Activity Based Modelling of Household Travel

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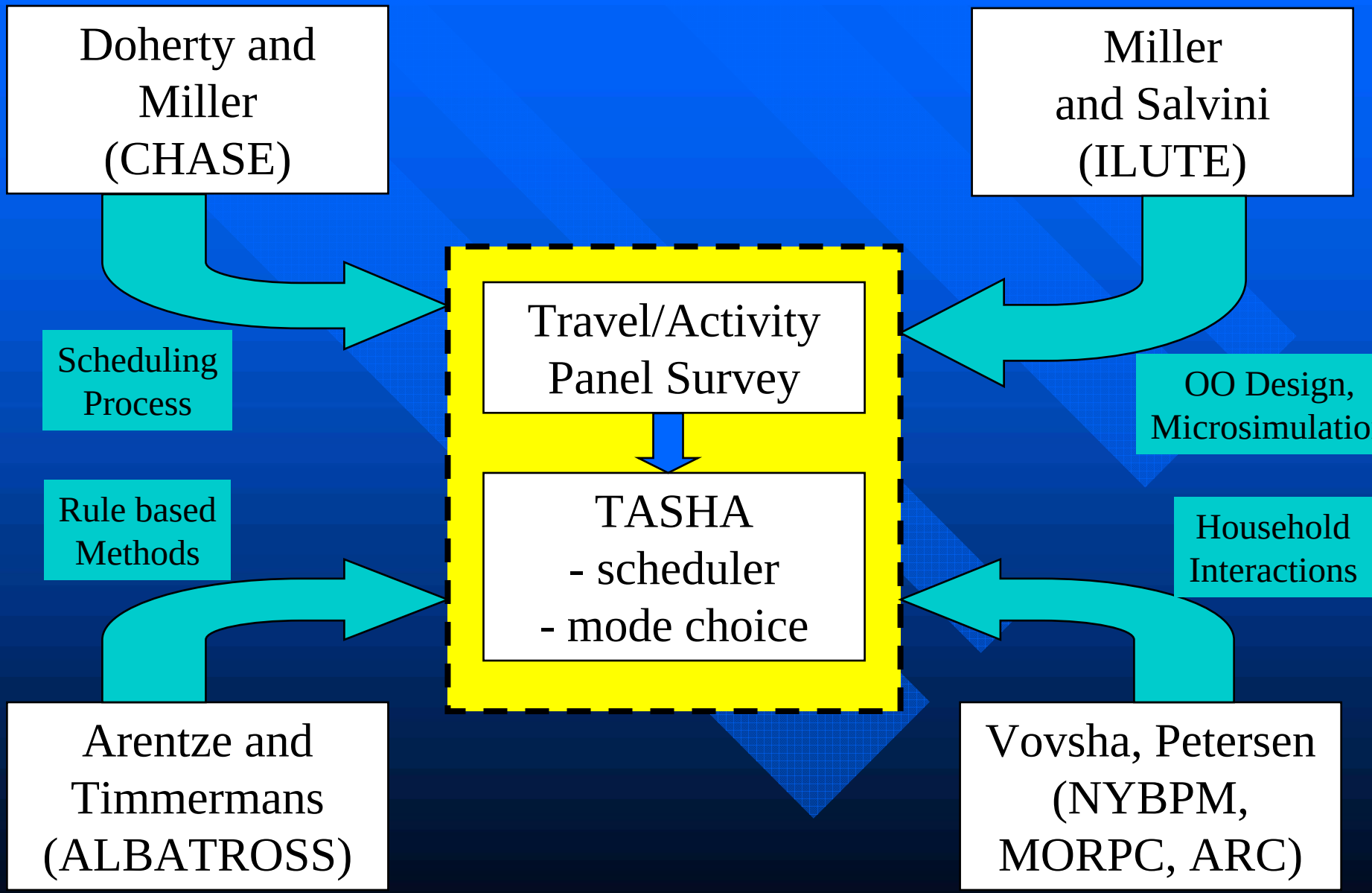
Research Objectives

- Build an **operational** microsimulation model of activity scheduling and mode choice for the Toronto Area
- **More precise and sensitive** to demand-oriented policies such as TDM, ITS technology, and HOV lanes
- Improved **behavioural** representation of **individual and household** decision making
- Develop the model to be **compatible within ILUTE** framework, but also operational as a **stand alone** piece of software based on **readily available data**
- Explore behaviour using **innovative survey methods**

Major Contributions

- Toronto Travel Activity Panel Survey (TTAPS)
  - 3 wave panel survey of activity scheduling behaviour
  - Data analysis for informing model structure
- Travel Activity Scheduler for Household Agents (TASHA)
  - Rule-based activity scheduling model
  - Tour-based mode choice model

Major influences on this work



Travel Activity Panel Survey
Substantive Objectives

Understand the *process* by which people schedule and reschedule activities and travel

Observe how activities, travel and the underlying scheduling process change or remain stable over time

Compare decision processes in two different study areas, Quebec City and Toronto

Provide an empirical basis for modelling

Travel Activity Panel Survey Methodological Objectives

Compare computerized versus non-computerized survey methods

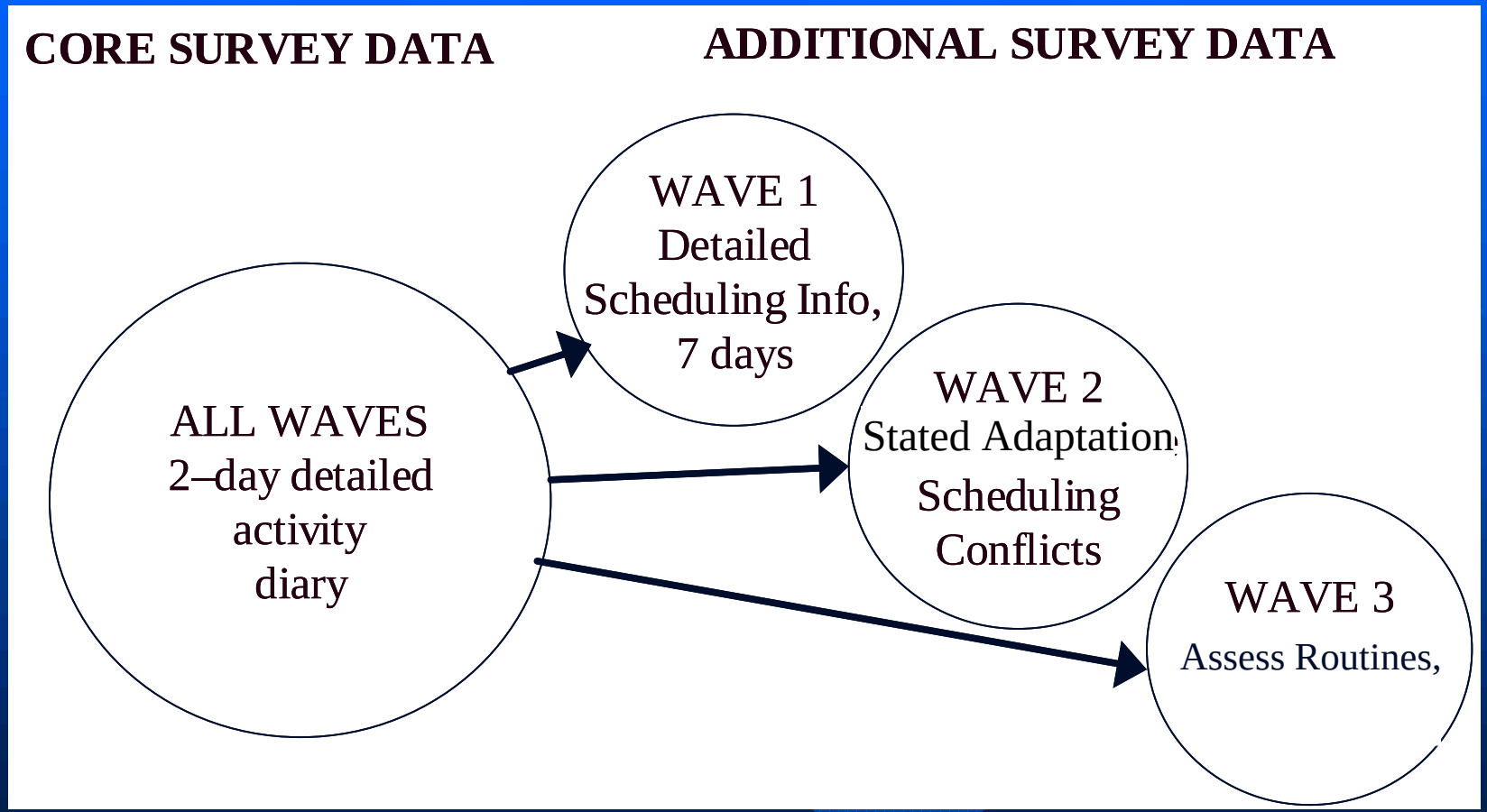
Compare telephone-survey to face-to-face interview

Test the use of GPS units in coordination with CHASE

New measures of data quality

Test CHASE on a medium-sized random sample

Travel Activity Panel Survey Methods

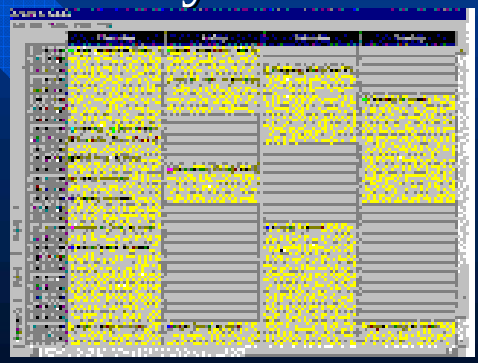


Wave 1 - CHASE Process (270 households)

Chase Scheduling Diary

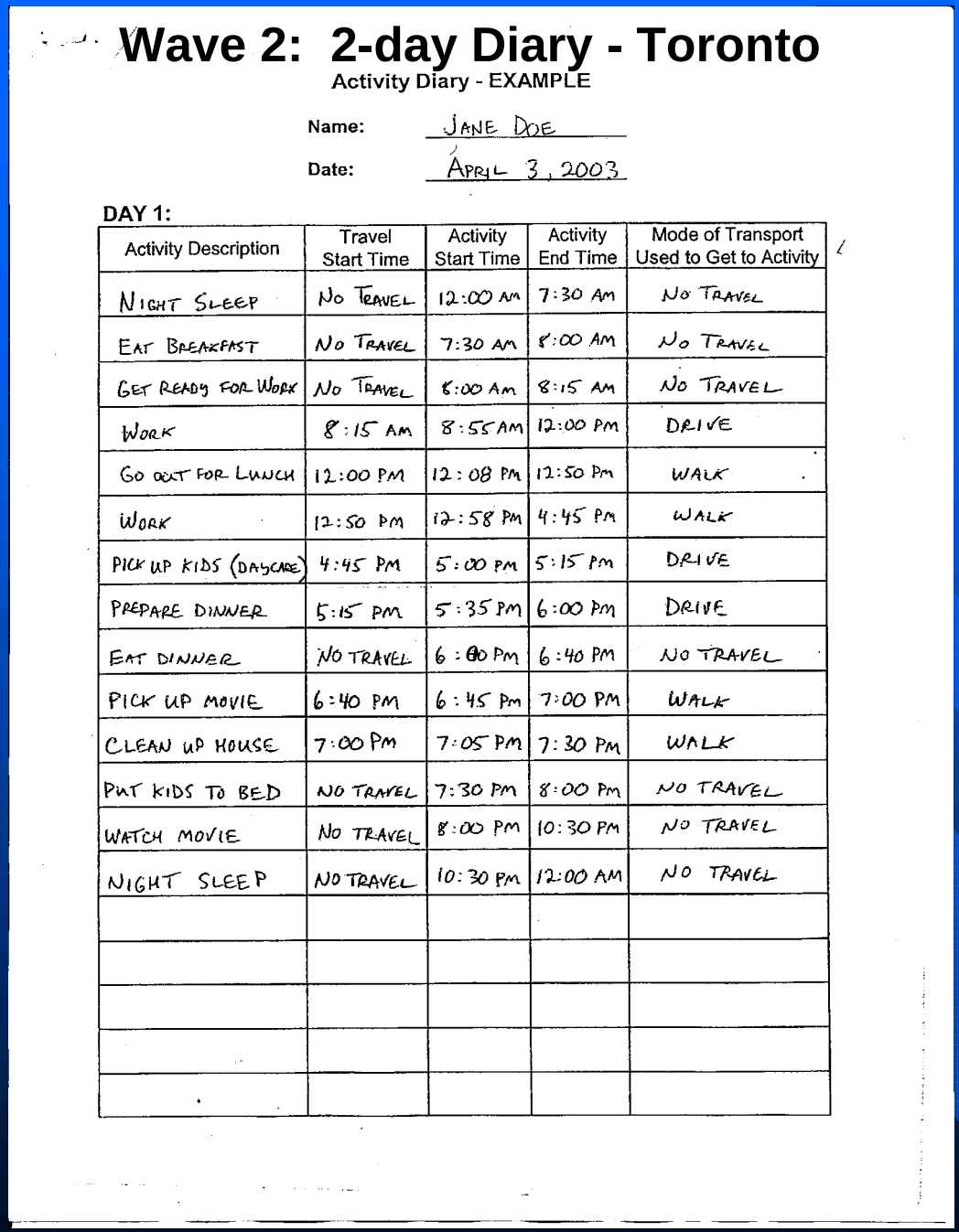
Interview Household

Household keeps schedules on laptop for 7 days



Follow-up Interview

Retrieve data from laptop



Wave 2: 2-day Diary - Toronto

Activity Diary - EXAMPLE

Name: Jane Doe

Date: April 3, 2003

DAY 1:

Activity Description	Travel Start Time	Activity Start Time	Activity End Time	Mode of Transport Used to Get to Activity
Night Sleep	No Travel	12:00 AM	7:30 AM	No Travel
Eat Breakfast	No Travel	7:30 AM	8:00 AM	No Travel
Get Ready for Work	No Travel	8:00 AM	8:15 AM	No Travel
Work	8:15 AM	8:55 AM	12:00 PM	Drive
Go out for Lunch	12:00 PM	12:08 PM	12:50 PM	Walk
Work	12:50 PM	12:58 PM	4:45 PM	Walk
Pick up kids (daycare)	4:45 PM	5:00 PM	5:15 PM	Drive
Prepare Dinner	5:15 PM	5:35 PM	6:00 PM	Drive
Eat Dinner	No Travel	6:00 PM	6:40 PM	No Travel
Pick up movie	6:40 PM	6:45 PM	7:00 PM	Walk
Clean up House	7:00 PM	7:05 PM	7:30 PM	Walk
Put kids to bed	No Travel	7:30 PM	8:00 PM	No Travel
Watch Movie	No Travel	8:00 PM	10:30 PM	No Travel
Night Sleep	No Travel	10:30 PM	12:00 AM	No Travel

Wave 2

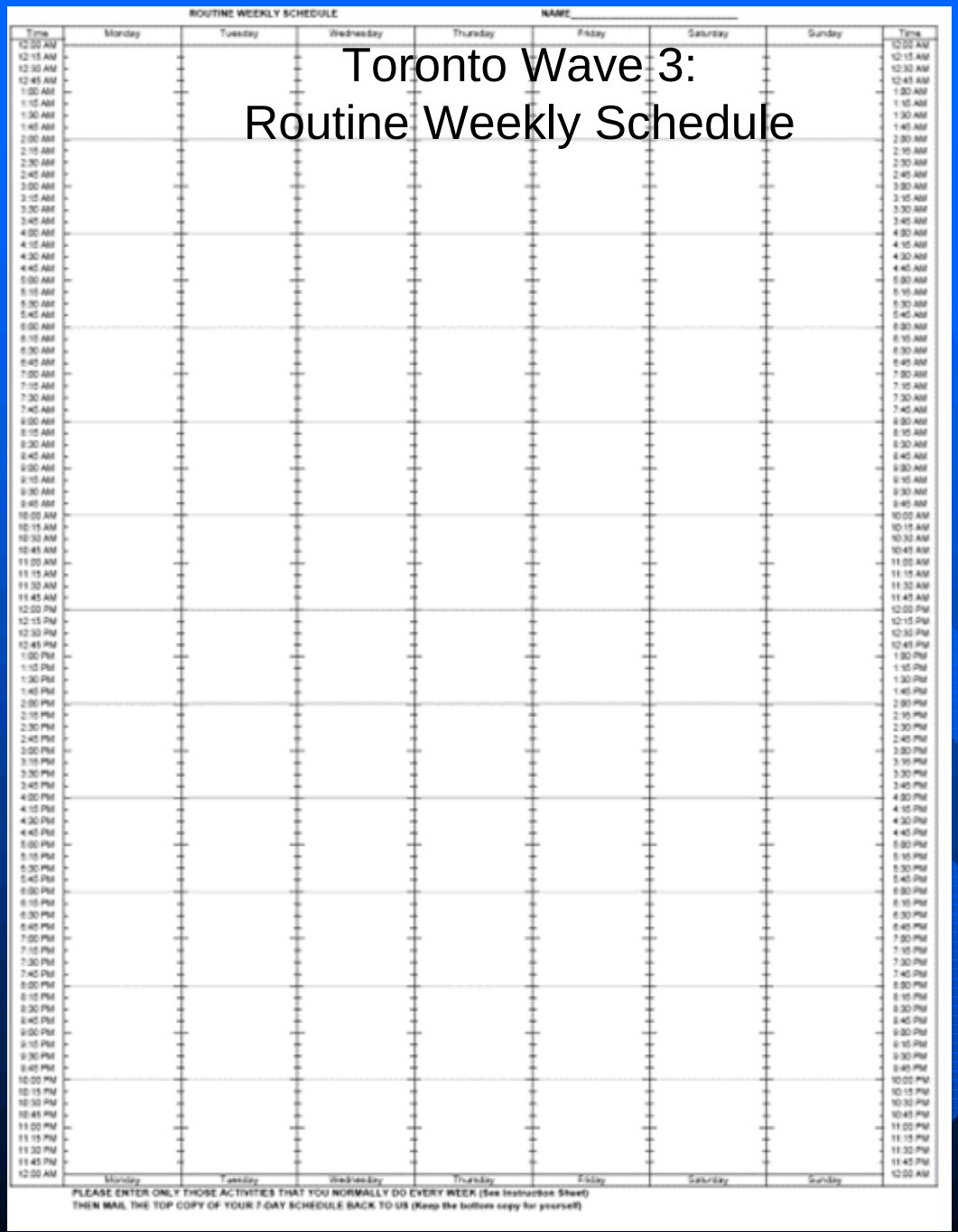
Stated Adaptation Questions:

"What would have happened if you had an unexpected one-hour delay in getting to this activity?"

"What would you have done if the ___mode were not available to get to that activity?"

How would it have affected:

- other activities the same day
- activities on other days
- other household members

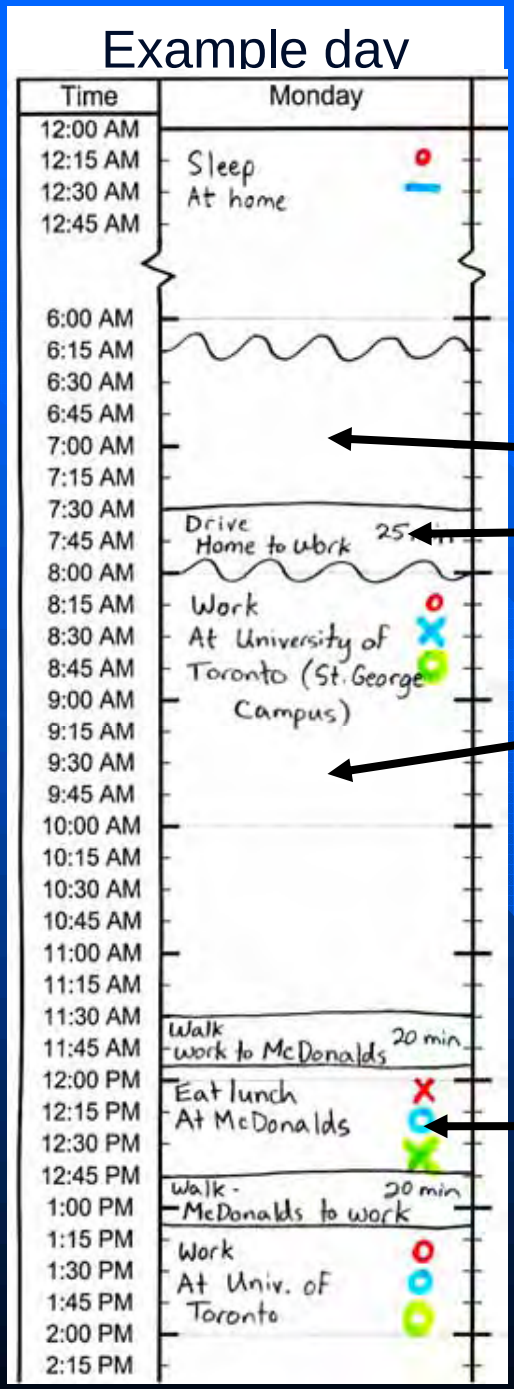


WAVE 3

- 2-day diary of activities
- 7-day routine weekly schedule
- Follow-up Interview
  - Details of the 2-day diary
  - How old are the routine activities?
  - Flexibility of activity times, modes, location
  - Commitments to other people

Wave 3:

Routine Weekly Schedule



Time in week with no routine

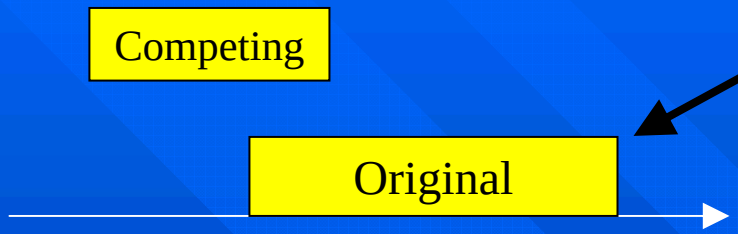
Routine travel

Routine activity

Colour coded symbols indicating time/ space/ interpersonal flexibility

Analyzing activity conflicts

In a conflict, what types of activities are likely to be scheduled first?



Optimal precedence ranking for conflicting activities

Precedence Ranking	Activity Group - Original Activity	Activity Group - Competing Activity									
		Work/ School	Basic Needs	Recreation/ Entertainment	Drop-off/ Pick-up	Social	Household Obligations	Services	Shopping	Other	Total
1	Work/School	49	113	92	57	22	33	23	28	6	423
2	Basic Needs	43	215	115	13	48	68	24	9	20	555
3	Recreation/Entertainment	39	108	82	25	33	46	22	24	23	402
4	Drop-off/Pick-up	24	18	8	4	5	17	3	8	4	91
5	Social	9	30	24	2	18	22	2	4	4	115
6	Household Obligations	32	43	38	13	18	48	13	16	6	227
7	Services	4	5	3	2	2	8	6	8	1	39
8	Shopping	6	7	14	1	3	8	3	5	1	48
9	Other	1	6	6		1	1	0	1	1	17
	Total	207	545	382	117	150	251	96	103	66	1917

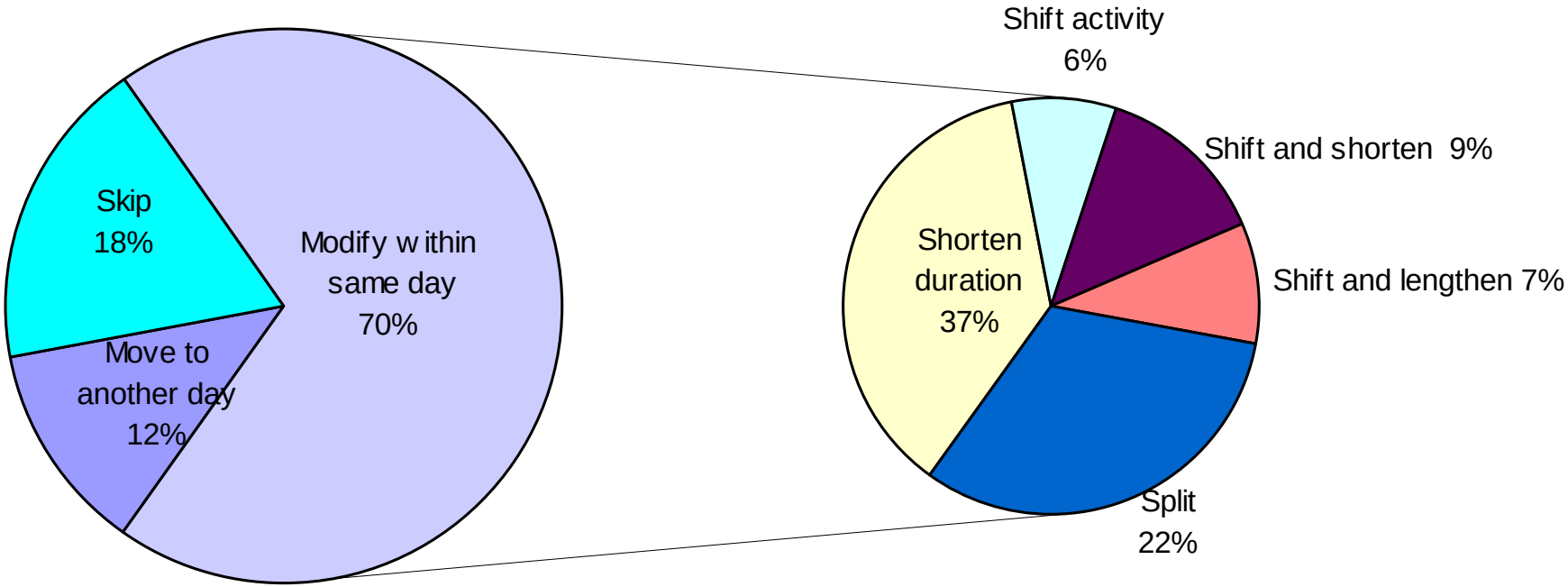
	Shading indicates for each pair of activity groups, the "competing"/"original" ordering that is observed more frequently		
	Total number of entries where the lower precedence activity displaces the higher precedence activity	958	50.0%
	Total number on the diagonal (same activity group)	428	22.3%
	Total number of entries where the higher precedence activity displaces the lower precedence activity	531	27.7%

Analysing response to scheduling conflicts

What modifications are made to the original activity when a scheduling conflict occurs?

Competing

Original



TASHA - Construction of Schedules - Method

- Randomly generate activity episodes
  - Frequency, start time, duration, location

- Preliminary sequencing of episodes into project agendas

- Construct person schedules
  - Insert episodes in order of priority
  - Joint episodes added simultaneously
  - Travel episodes added

- Trip chains emerge naturally

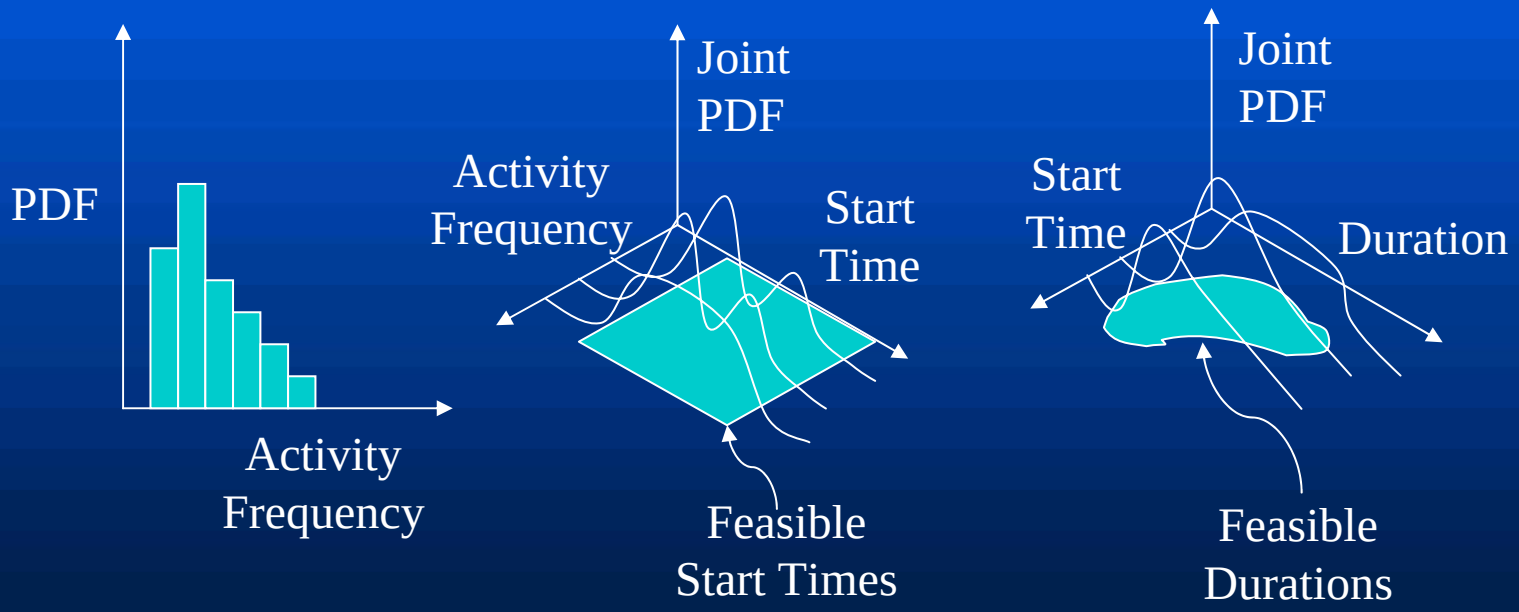
- Run tour-based mode choice model

Activity Episode Frequency, Start Time and Duration Generation

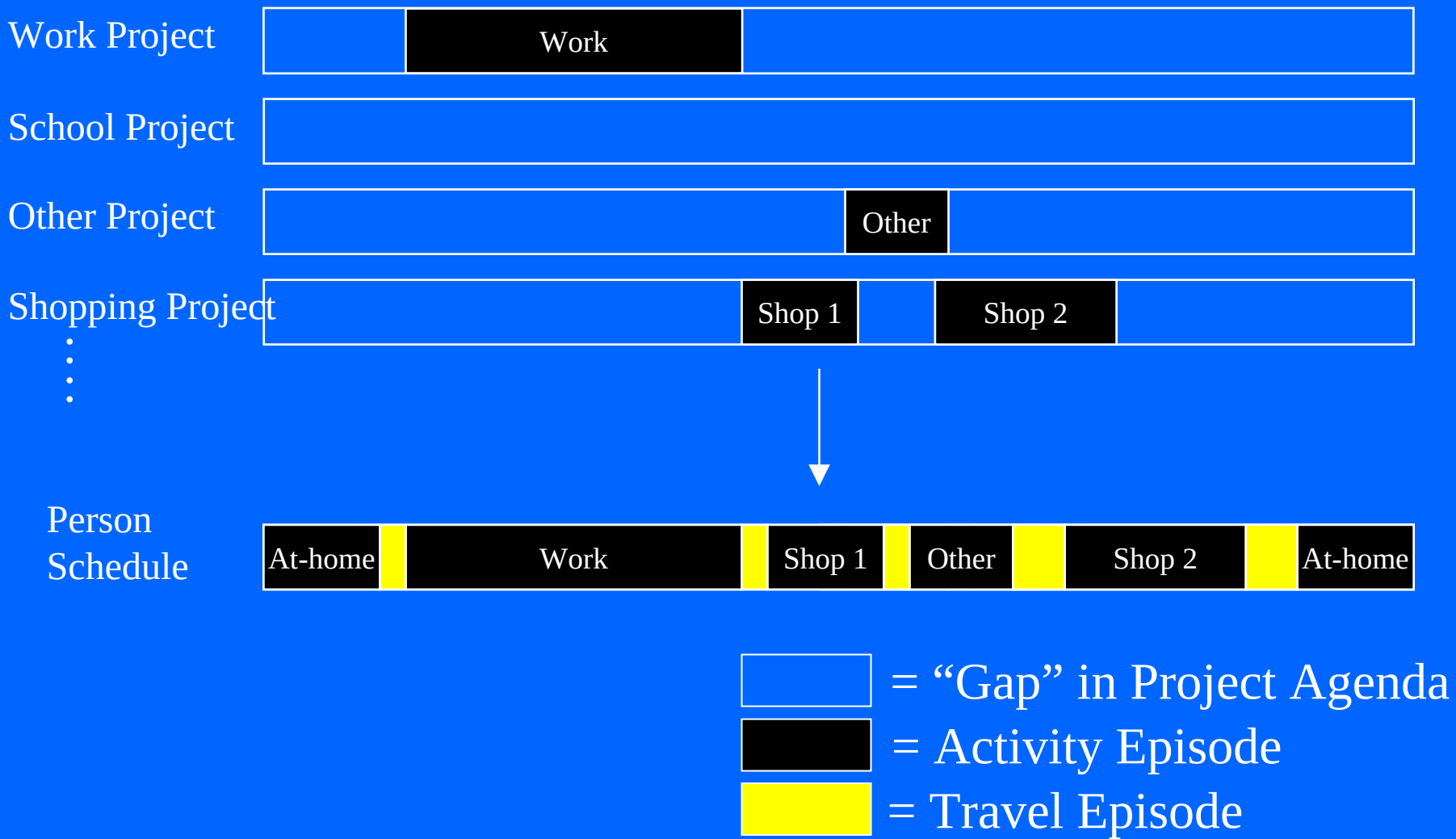
(a) Draw activity frequency from marginal PDF

(b) Draw activity start time from feasible region in joint PDF

(c) Draw activity duration from feasible region in joint PDF

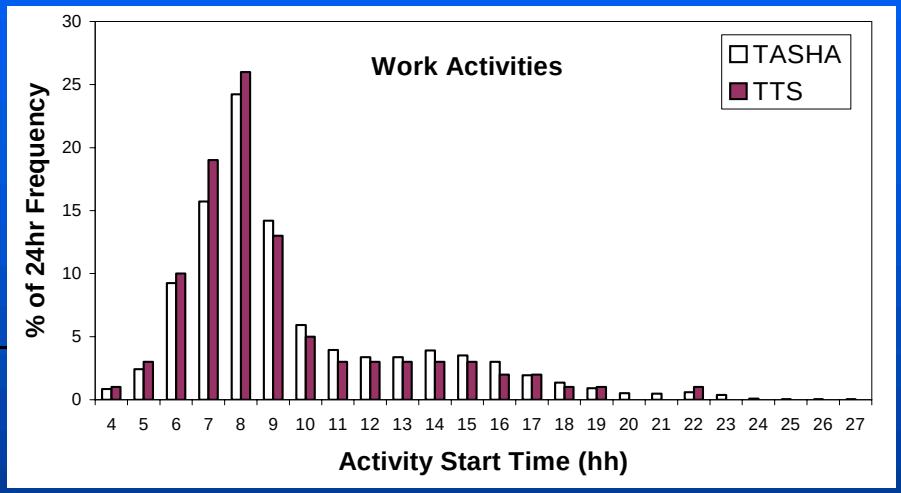


Moving Activity Episodes into the Person Schedule

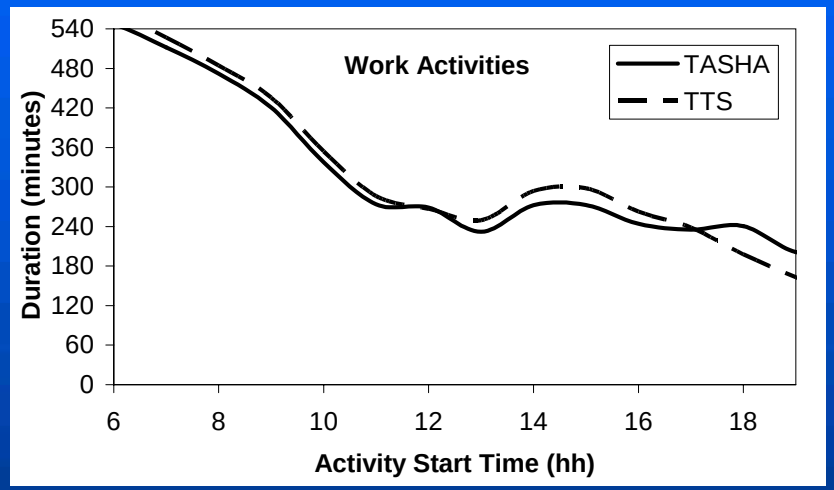


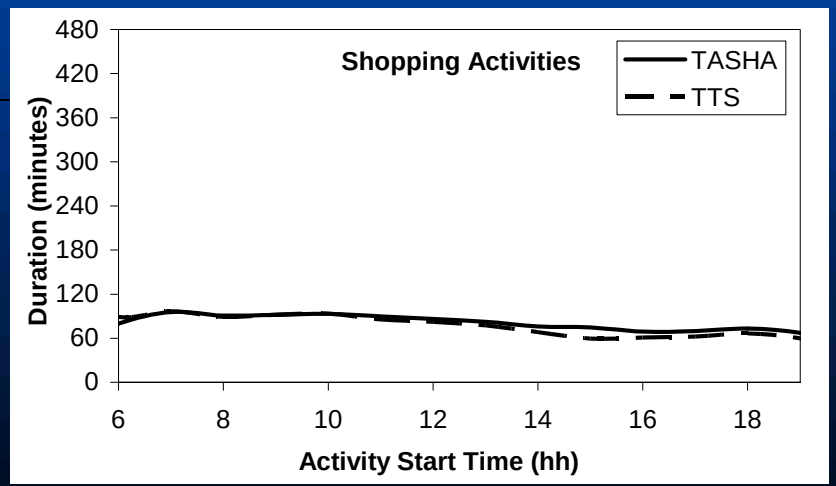
Comparison of Model to Observed (TTS) Activities for a 5 year forecast (1996-2001)

Start time distribution



Duration distribution





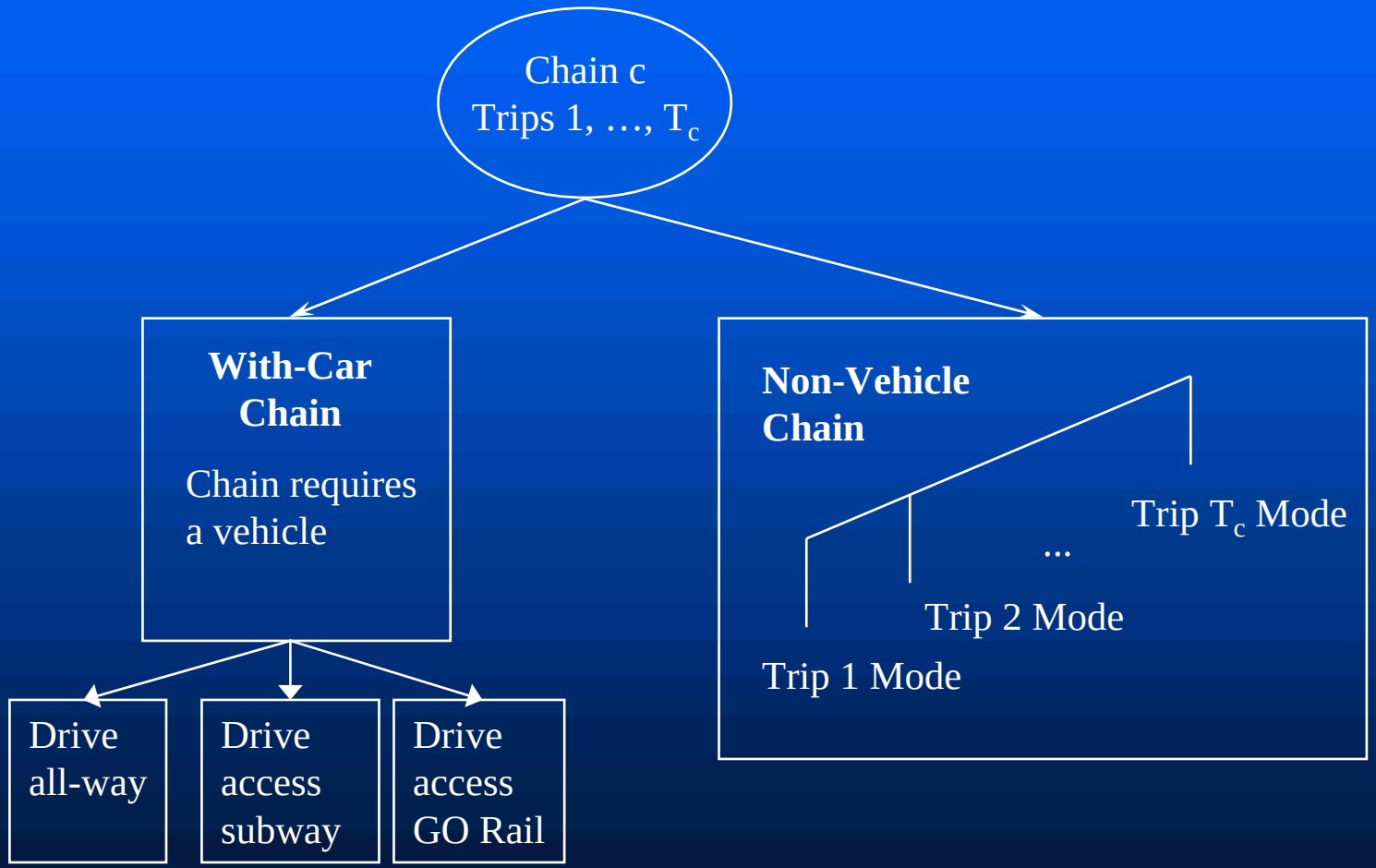
TASHA - Mode Choice Model

- Household utility-maximizing approach
- Tour-based model
- Vehicle allocation
- Ridesharing explicitly modelled

- Not a typical mode choice model!
  - Complex error structure
  - No analytical solution for maximum likelihood
  - Estimate likelihood using a simulation technique
  - Estimate parameters using a genetic algorithm using distributed computing

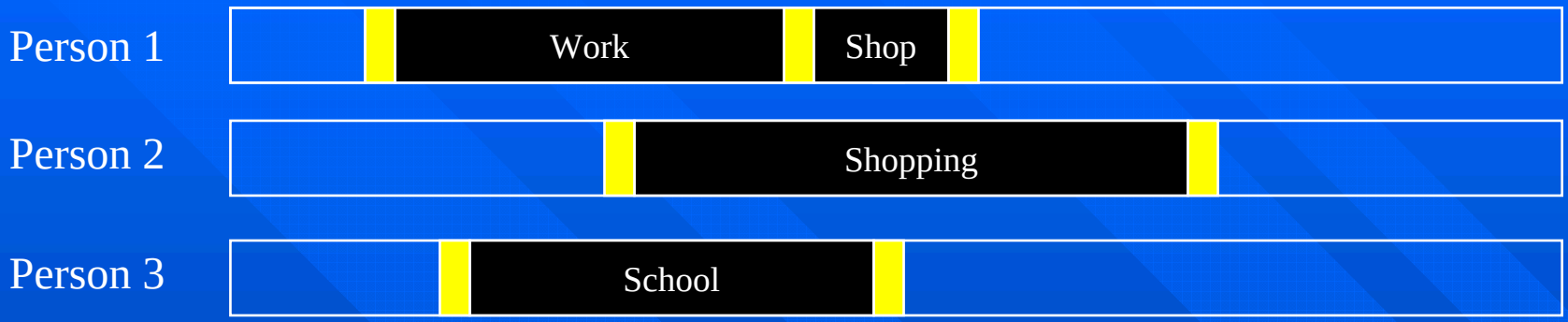
Mode Choice Model Structure

- Decision tree for a simple chain

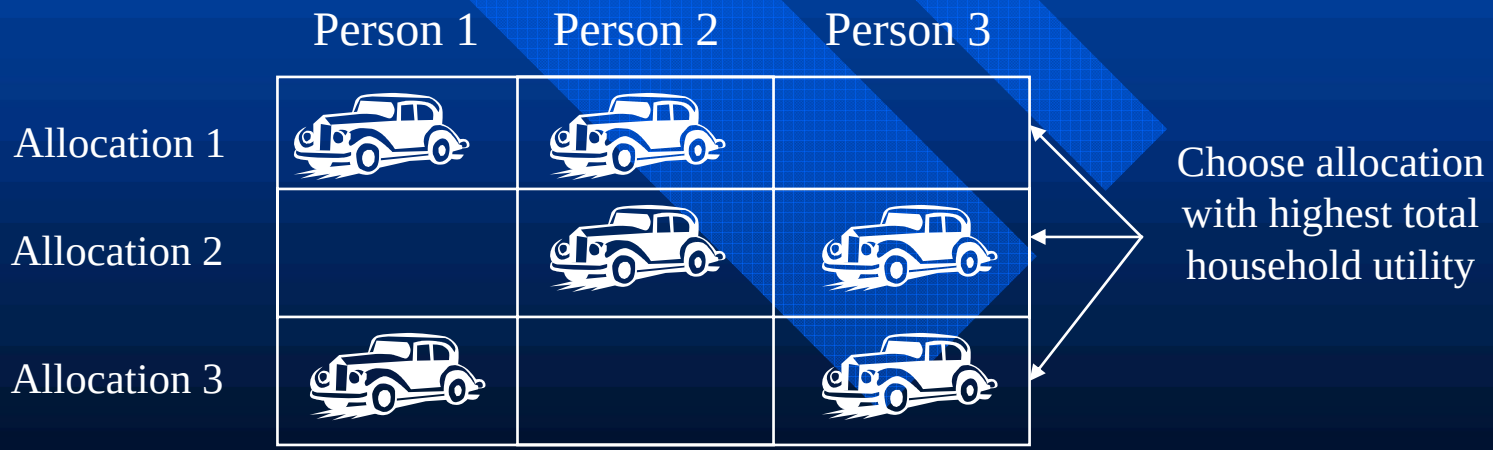


Vehicle Allocation (E.g. 3 drivers, 2 cars)

3 Conflicting With-Car Chains

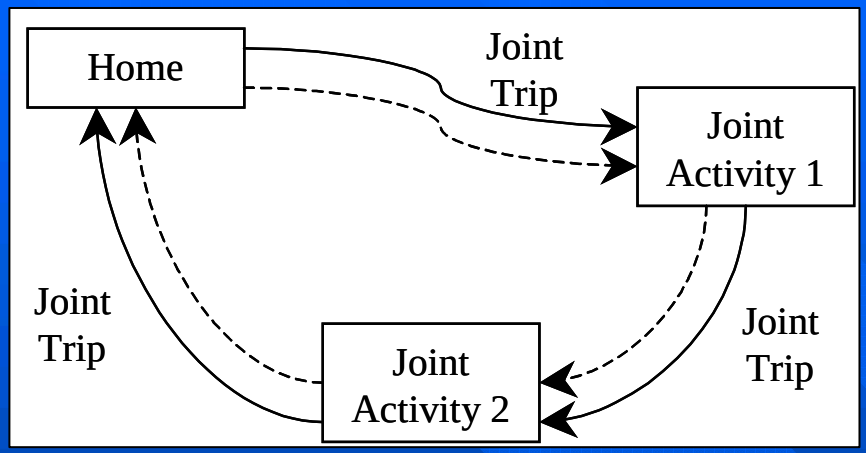


3 Possible Vehicle Allocations

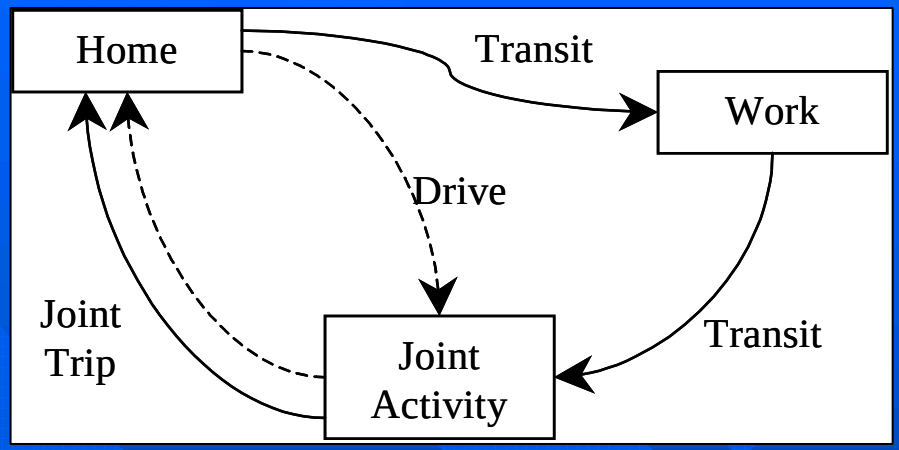


Ridesharing

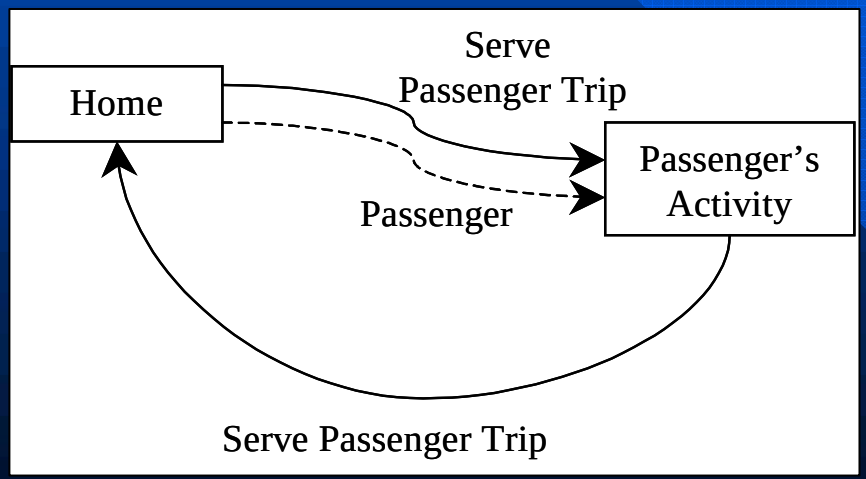
Pure Joint Tour



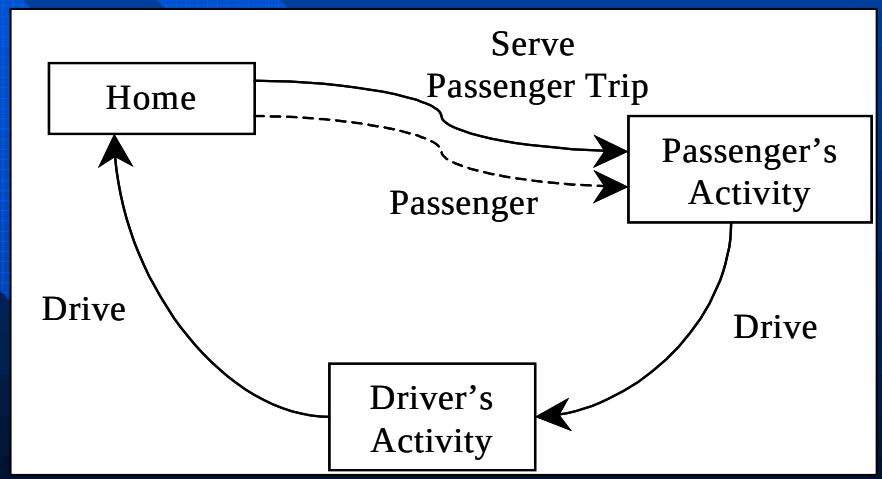
Partial Joint Tour



Pure Serve Passenger Tour



En route Serve Passenger Tour



Ridesharing

Rules to determine whether rideshare would be considered by a household:

- e.g. A person can get a ride to school only if a driver and a vehicle are available at the right time.

Then the decision to share a ride is utility based.

- Driver and passenger make rideshare decisions simultaneously to maximize **total** household utility

Parameter Estimation

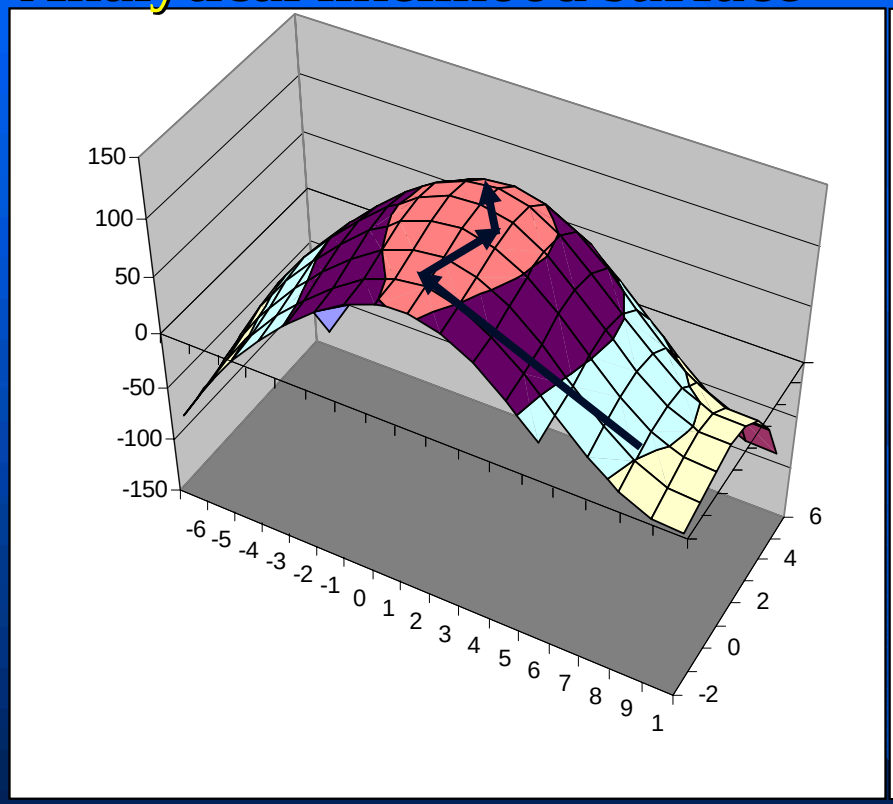
$$U_{trip}(m) = V_{trip}(m) + \varepsilon_{trip}(m)$$

For each trip, we simulate the random error term directly for each mode

- Then choose modes for the entire household based on $U_{trip}(m)$
- Replicate many times to calculate the likelihood that the observed modes are chosen
- Choose model parameters to maximize that likelihood

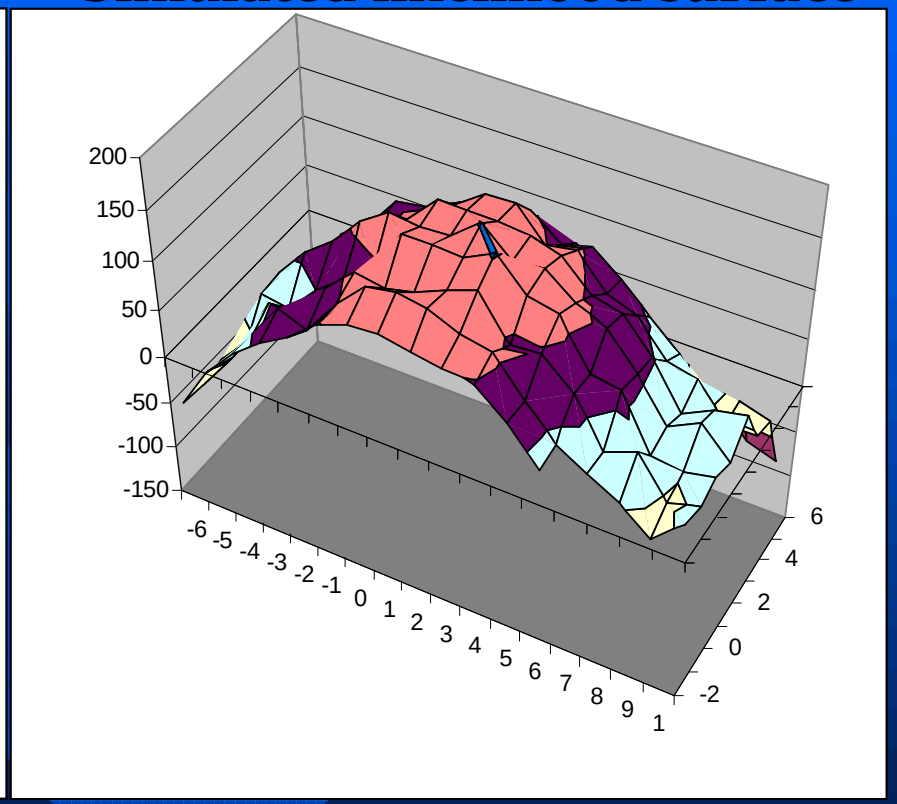
Finding the Maximum Likelihood Parameters

Analytical likelihood surface



- Smooth surface
- Can use gradient search

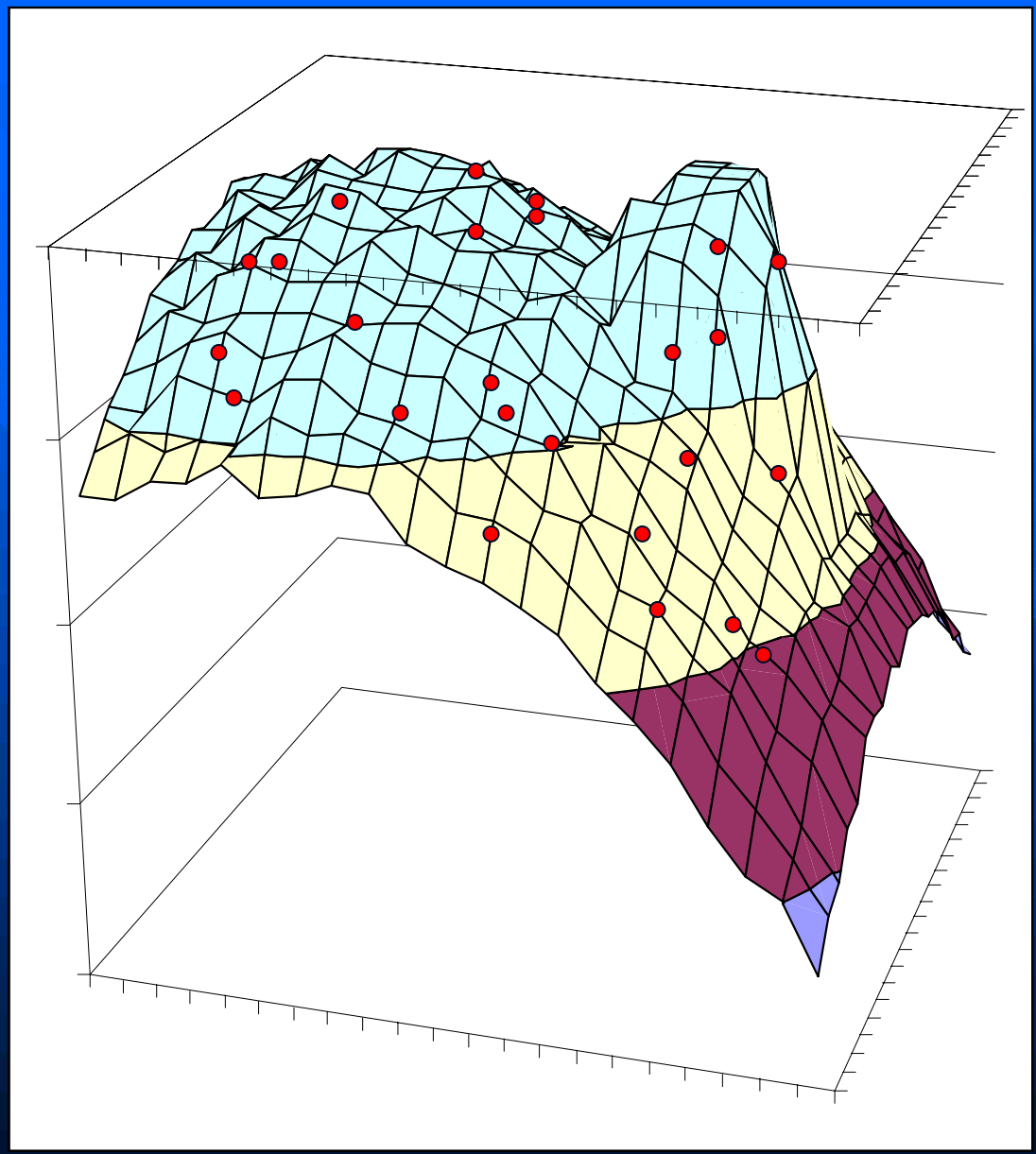
Simulated likelihood surface



- Bumpy surface
- Can't use gradient search

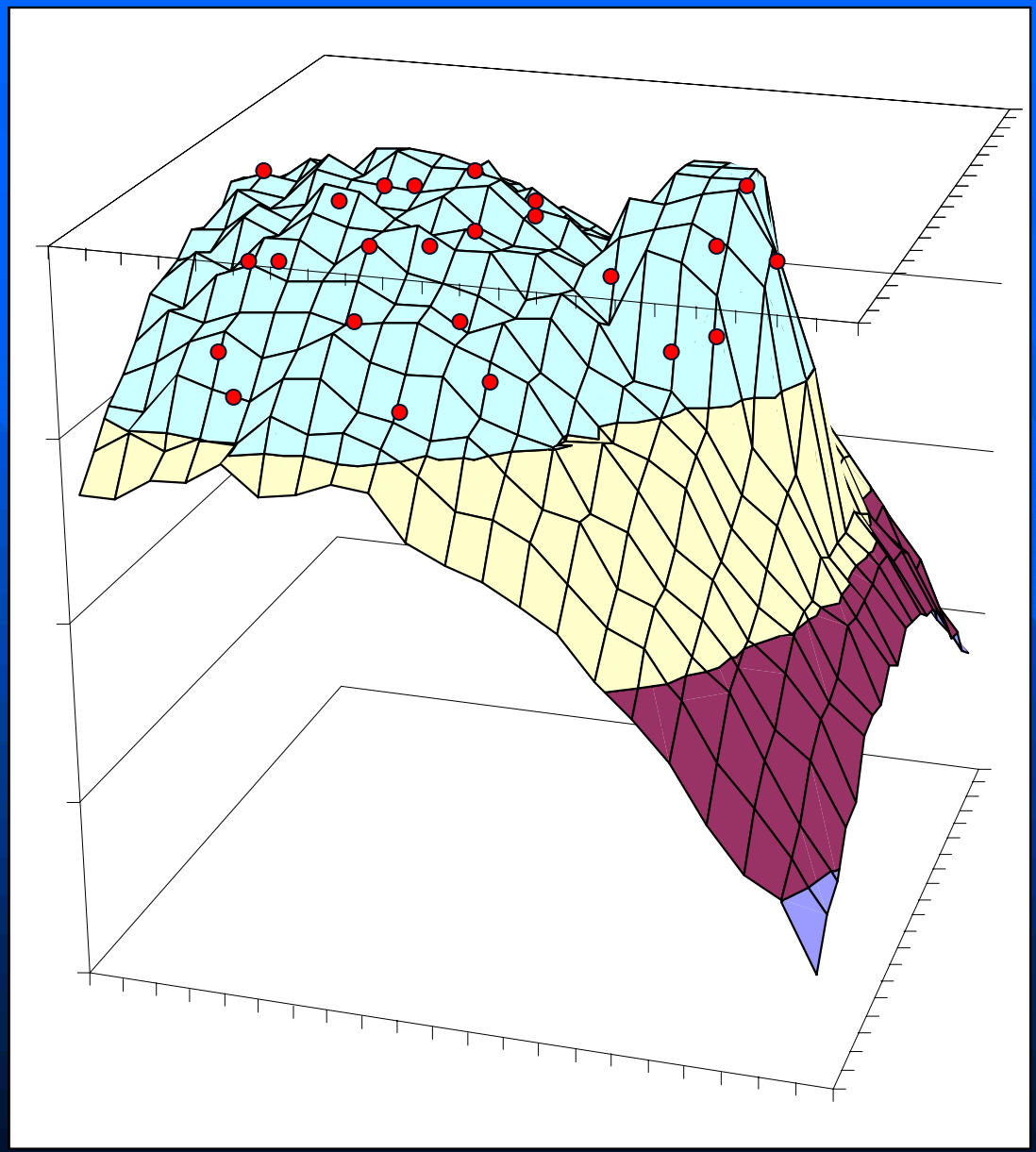
Genetic Algorithm

Initial Population



Genetic Algorithm

Fitness of population improves with each generation



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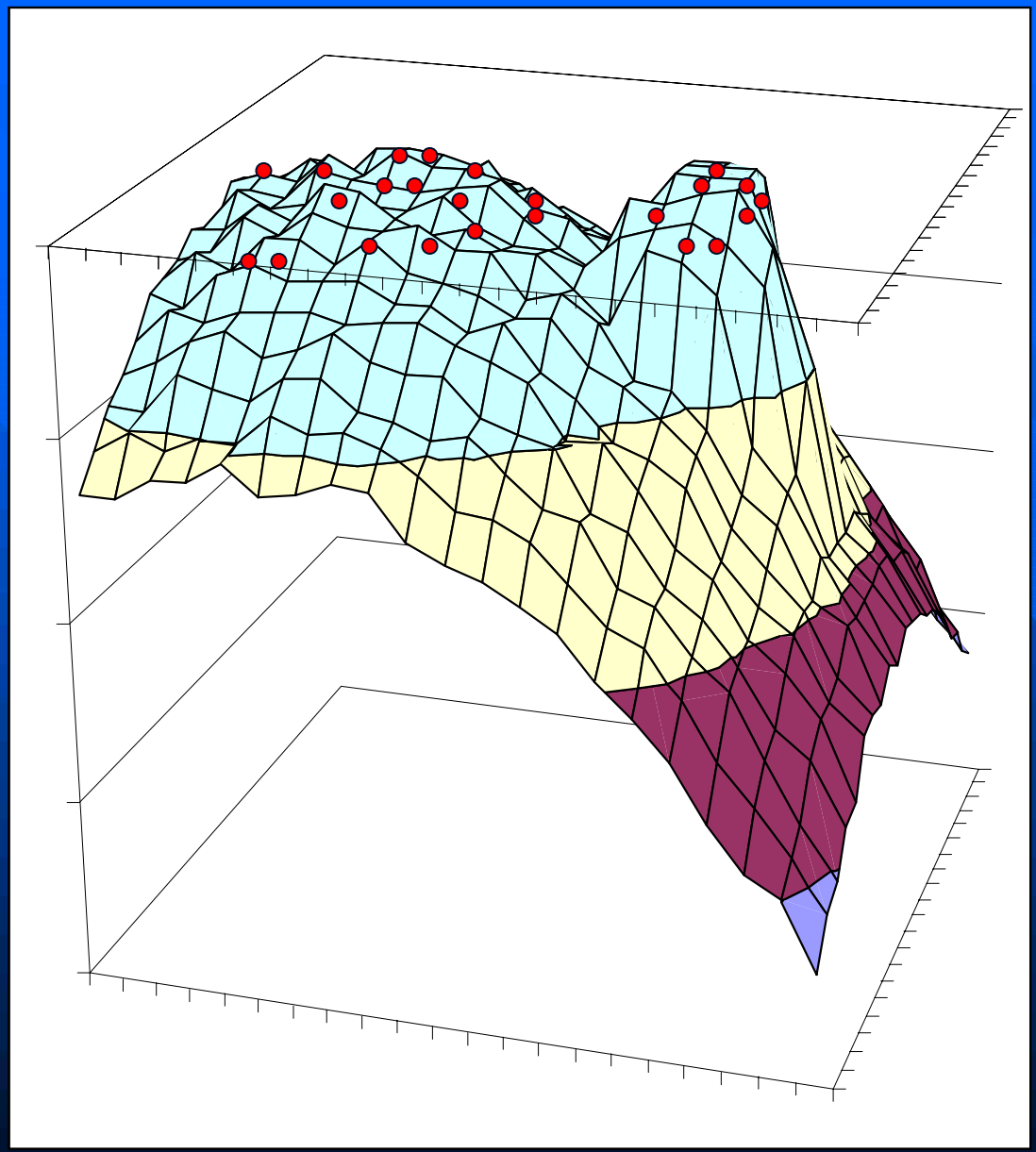

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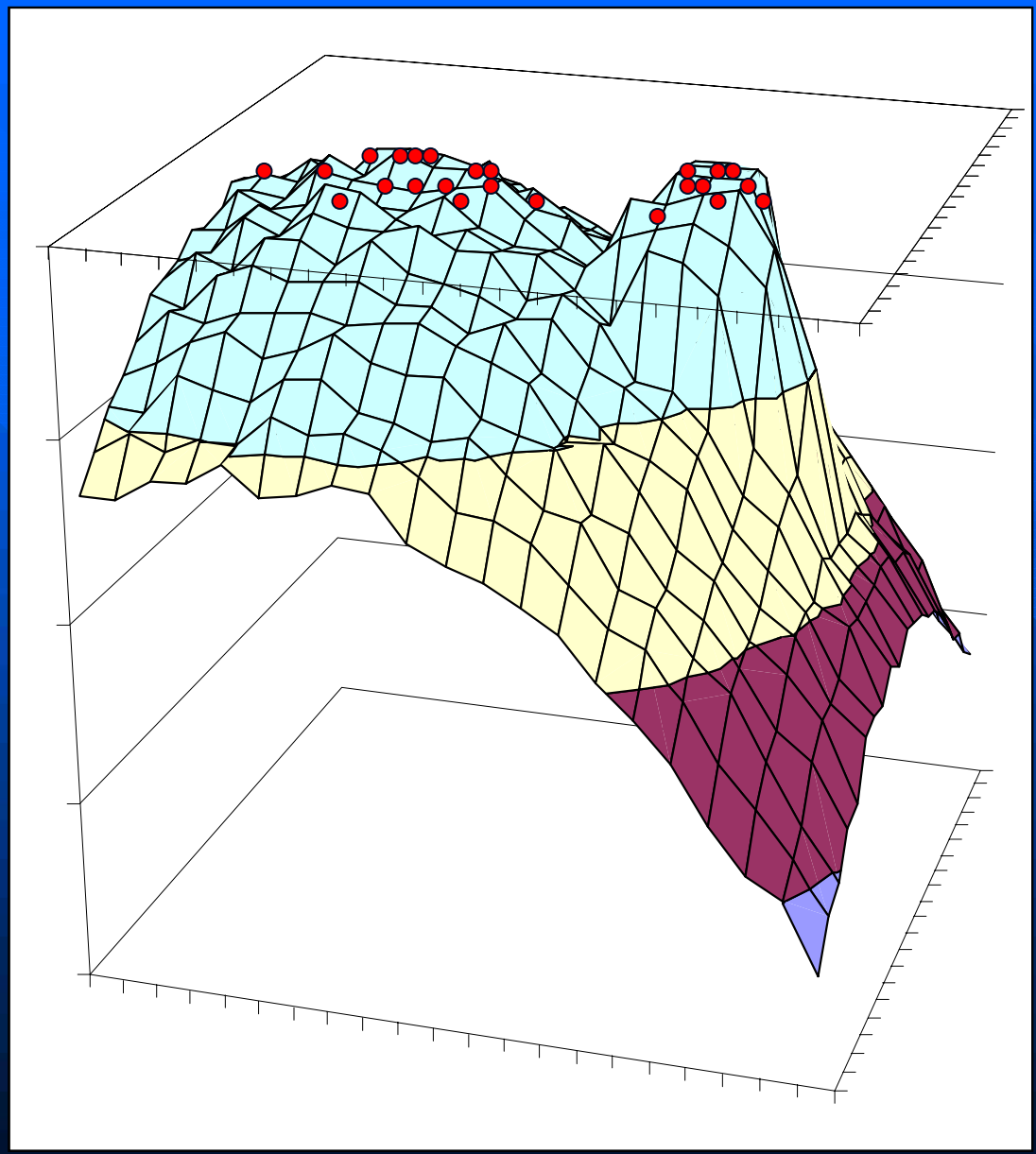

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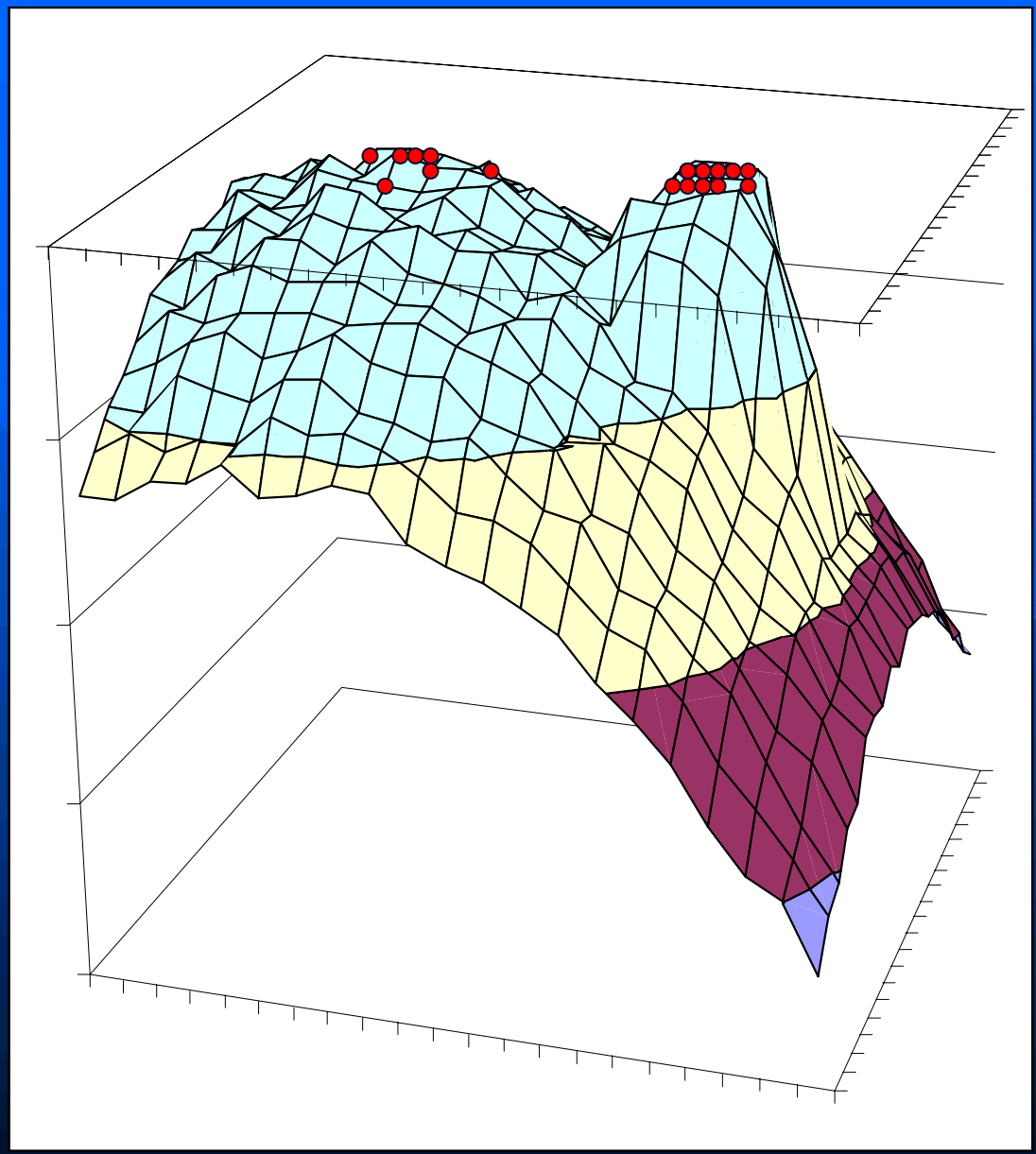
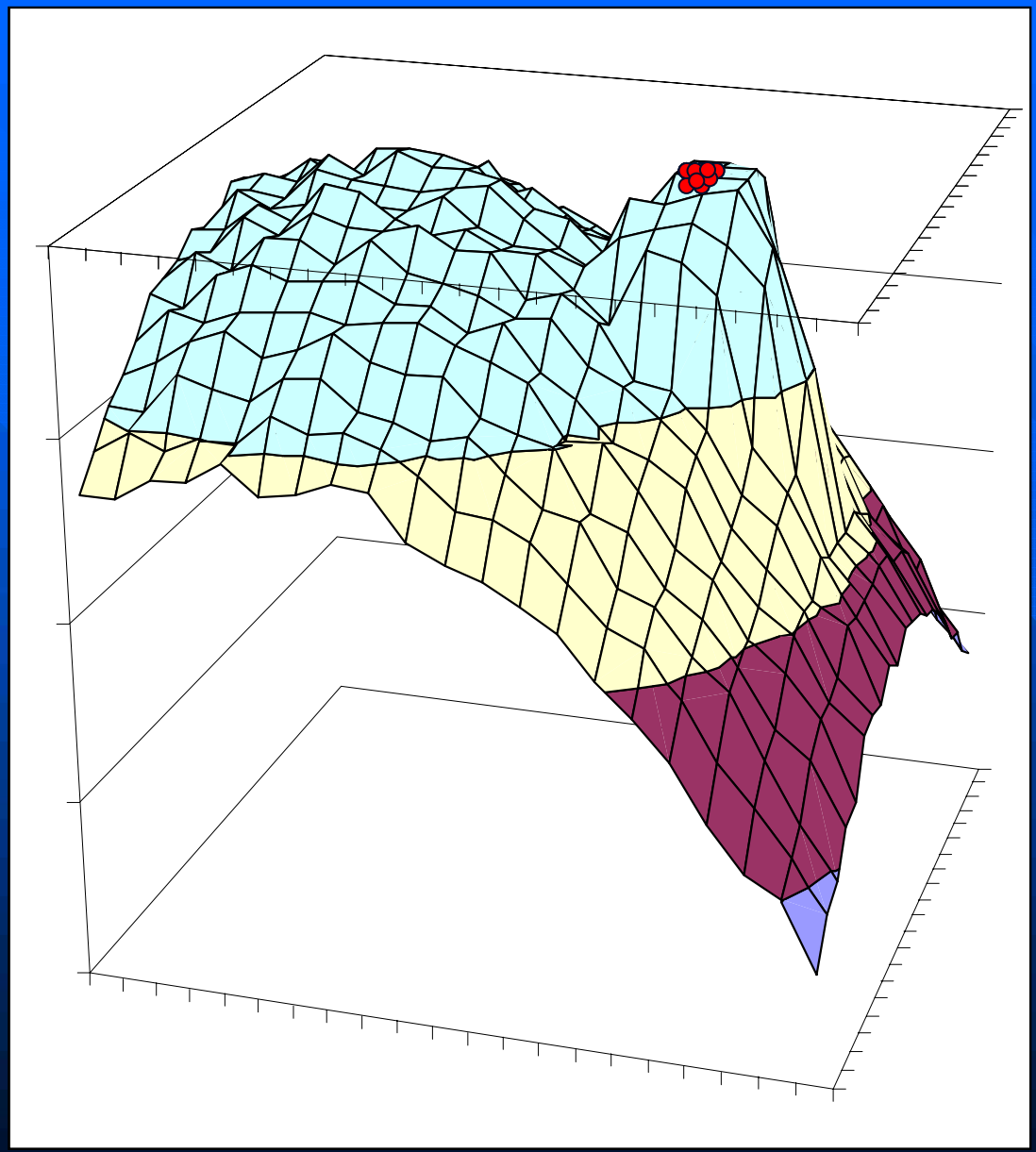


Genetic Algorithm

Population converges to the Maximum Likelihood Solution



Model Validation and Application

- The thesis includes the first stage of model verification
- Since then, preliminary validation of forecasts

- Validation Strengths:
  - Total trips by time of day, destination purpose, OD district are modelled with good accuracy
- Validation Weaknesses:
  - Unable to fully predict increases in trip generation rate
  - Location choice model needs improvement

- City of Toronto GHG Emissions Study
  - Models applied to a 5% sample of the GTA population (250,000 people)
  - Alternative growth scenarios evaluated for a 2031 forecast

Summary of Contributions

- Travel Activity Panel Survey
  - An in-depth longitudinal survey of the activity scheduling process
  - Much analysis still to be done on these data
- TASHA scheduler
  - Rule-based alternative to econometric model techniques
  - Substantial interest from city and provincial planning organizations
- TASHA mode choice
  - Explicit simulation household interactions (rideshare, vehicle allocation)
  - Flexible parameter estimation technique for difficult estimation problems

Thank you