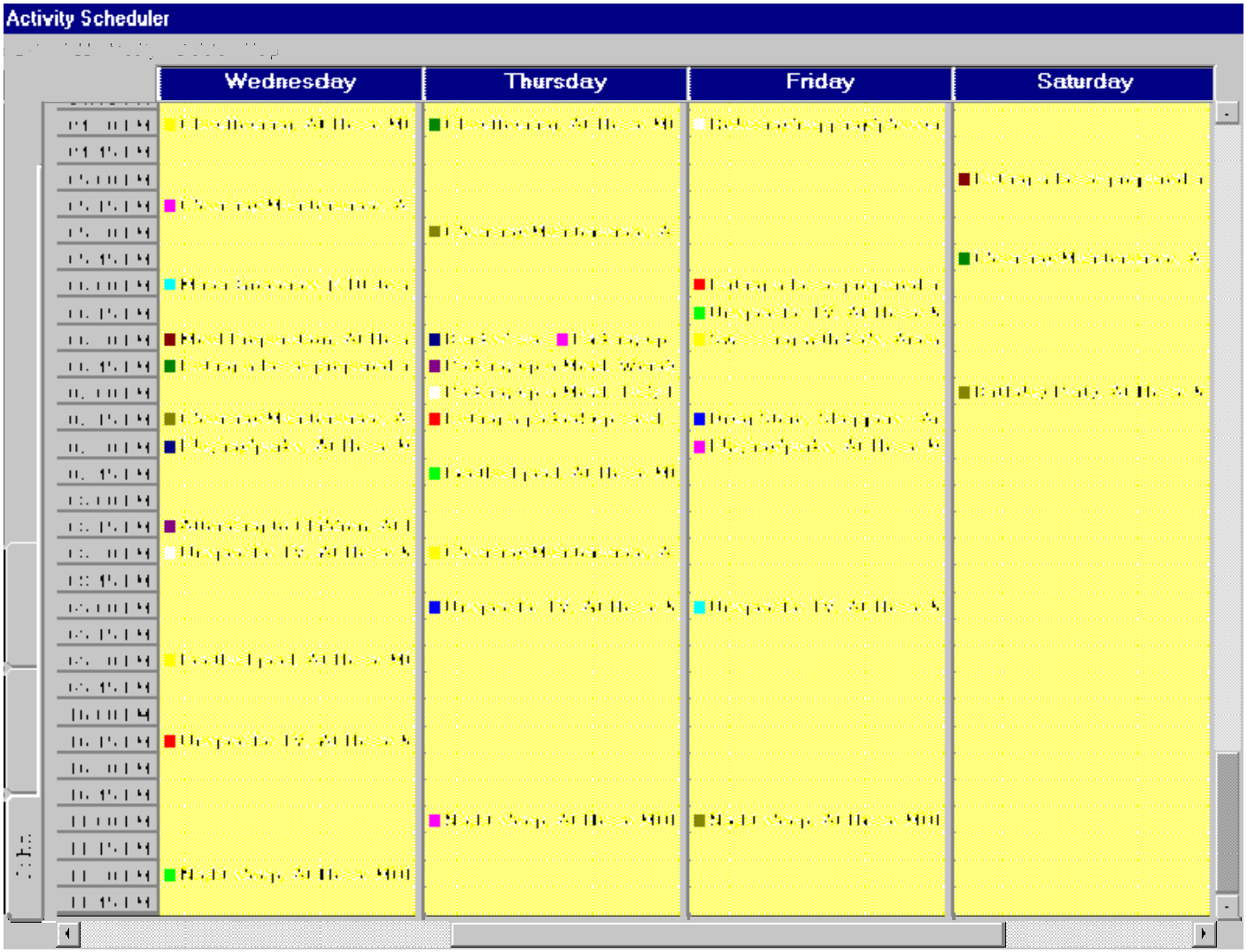
Add/Modify Dialog Box



Example Partially Completed Schedule



Example Completed Schedule



CHASE Functionality

- Array of data accuracy checks
- Functionality to make data entry faster and easier
- Supplemental information prompts
- Dialog boxes for new activities, modes, or locations

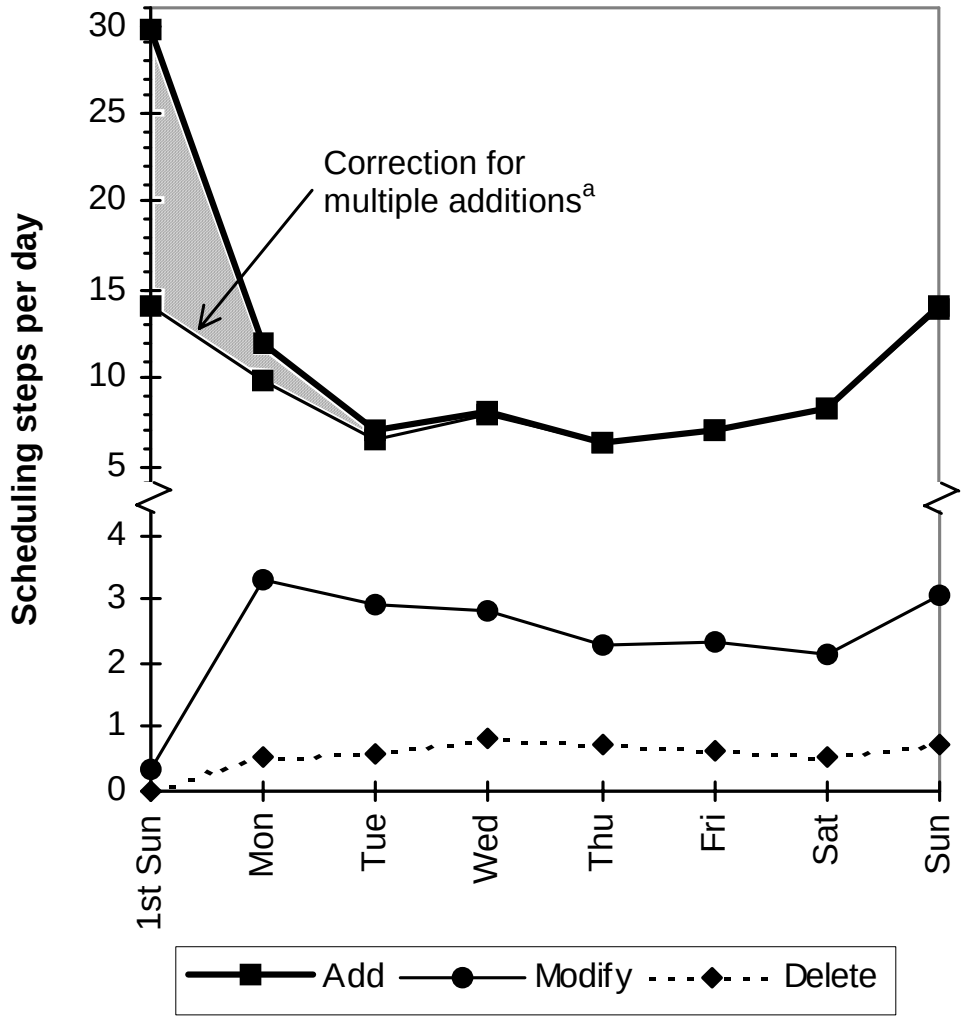
CHASE Applications

- Hamilton 1997 (40 mixed households)
- Aachen and Zurich 1999-2000 (small samples of students)
- Quebec City 1999 (40 mixed households), 2000 (3 households in SA experiment)
- On-going studies:
  - Irvine California (50 students using internet version)
  - Karlsruhe, Germany (*x* households using GIS version)
  - Waterloo - 90 individuals (45 teleworkers)

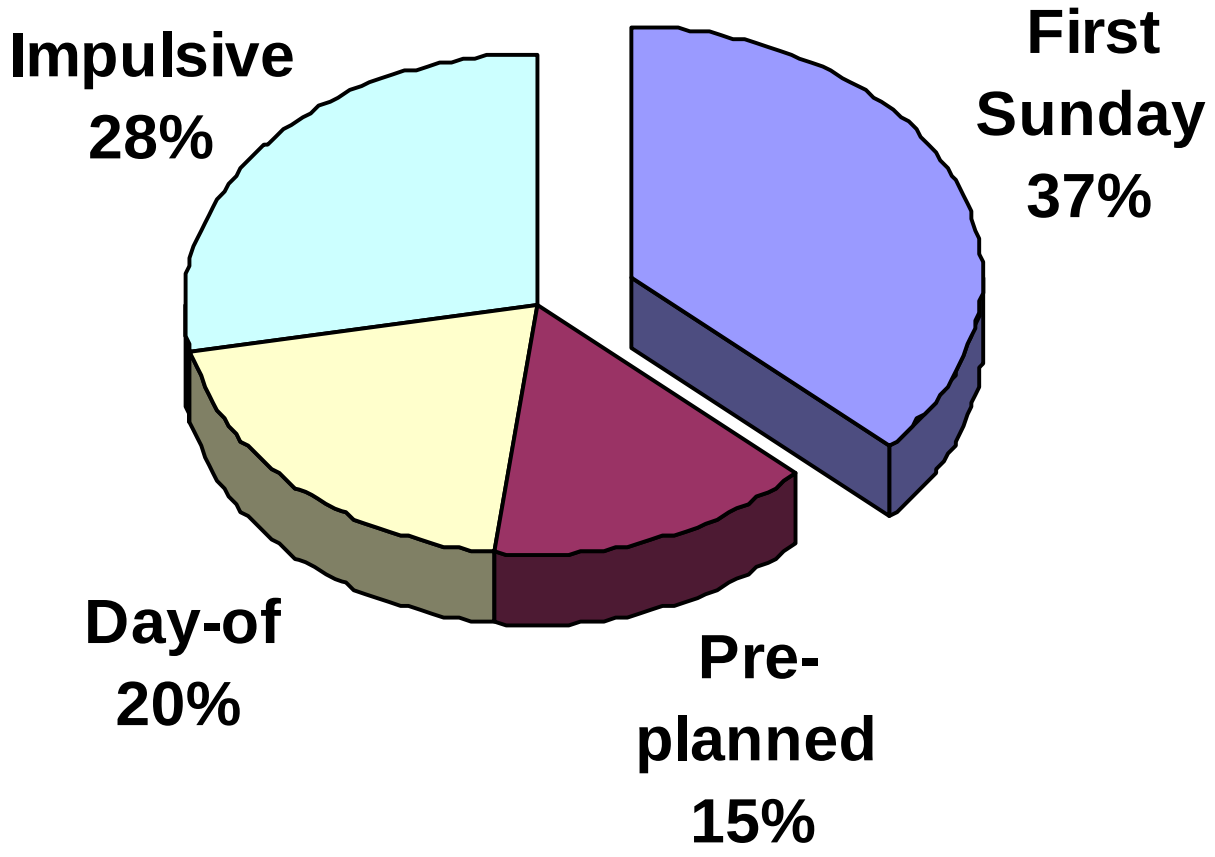
Scheduling Process Fundamentals

Key CHASE survey results

Scheduling Decisions by Day



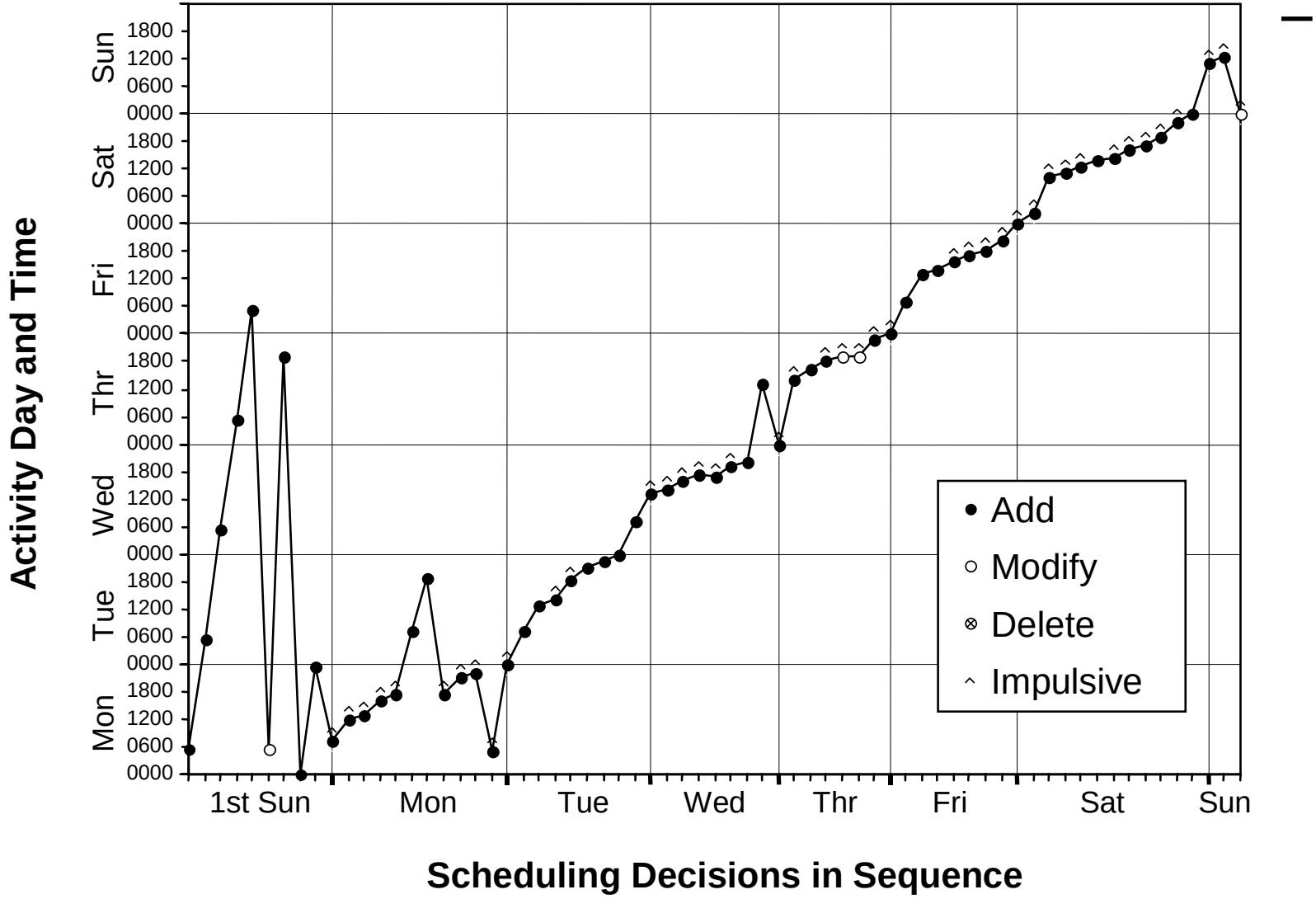
Planning Time Horizons



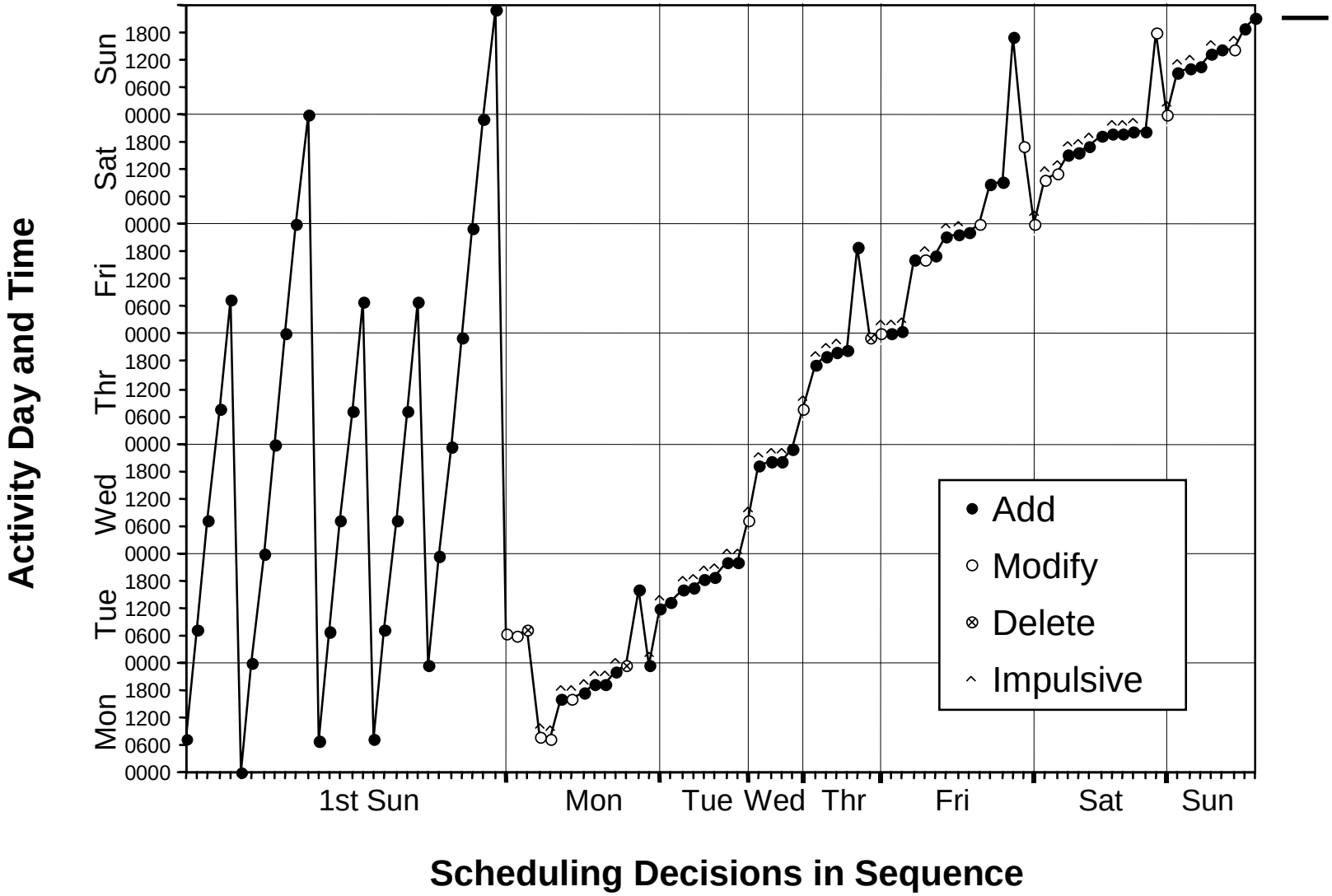
Visualizing the Sequencing Process

- Examined the sequence of scheduling decisions graphically over time for 65 adults
- If activities planned and executed in sequence, then points on graph would line up in a linearly increasing fashion
- Three unique styles of scheduling behavior were evident.

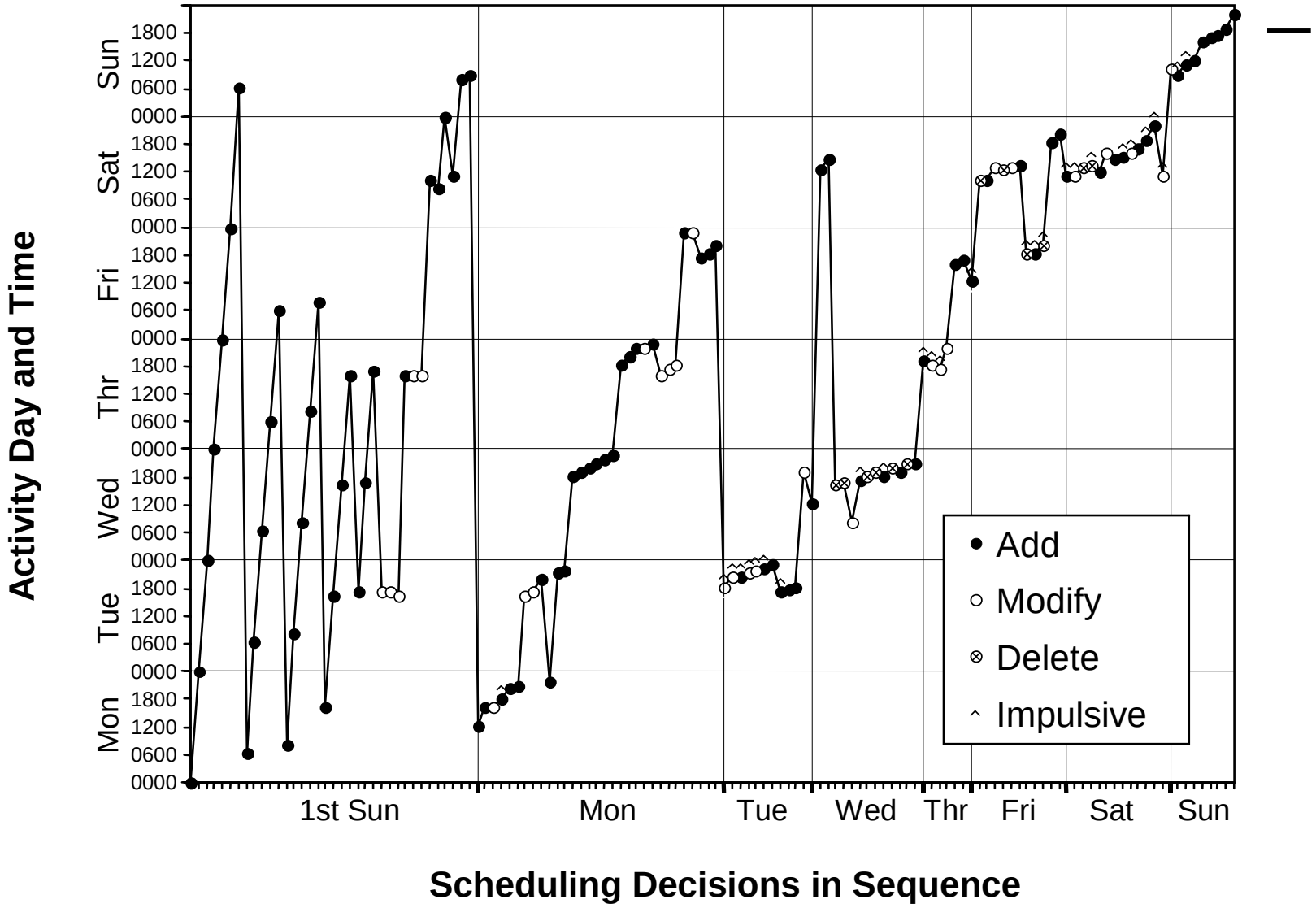
Example 1: Straightforward scheduling behaviour



Example 2 - Semi-structured, but straightforward



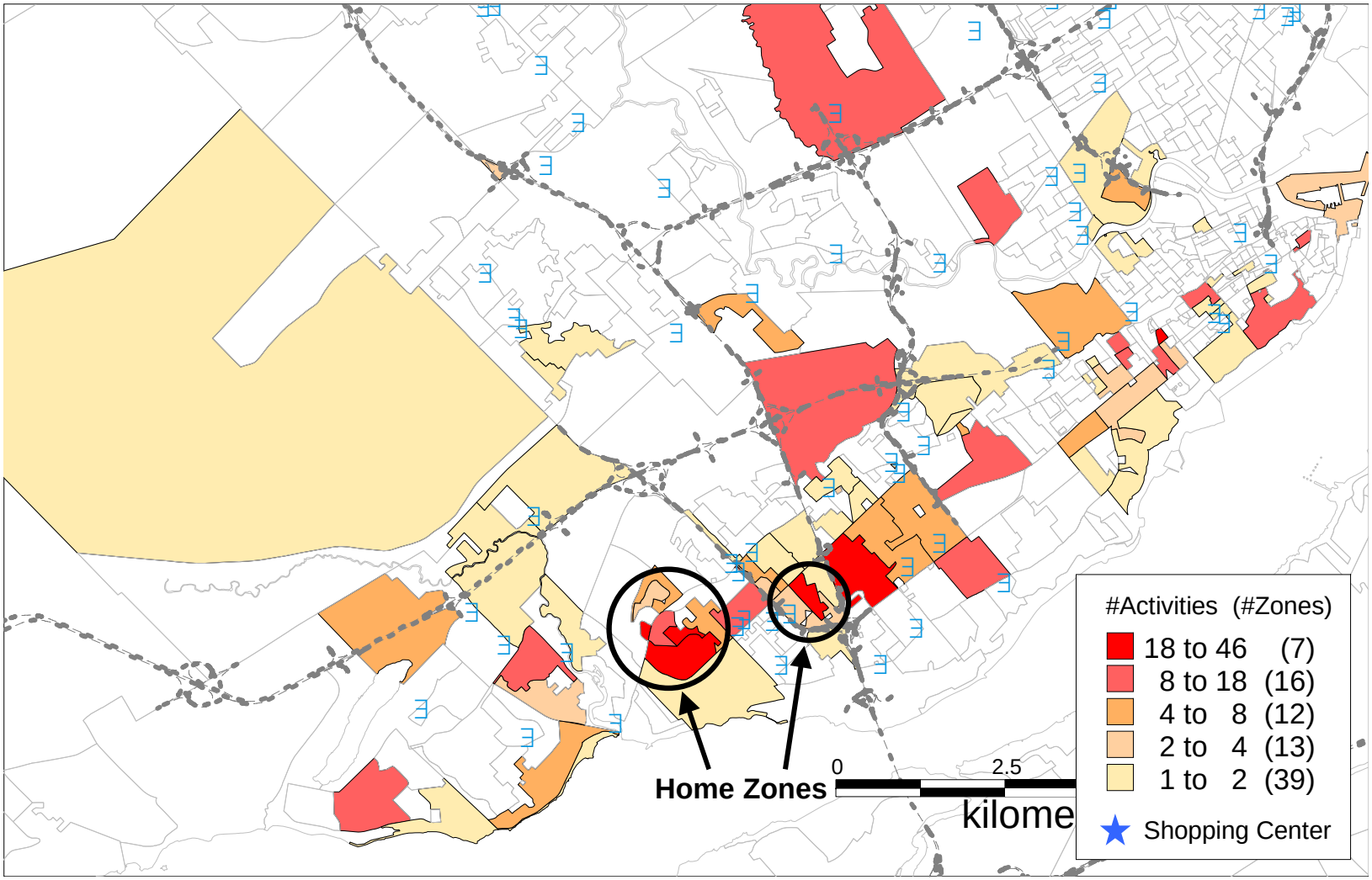
Example 3 - Highly structured, unordered and opportunistic



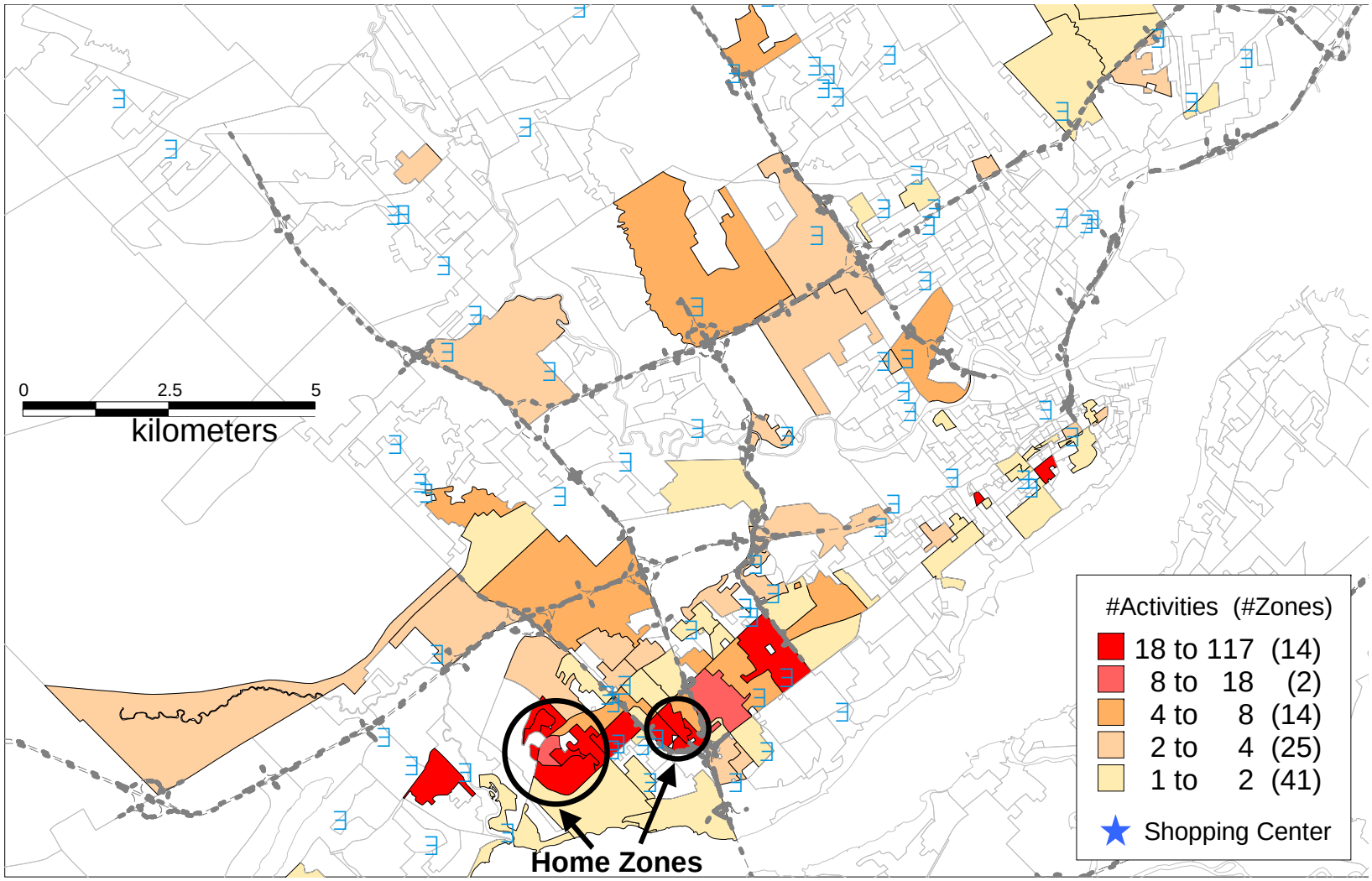
Activity Scheduling in Space

- Used CHASE data from Quebec City
- Examined the distribution of activities over space by when they were planned:
  - Prior to the week
  - During the week
  - Same day
  - Impulsive
- Relationships between scheduling and energy efficiency also explored in depth

Preplanned Activities



Impulsive Activities



Stated Adaptation Survey

- CHASE provided
  - base-line patterns
  - multi-day/user interactive display
- Follow-up SA interview to discuss
  - discuss general strategies of vehicle reduction
  - participate in a gaming exercise in which strategies implemented in context of prior weeks schedule

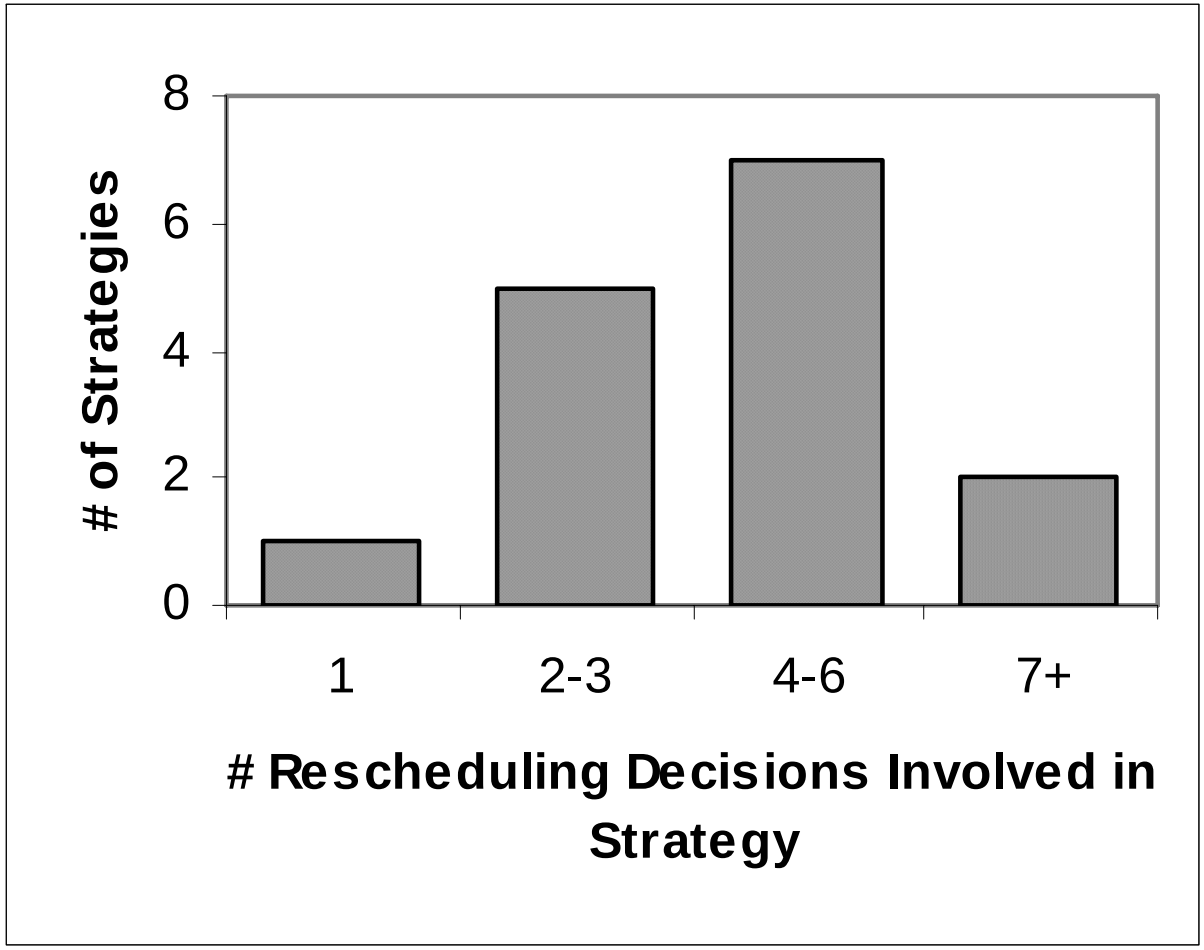
Recruited Households

Household 1: Single female, full-time employed, one automobile.

Household 2: Married couple, one full-time one part-time employed, two automobiles (two adult children also lived in the household)

Household 3: Married couple with one young child, both full-time employed, one automobile and one light truck.

Distribution of RE-scheduling decisions



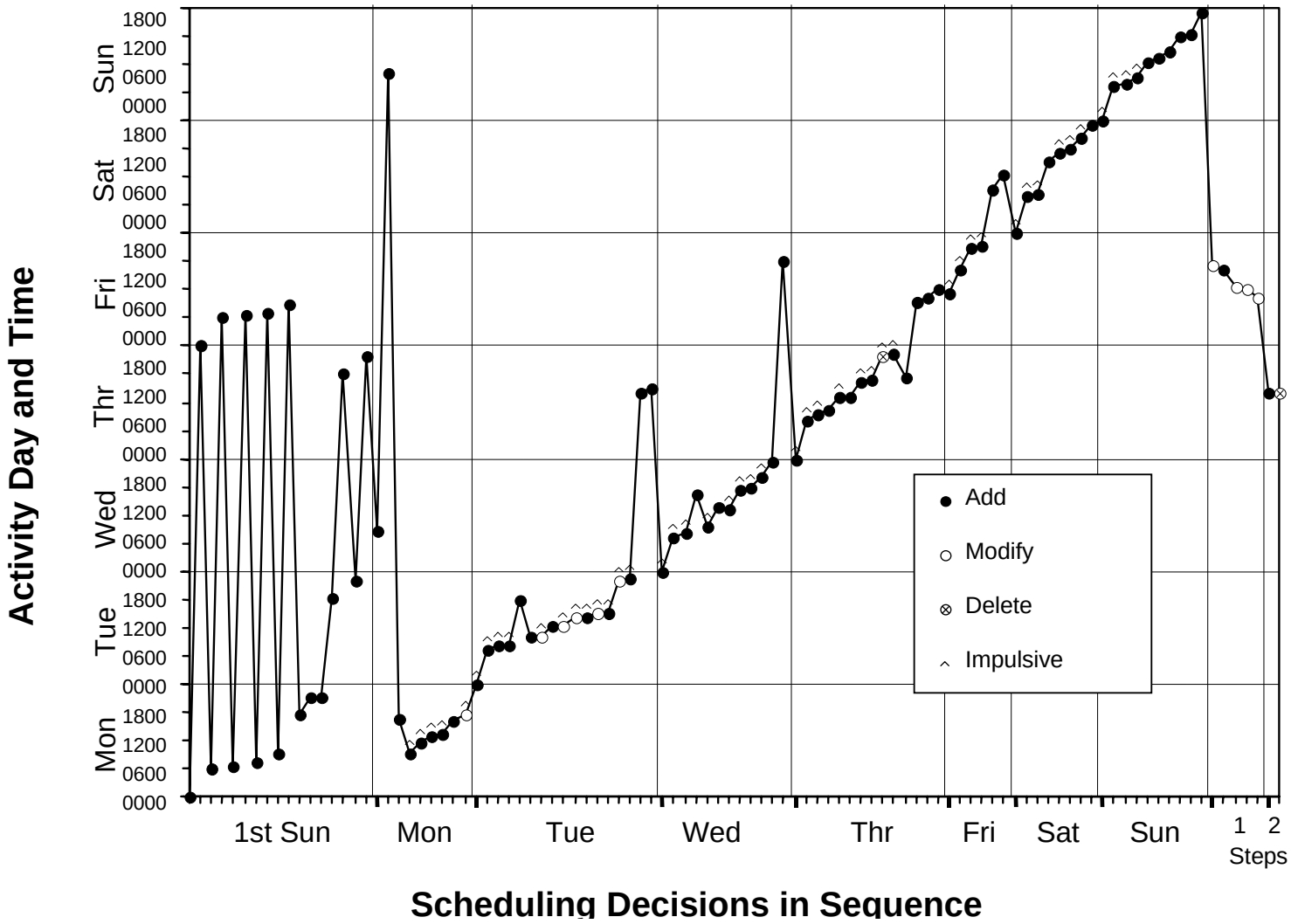
Rescheduling by Day

Adult	Mon	Tue	Wed	Thr	Fri	Sat	Sun	TOTAL
1						3	20	23
2				2	5			7
3	3	2	6	4				15
4	4	3	8			1	5	21
5		2	6	6	4		1	19
TOTAL	7	7	20	12	9	4	26	85

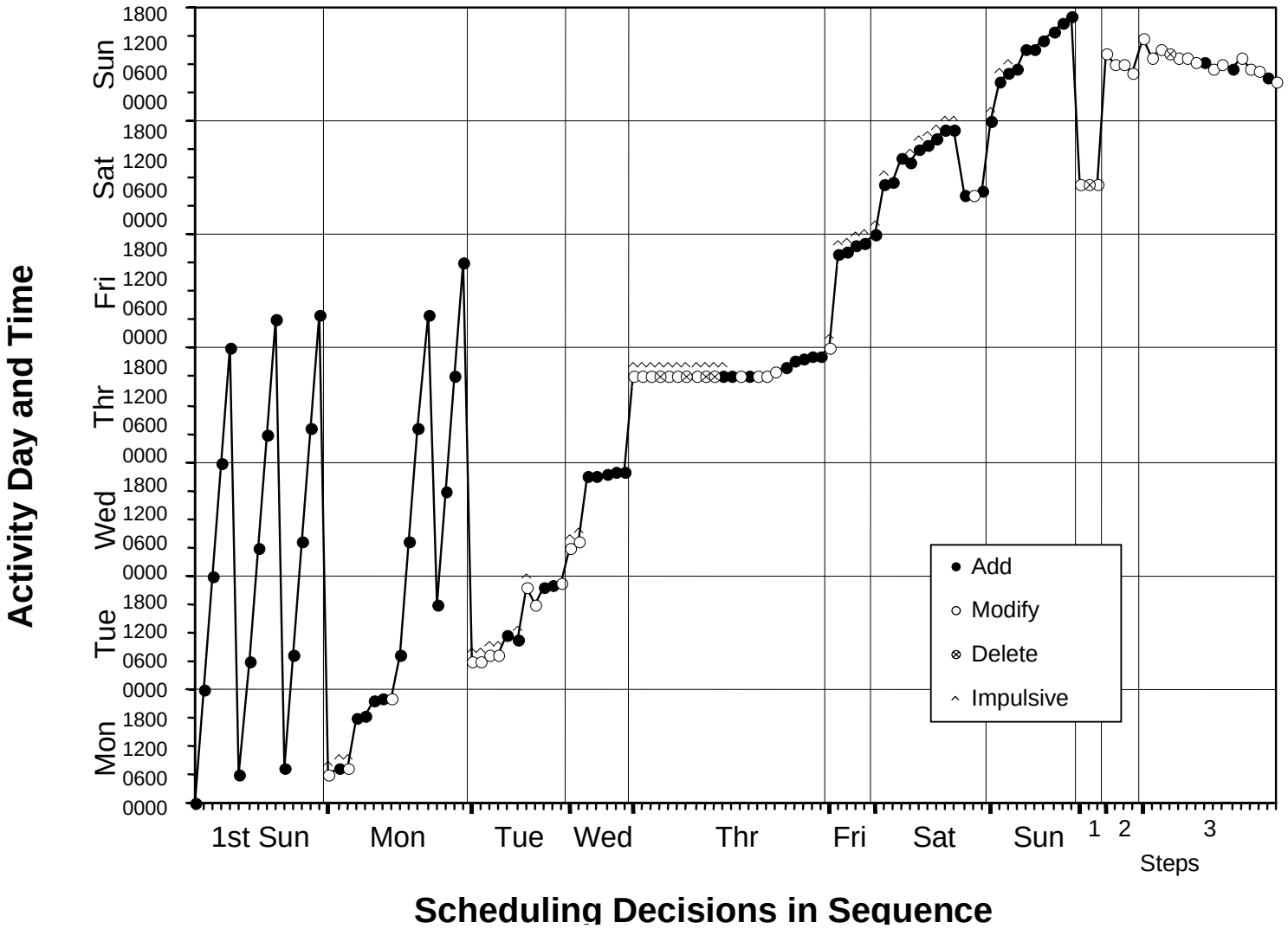
Rescheduling by When Planning

	All Activities			Modified/ Delete Activities Only	
When Planned	Count	(%)		Count	(%)
Routine	66	(24.4)		11	(18.6)
Preplanned prior to the week	70	(25.9)		7	(11.9)
Preplanned during the week	14	(5.2)		4	(6.8)
Same day	53	(19.6)		16	(27.1)
Impulsive	67	(24.8)		21	(35.6)

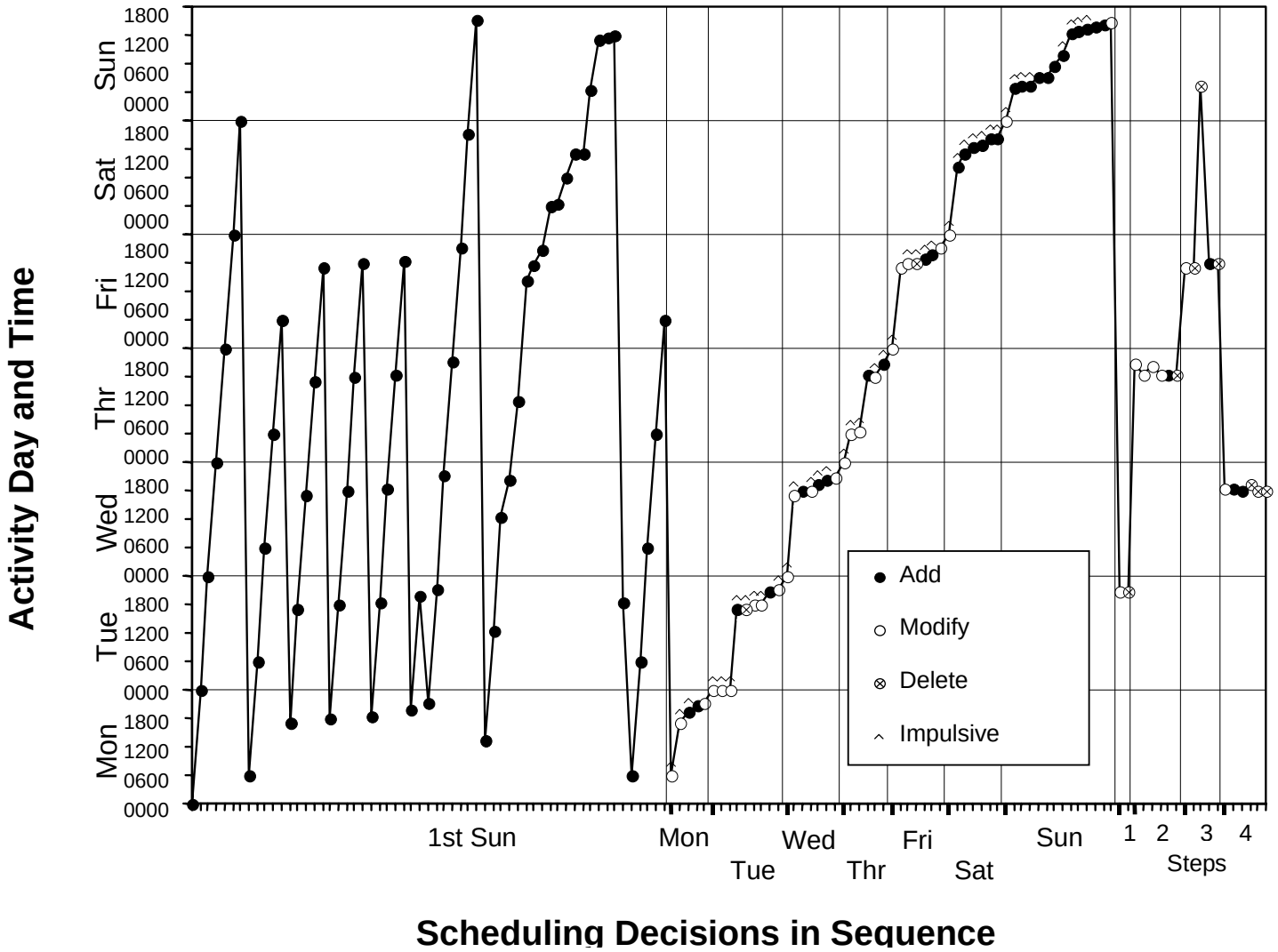
Example 1: Sequence of Scheduling Decisions Over Time



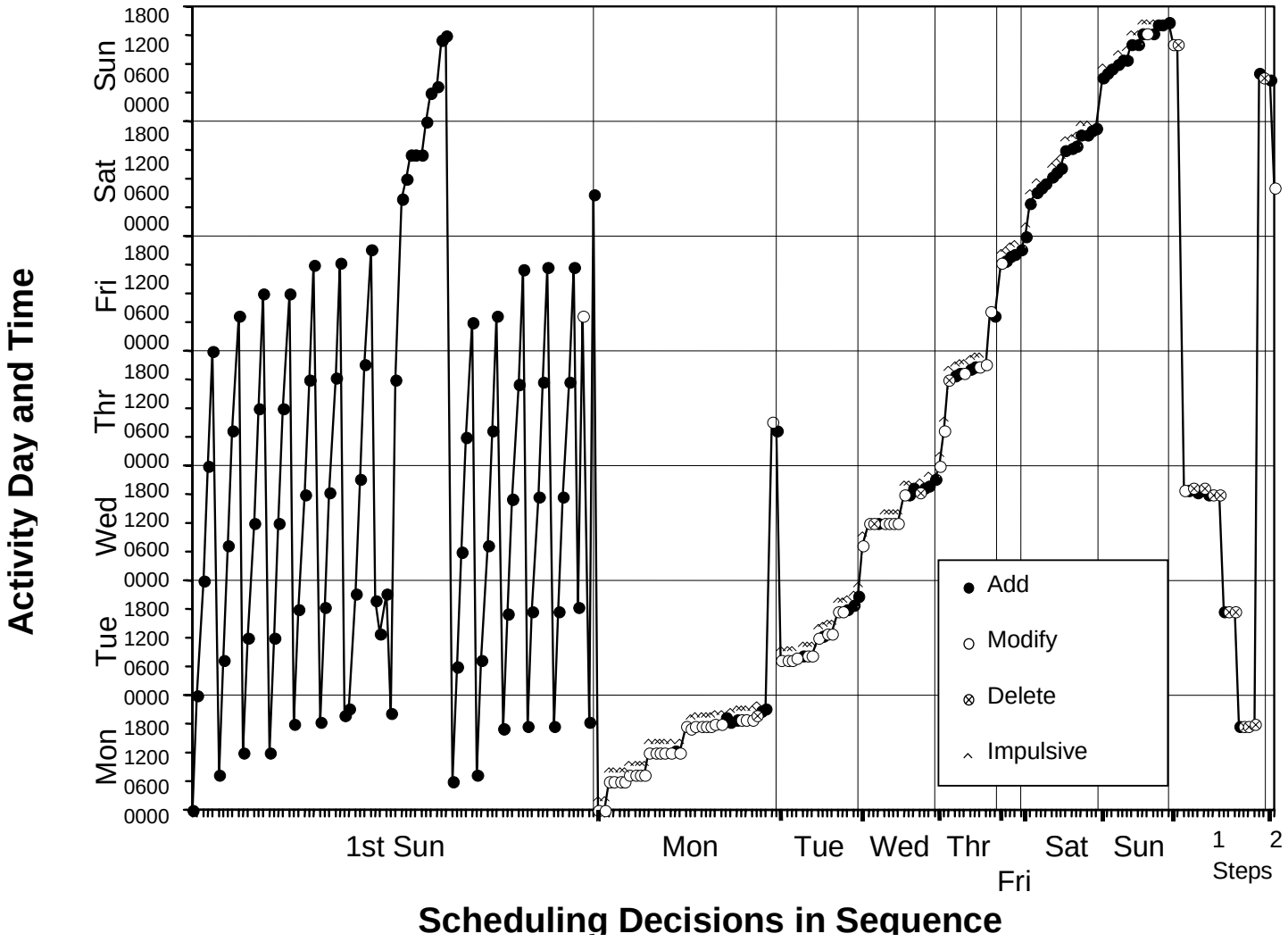
Example 2: Sequence of Scheduling Decisions Over Time



Example 3: Sequence of Scheduling Decisions Over Time



Example 4: Sequence of Scheduling Decisions Over Time



Results Summary - Scheduling Processes

- Dynamic process
  - many time horizons
  - rescheduling during execution
  - spatial dimension important
- Can be opportunistic and highly impulsive
- Not static and/or sequential

Results Summary - REscheduling Processes

- Fundamental response is to reschedule in time
- Involves multiple decisions and a variety of modifications across several days and activities
- Simple strategies often lead to elaborate responses in reality
- Decisions likely to be made over a variety of time horizons

Modelling Implications

- *Simultaneous models* - results challenge the assumption that activity scheduling is a static process
- *Sequential models* - the assumption that activities are planned and executed in order does not always hold - should consider past and “future” dependencies
- *Priority models* - instead of assigning priority statically by activity type, it could be modeled as a function of activity attributes and the situational factors

Specific implications for TRANSIMS

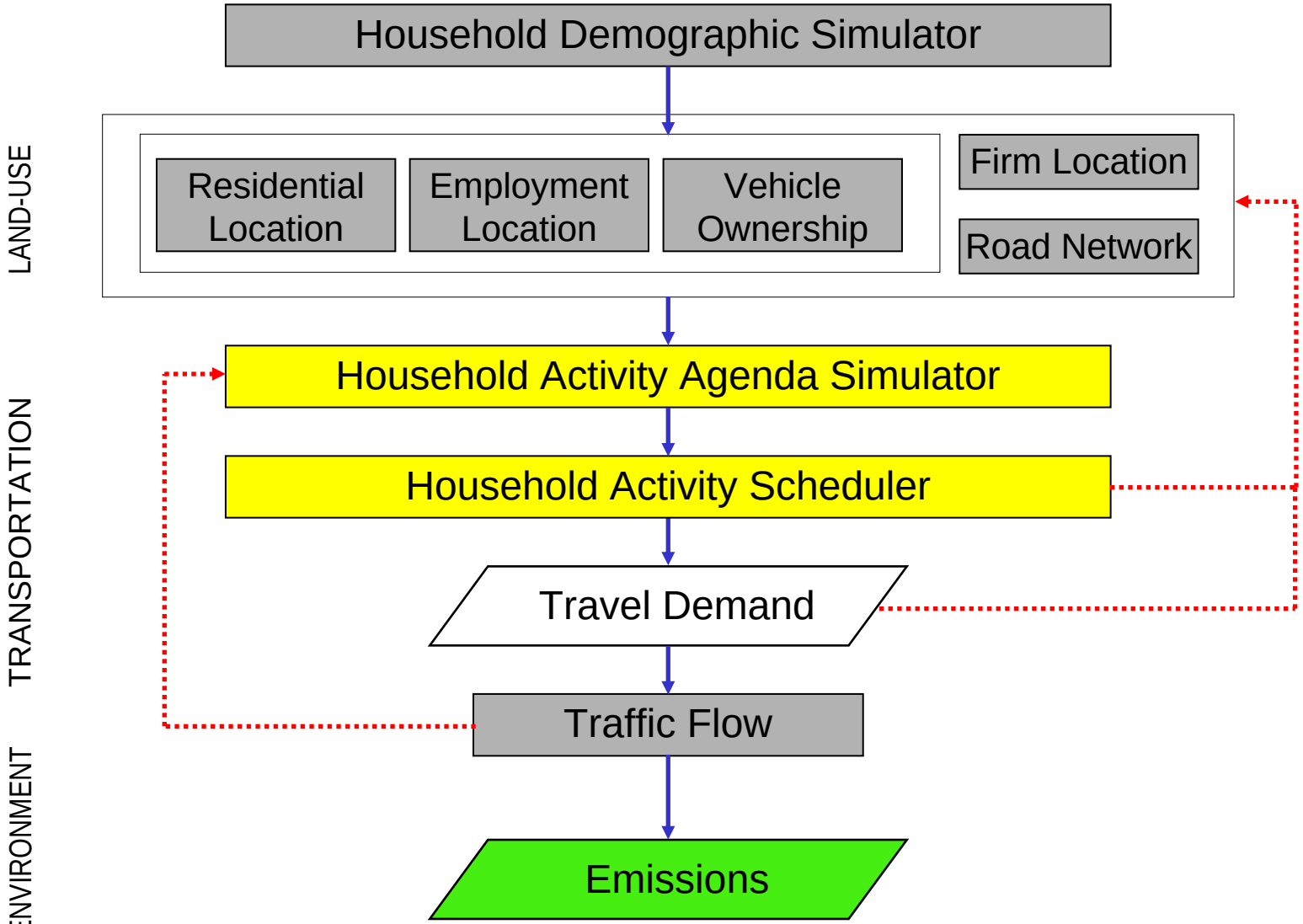
- Results supports notion of agenda, but suggest that ‘priority’ not be fixed
- Supports skeleton formation approach, but challenges assumption that only locations left out of skeleton
- Challenges tour structure that assumes fixed decision sequence (i.e. HB tour main activity - timing - location - mode choice - WB tour - intermediate stops). Suggest further investigation of tour decision sequence.
- Challenges adequacy of timing decisions as a nested choice among macro ‘time periods’- scheduling, and especially rescheduling, focuses on micro and macro changes in time.
- Supports notion of reassignment/replanning/ resimulation module, but left wondering how this will be calibrated - rescheduling clearly not a simple process.

Policy Implications

- Underlying scheduling and rescheduling process is key to understanding and forecasting emerging policies that inherently invoke a rescheduling response (e.g. TDM, ITS, telecommuting)
- Why?
  - Captures elaborate responses & secondary effects
  - Situational context helps explain specific decisions and sequence of decisions leading to observed outcomes
  - Scheduling context provides new variables for modelling

What does all this mean for ILUTE models?

Activity Scheduling within ILUTE Modelling Framework REVISITED



Simplified Agenda Example

Activity	Applicable Household members	General location	Attributes			
			Duration (mean)	Freq. (per week)	# Perceived locations	etc.
Work	Male head	home	2	2	1	
Work	Male head	out-of-home	8	5	1	
School	Child1	out-of-home	8	5	1	
Grocery Shop	Female head	out-of-home	1	3	12	
Grocery Shop	Male & female	out-of-home	2	1	12	
Active Sport	Male	out-of-home	1	1	2	
Activity Sport	Male & female	out-of-home	2	1	1	
Chauffeuring	Male & female	out-of-home	.5	5	1	
Socializing	Male & female	in or out	3	2	10	
etc.						

Agenda Simulation

- Require large scale diary survey data and microsimulation
- Key attributes include spatial/temporal flexibility, perceived locations, although still under investigation
- Policy change embedded within

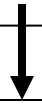
Activity Scheduling Models

- Four basic dimensions: activity choice, duration, location, sequencing
- Models can be classed as either
  - *Simultaneous*: assume scheduling process is static (e.g. STARCHILD, CARLA)
  - *Sequential:* assume activities are planned and executed in sequence (Kitamura et al. history dependent model) or according to a tour-based structure (Bowman et al.)
  - *Priority-based:* considers that activities are planned in order of priority, but mostly assign priority statically by activity type (SMASH, SCHEDULER, ALBATROSS)
- Can also be classed according to whether they use econometric vs. rule-based methods

Sequential Example: SMASH

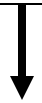
Activity agenda

List of activities to perform along with their attributes including the earliest start and end times, fixed durations, fixed priorities (measured on a 1-10 scale) and the attractiveness of locations.



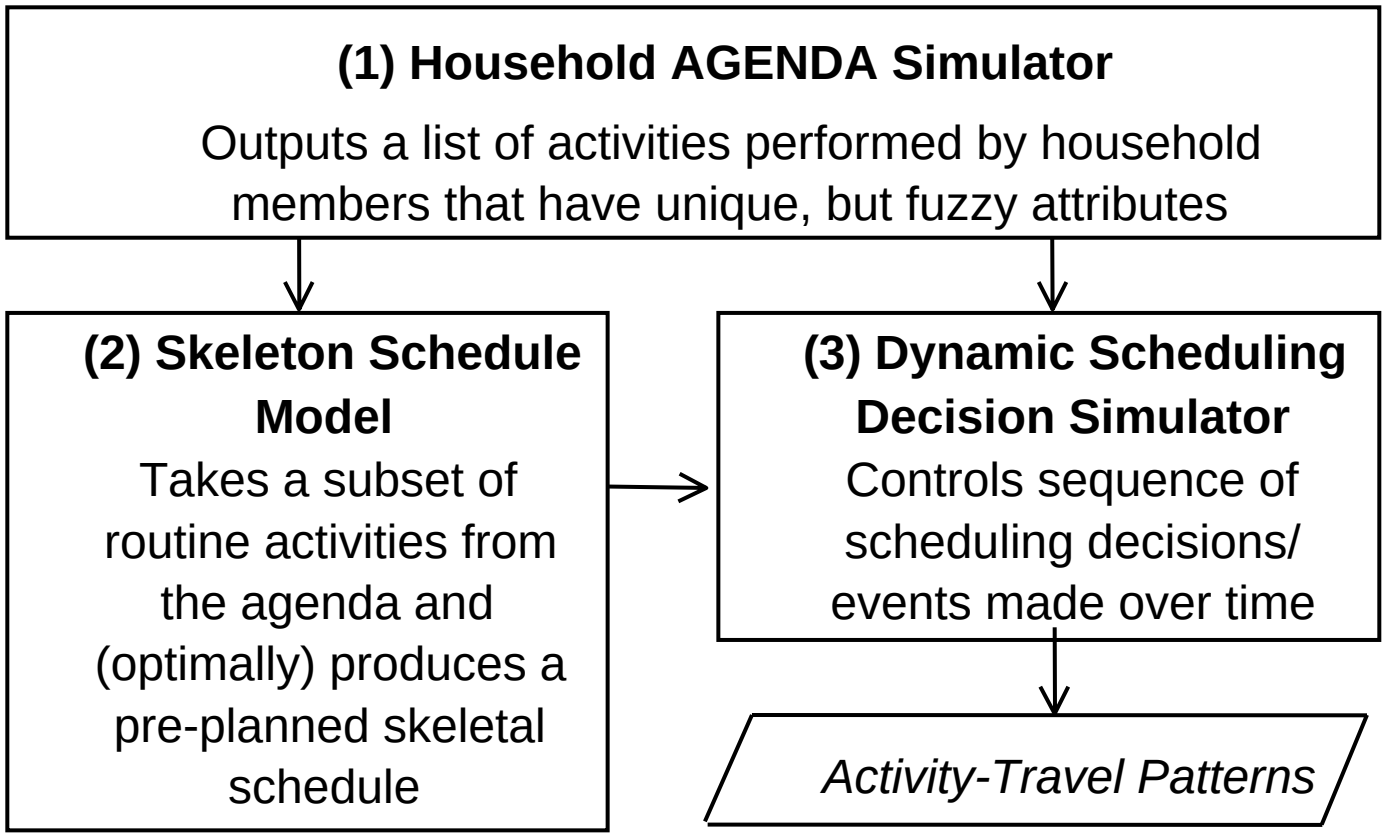
Scheduling process - Sequential steps:

1. Add activity anywhere in schedule
2. Delete an activity (placed back on agenda)
3. Substitute an activity on agenda for one on the schedule
4. Stop scheduling

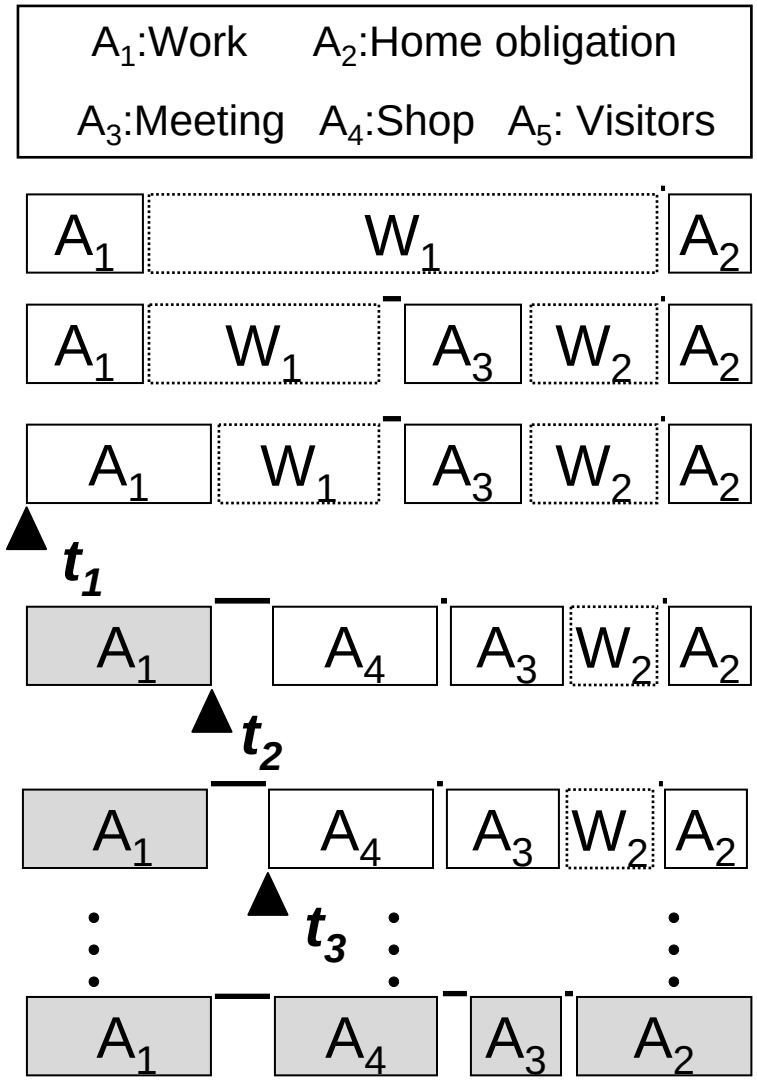


Final Schedule

Priority-based Example: ASPIRE



ASPIRE Event Simulation Example



Agenda

Optimized skeleton schedule

Pre-planned or Day-of activity decision(s)

Move to start of 1st activity - finalize duration

Impulsive activity decision

Movement - route and mode decisions

Final schedule

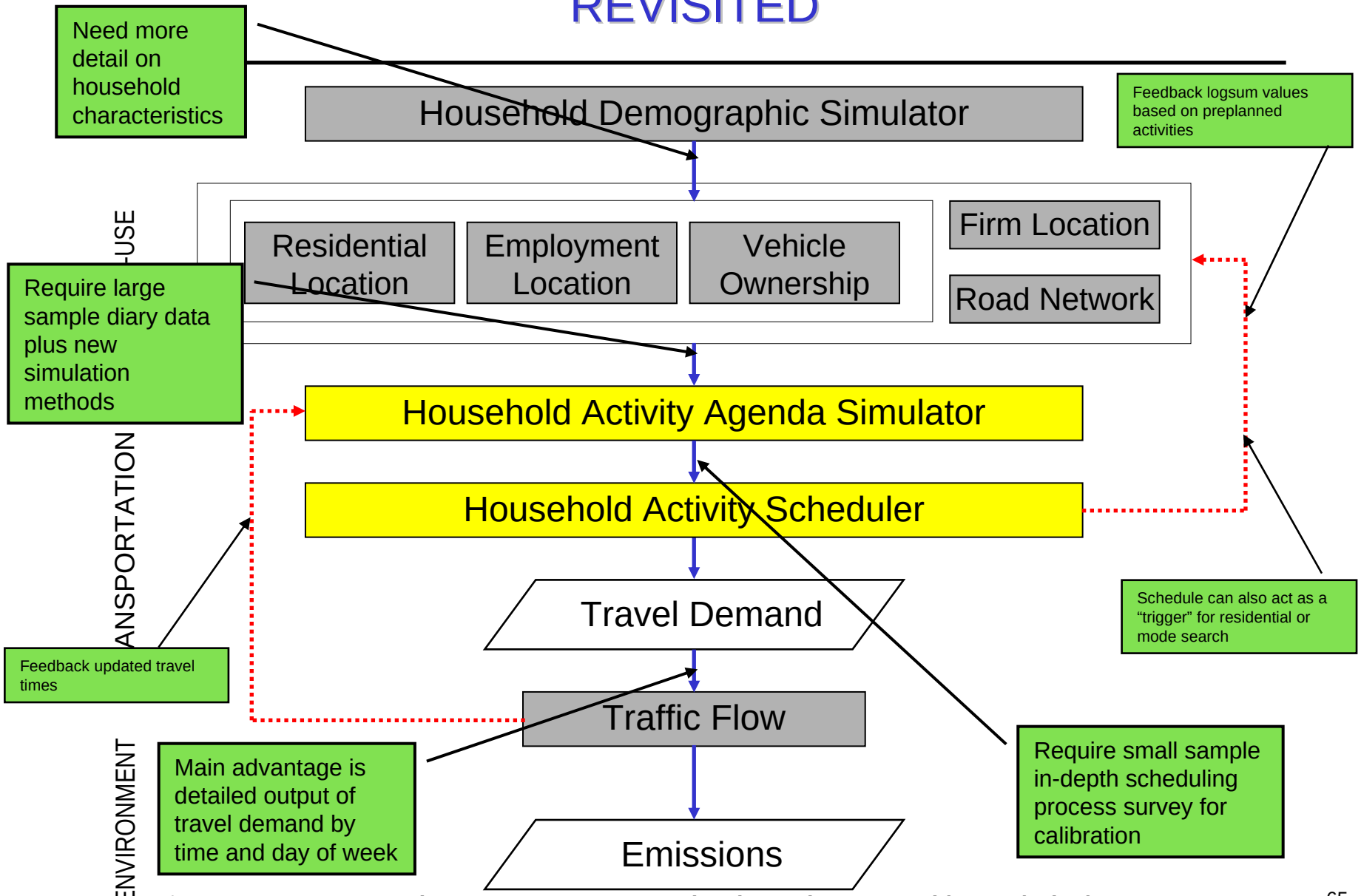
Legend

- Time Window, W_n
- Planned Act, A_j
- Executed Act, A_j
- Travel

Future Development

- Evidence suggests that an integrated framework combining optimization and dynamic simulation required
- Agenda simulation is key in terms of detail and policy assessment
- Estimation of various components of such models is ongoing
- Cognitive decision rule investigation still required

Activity Scheduling within ILUTE Modelling Framework REVISITED



Conclusions

- Natural progression from trips, to activities, to an activity scheduling *process*
- Investigating underlying processes, while maintaining link to observed patterns is possible
- Fundamental insights are being gained
- Results challenge assumptions and provide new directions for integrated framework
- Scheduling process models are on the horizon
- Integration within ILUTE models could add substantially to behavioral validity and policy sensitivity

Publications of Interest

The following publications provide additional detail on the topics covered in this presentation:

Doherty, S. T. and Miller, E. J. 2000. A computerized household activity scheduling survey. *Transportation* 27 (1): 75-97.

Doherty, S. T. and Axhausen, K. W. 1999. The development of a unified modelling framework for the household activity-travel scheduling process. In W. Brilon, F. Huber, M. Schreckengerg, and H. Wallentowitz (eds.) *Traffic and Mobility: Simulation-Economics-Environment*, pp. 35-56. Berlin: Springer.

Doherty, S. T. 2000. An activity scheduling process approach to understanding travel behaviour. Paper presented at the *79th Annual Meeting of the Transportation Research Board*, Washington, DC, January 9-13th, 2000.

Doherty, S. T. and Lee-Gosselin, M. E. H. 2000. Activity scheduling adaptation experiments under vehicle reduction scenarios. Paper to be presented at the *9th International Association for Travel Behaviour Conference*, Gold Coast, Australia, July 2-7, 2000.

Doherty, S. T., Noël, N., Lee-Gosselin, M., Sirois, C., and Ueno, M. 2000. Moving Beyond Observed Outcomes: Integrating Global Positioning Systems and Interactive Computer-Based Travel Behaviour Surveys. To appear in *Transportation Research Circular: Personal Travel: The Long and Short of It*. Transportation Research Board, National Research Council, Washington, D.C. (in preparation).

Contact Sean Doherty at sdoherty@wlu.ca to obtain copies.

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