Microsimulating Activity & Travel by Person & Household Agents

Eric J. Miller, Ph.D.
Bahen-Tanenbaum Professor, Dept. of Civil Engineering
Director, Joint Program in Transportation
University of Toronto

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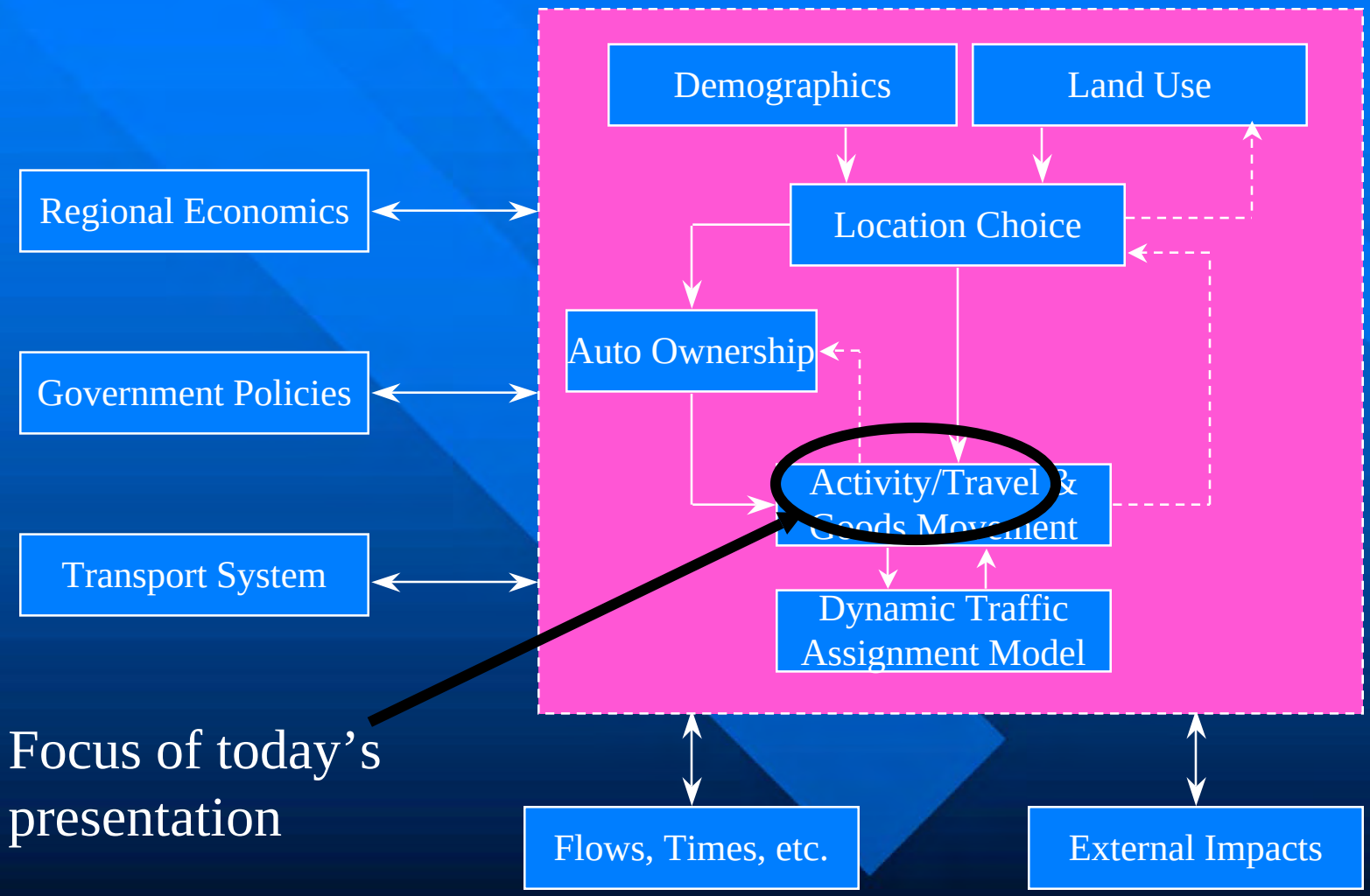
Presentation Outline

- Research Objectives: Long Term vs. Short Term
- Major Components of the Model
- The Theoretical Model
- The Operational Model
  - Program class structure
  - Construction of schedules
  - Mode choice
  - Ridesharing
  - Auto transactions
- Model Validation
- Next Steps

Research Objectives

- Long Term Objectives
  - Create a fully dynamic, integrated microsimulation model of household activity scheduling with interactive household agents
  - Integrated with ILUTE
- Short Term Objectives
  - Operational 24-hour activity scheduling model for use in policy analysis in the Greater Toronto Area (GTA)

The ILUTE Modelling Framework



Theoretical Model - Major Components

- Household agents
  - Person
  - Household
- Household resources
  - Time, Money, Vehicles
- The “episode”
  - Activity episodes, Travel episodes
- The “project”
- The “project agenda”
- The “person schedule”

Papers presenting the conceptual model:

Miller, E.J. (2005) Propositions for Modelling Household Decision-Making. *Integrated Land-use and Transportation Models: Behavioural Foundations*, M. Lee-Gosselin and S.T. Doherty (eds), Oxford: Elsevier, 21-60.

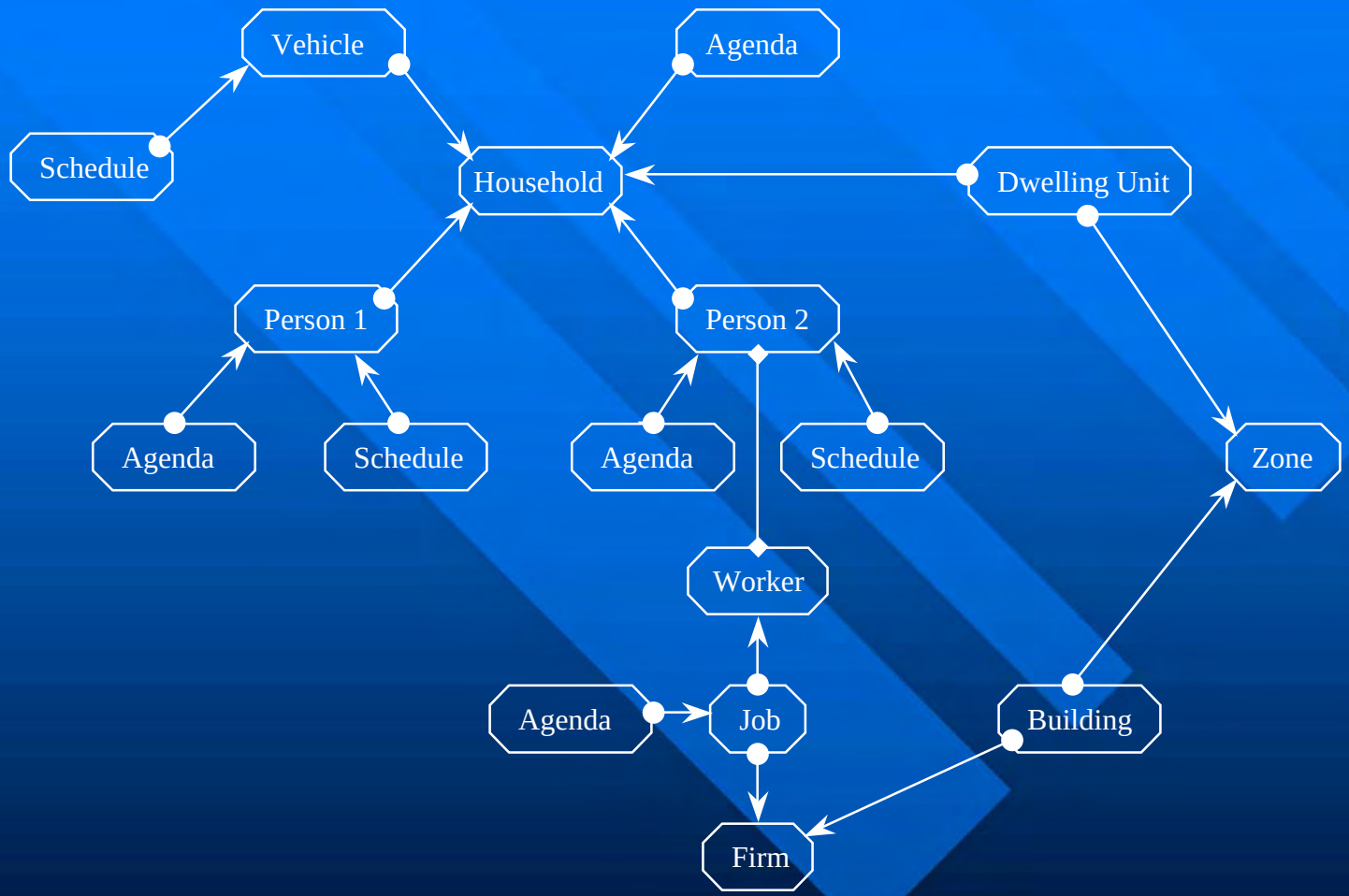
Miller, E.J.(2005) An Integrated Framework for Modelling Short- and Long-Run Household Decision-Making. *Progress in Activity-Based Analysis*, H. Timmermans (ed), Oxford: Elsevier, 175-202

Miller, E.J. (2005) Project-Based Activity Scheduling for Household and Person Agents. *Transportation and Traffic Theory, Flow, Dynamics and Human Interaction,Proceedings of the 16th International Symposium on Transportation and Traffic Theory*, H.S. Mahmassani (ed), Oxford, Elsevier, 565-584.

Object-Oriented Programming

- The model is being developed within the OOP paradigm (C++)
- OOP ideal for microsimulation applications
- Model design focuses on definition of the objects which exist & interact within the system

Partial View of Relationships Among System Objects

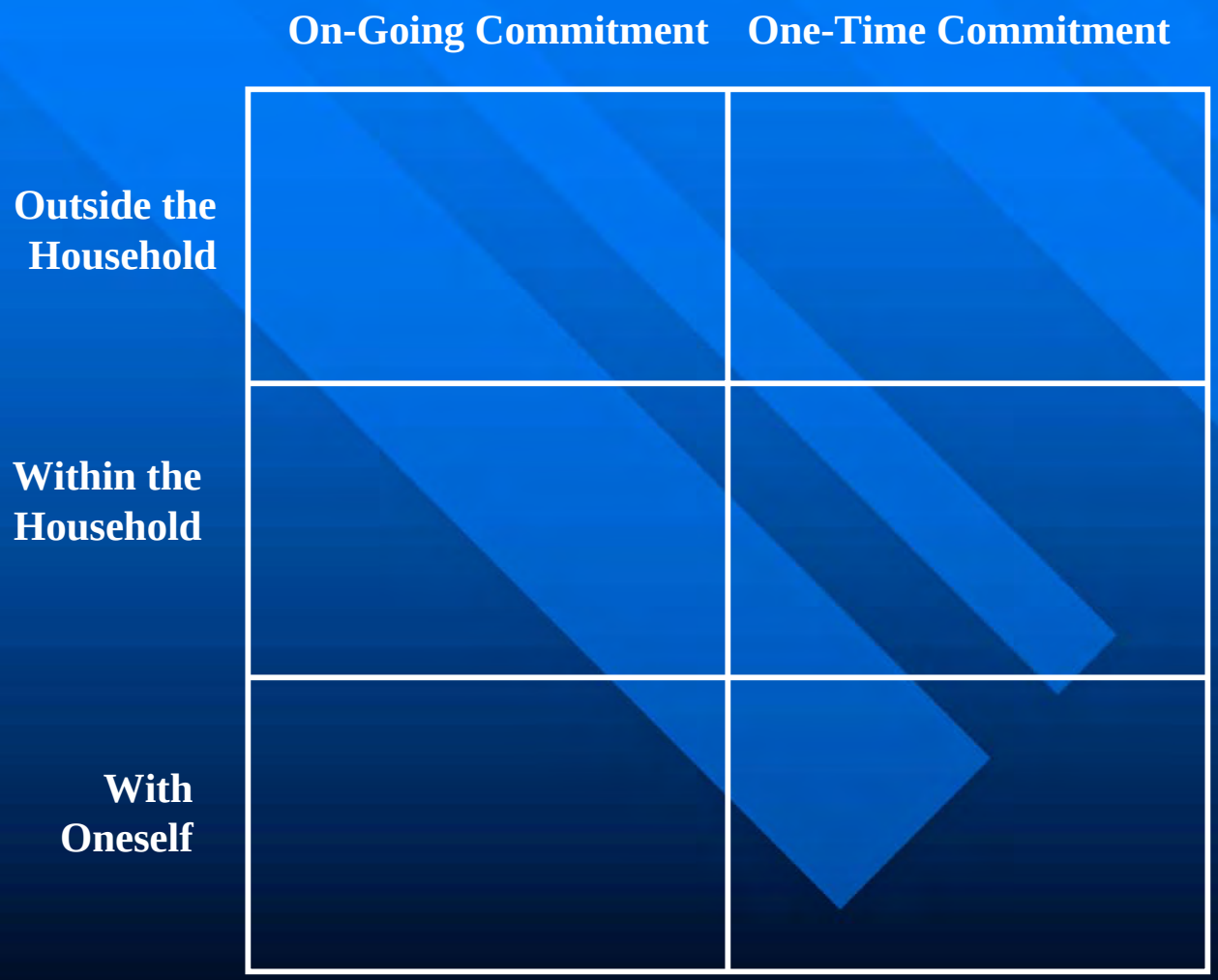


Definitions: Activity

Activity: The various ways in which we spend our time (work, school, shopping, watching TV, …)

In our model, activity is actually a rather loose concept (e.g., "activity" *per se* does not exist as a class within the model.

Typology of Activity Commitments



Definitions: Episode

Episode: A specific instance of participating in a given activity; at a minimum, episodes have:

- type
- location
- start time
- duration (end time)
- mode

The episode is a primary unit of analysis (class/object) in our model. Two sub-classes exist:

- activity episode
- travel episode

Definitions: Primary Episode

Primary Episode: A special type of episode that may be sub-divided into smaller episodes

At the moment, only work and in-home activities possess primary episodes.

Shopping might also benefit from this concept.

Definitions: Project

Project: A set of activities, logically connected by a common goal or other organizing principle

e.g.: a dinner party; a home renovation project; work; education; child-rearing; ….

The primary unit of analysis (class) in the model.

Note that both persons and households may have projects.

Conceptual Potential of Projects

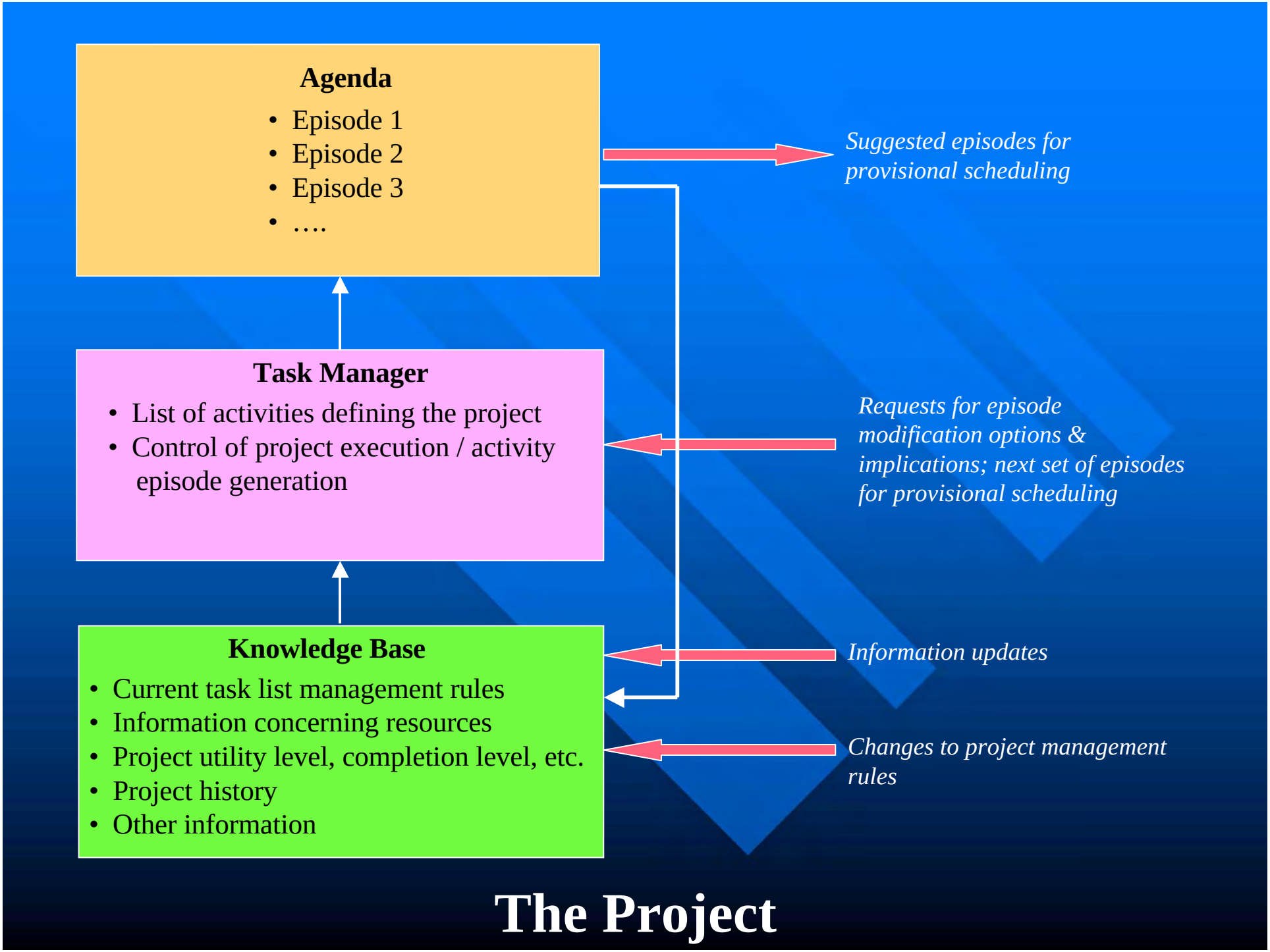
It is hoped that we can *encapsulate* behavior within the project class in a way that will allow us to model very complex behavior in a manageable manner.

That is, each project needs only to "know about" its own activities -- can therefore decompose the complexity of daily activities into separate, more "bite size pieces" in a theoretically defensible way.

Projects interact with one another through the scheduling process, and through competition for household (and personal) resources.

Definitions: Agenda

Agenda: The agenda is the list of activity episodes which might be engaged in by the project within the current planning period.


Agenda
• Episode 1
• Episode 2
• Episode 3
• ….
Suggested episodes for provisional scheduling
Task Manager
• List of activities defining the project
• Control of project execution / activity episode generation
Requests for episode modification options & implications; next set of episodes for provisional scheduling
Knowledge Base
• Current task list management rules
• Information concerning resources
• Project utility level, completion level, etc.
• Project history
• Other information
Information updates
Changes to project management rules
The Project

Definitions: Schedule

Schedule: A planned, feasible sequence of activity and travel episodes that collectively fill the day.

Persons and vehicles have schedules; households do not.

A primary objective of the model is to determine the schedule for each person in the household.

When actually executed, the schedule represents the person's **activity pattern** for the day.

Trip chains or **tours** are the natural outcome of sequences of out-of-home activity episodes being scheduled "back to back".

Scheduling Episodes

Project 1
- episode 1.1
- episode 1.2
- ….

Project 2
- episode 2.1
- episode 2.2
- ….

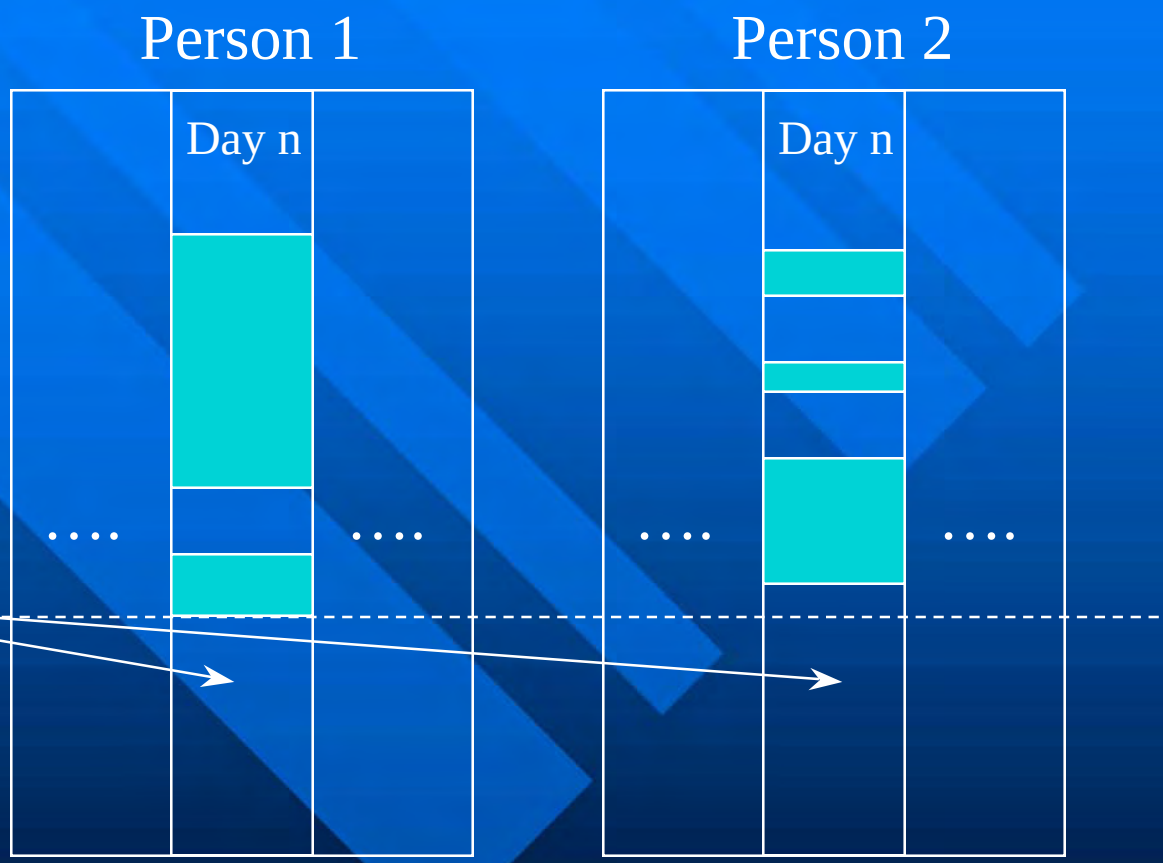
……

Project N
- episode N.1
- episode N.2
- ….

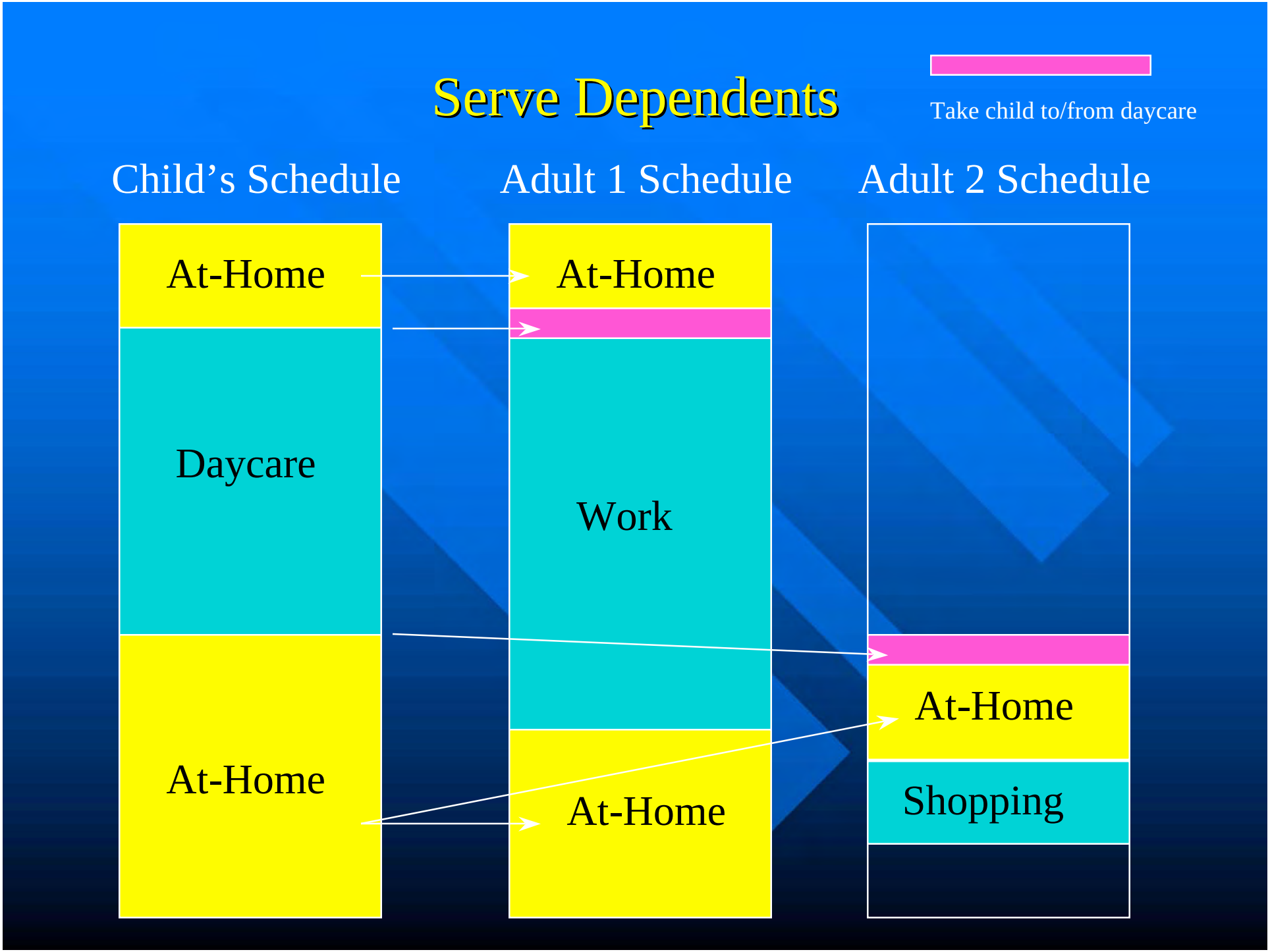
Joint Activities

Joint Shopping Activity:
Duration: 2 hrs
Location: The Mall

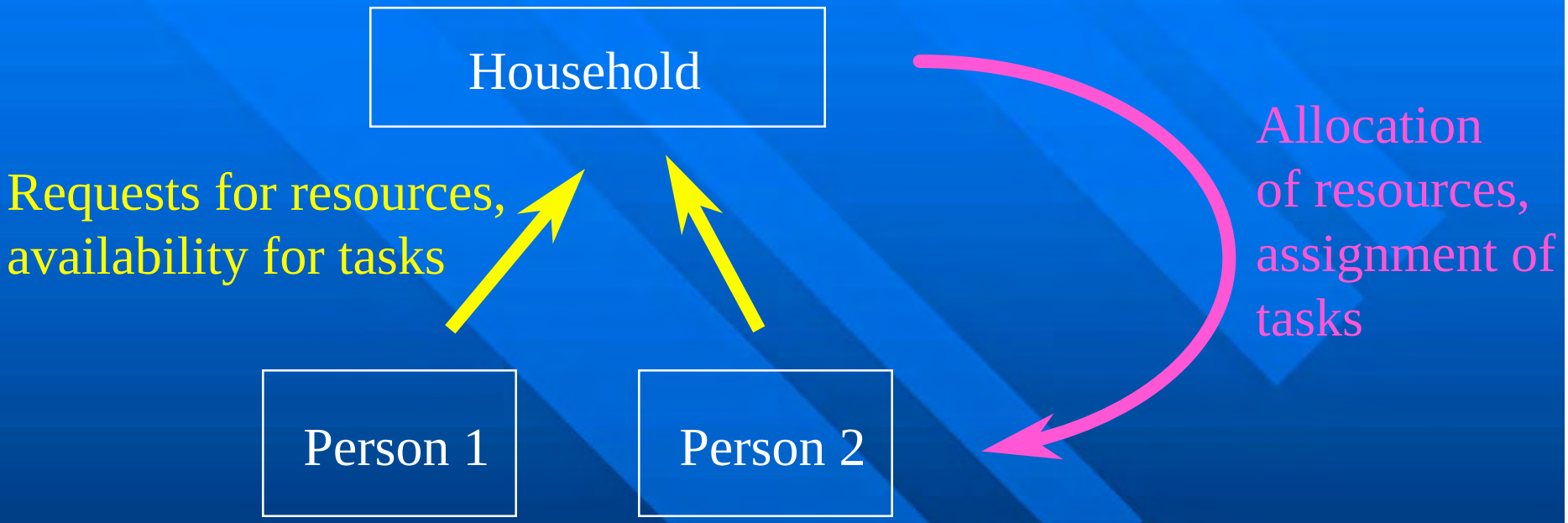
Search for feasible joint time slot



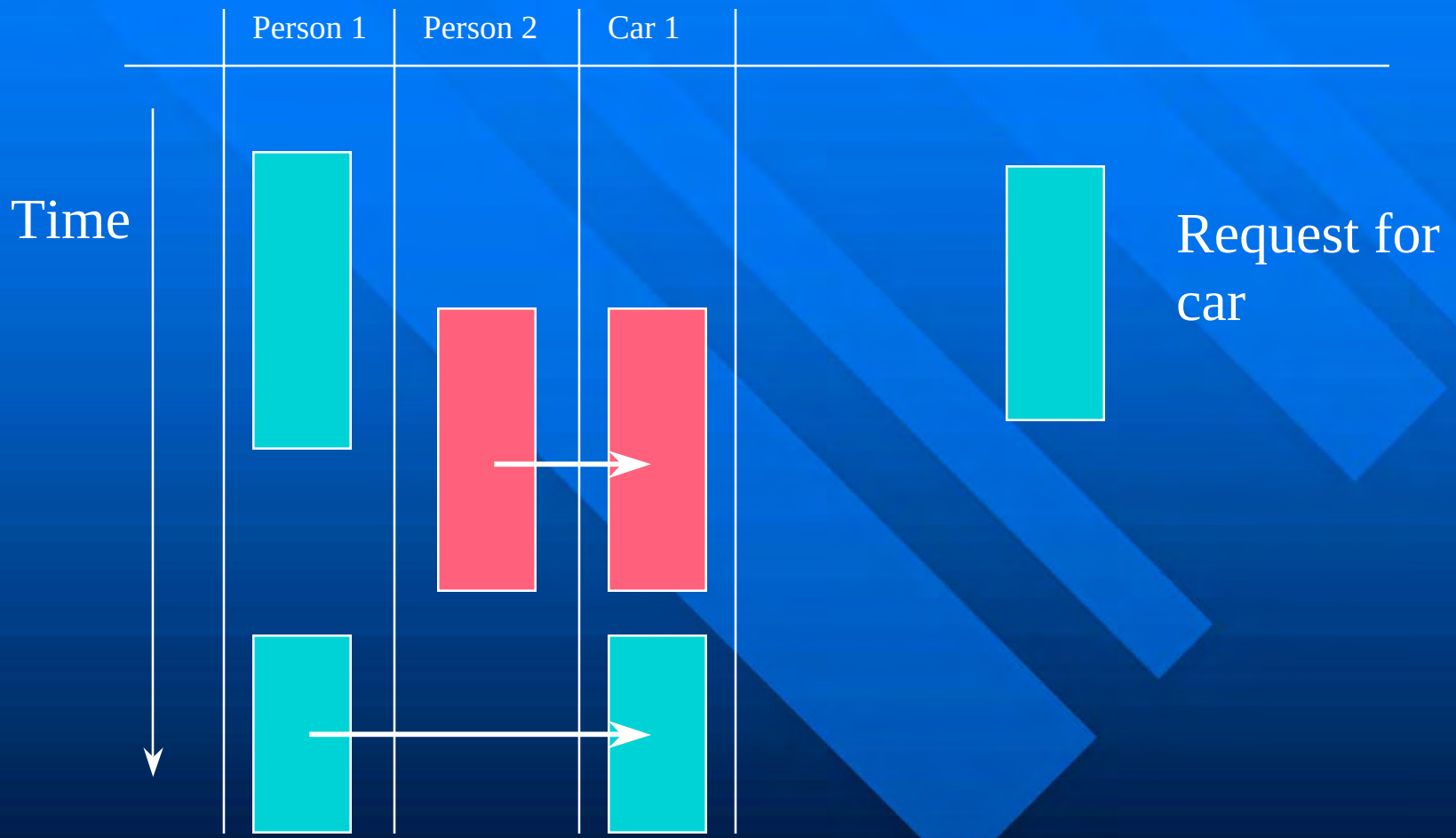
Serve Dependents



Relationship Between Persons & Household



Vehicle Allocation, 1-Car Household



An Operational Agent-Based Activity/Travel Scheduling Model

The Travel/Activity Scheduler for Household Agents (TASHA) is an operational activity/travel scheduler for the Greater Toronto Area (GTA).

- Multi-agent: persons and households
- Microsimulation
- Developed using ordinary travel survey data

References:

Miller, E.J. and M.J. Roorda, "A Prototype Model of Household Activity/Travel Scheduling", *Transportation Research Record, Journal of the Transportation Research Board*, No. 1831, 2003, pp. 114-121.

Roorda, M., S. Doherty and E.J. Miller (2005). Operationalizing household activity scheduling models: addressing assumptions and the use of new sources of behavioural data. In M. Lee-Gosselin and S.T. Doherty, (Eds.) *Behavioural Foundations of Integrated Land-use and Transportation Models: Assumptions and New Conceptual Frameworks.* New York: Elsevier, 61-86.

Features of the Theoretical Model

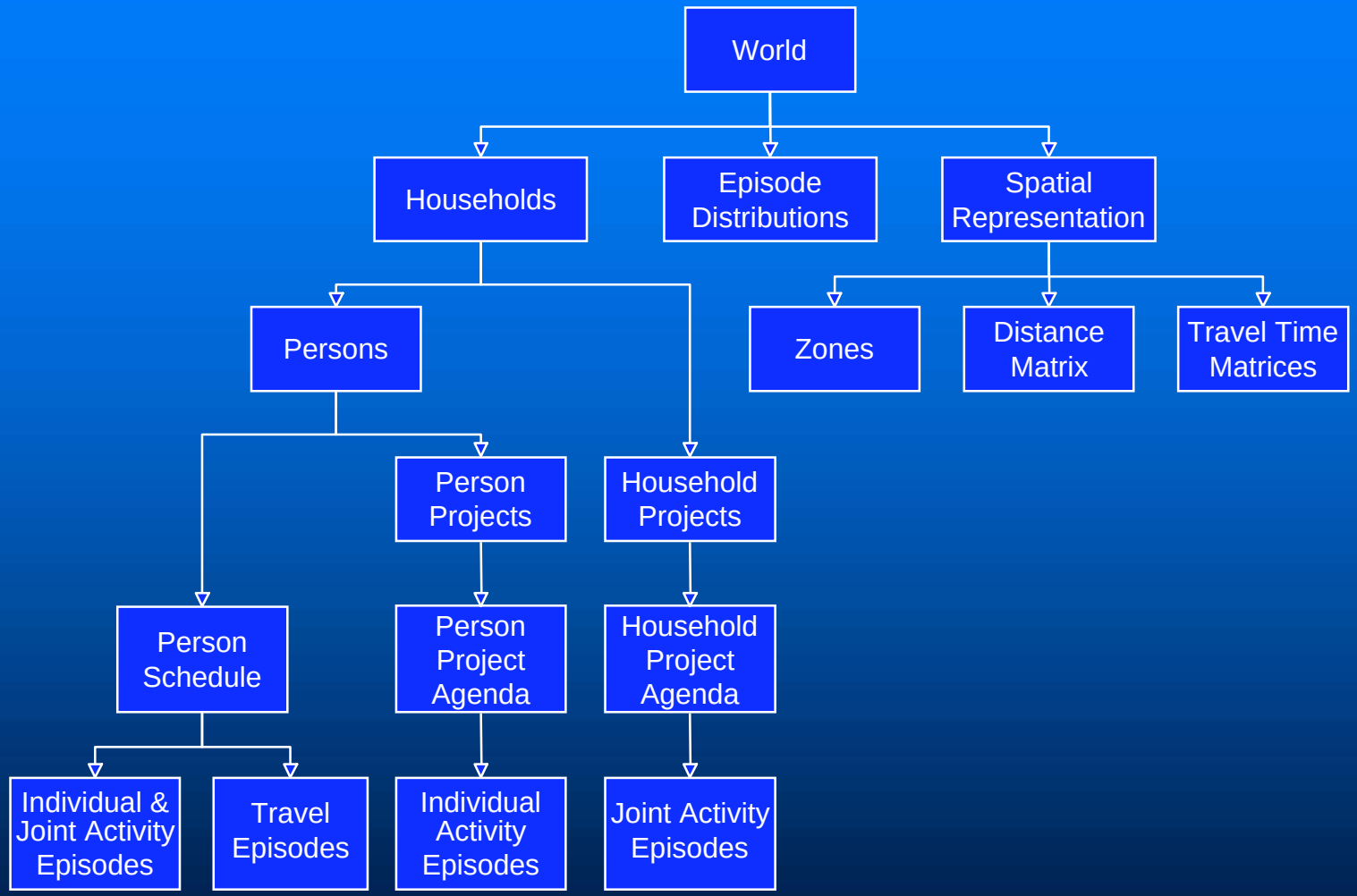
- Long term schedule (e.g., 1 week)
- Dynamic schedule
- Interactive agents
- Detailed project types
- Fully microsimulated (i.e., 100% population)
- Integrated with other household decisions

Features of the Operational Model

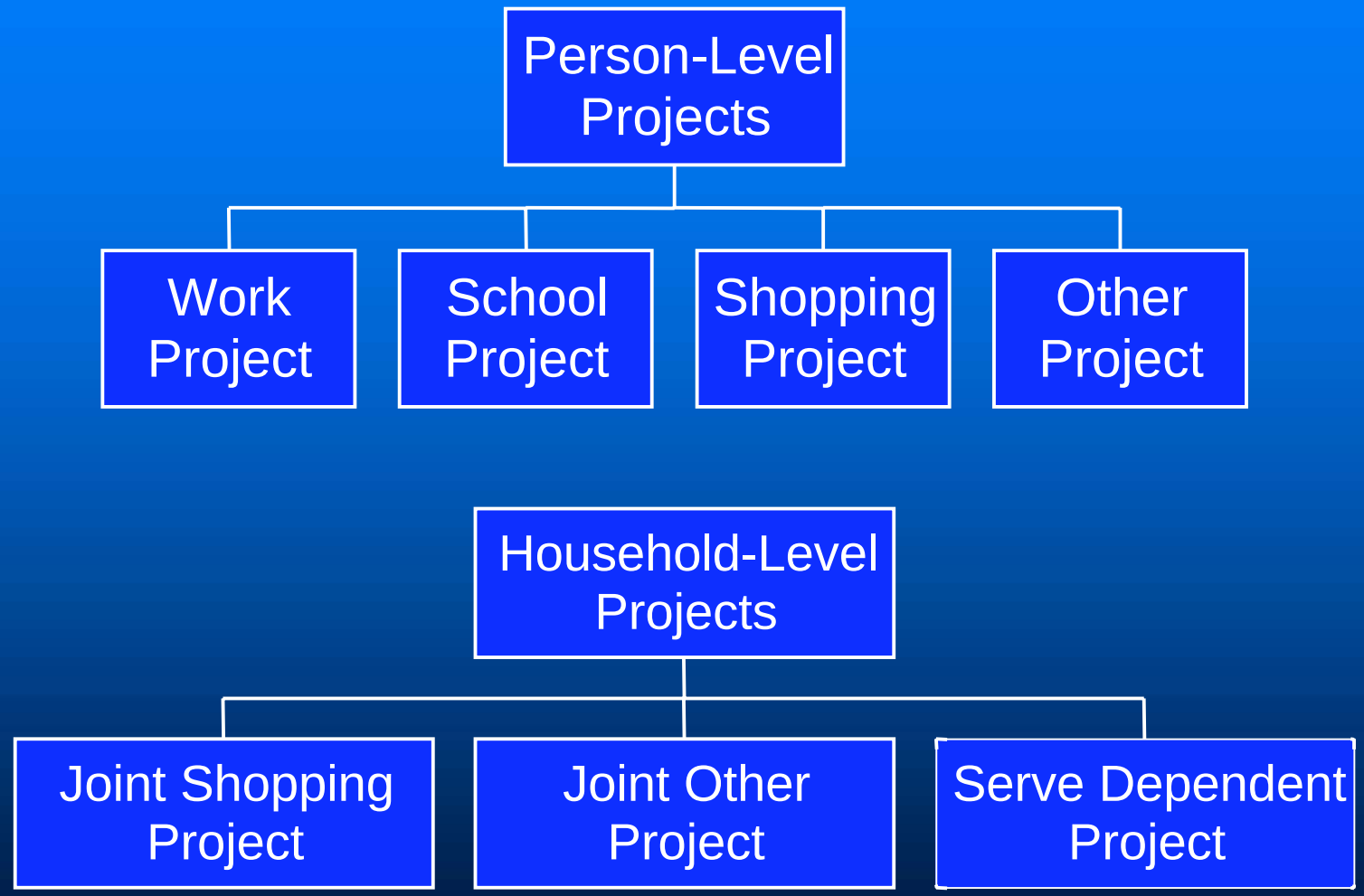
- 24-hour schedule
- Semi-dynamic schedule
- Interactive agents
- Broad project and episode types
- Microsimulation of 5% sample
- Sequential household decisions
  - Residential location, work location, auto ownership are inputs
  - Determine the schedule based on auto-drive travel times
  - Mode choice is done after the schedules are complete

Many of the restrictions in the operational model stem from the use of data from a conventional trip-based survey to develop the model.

TASHA Class Structure



Project Types

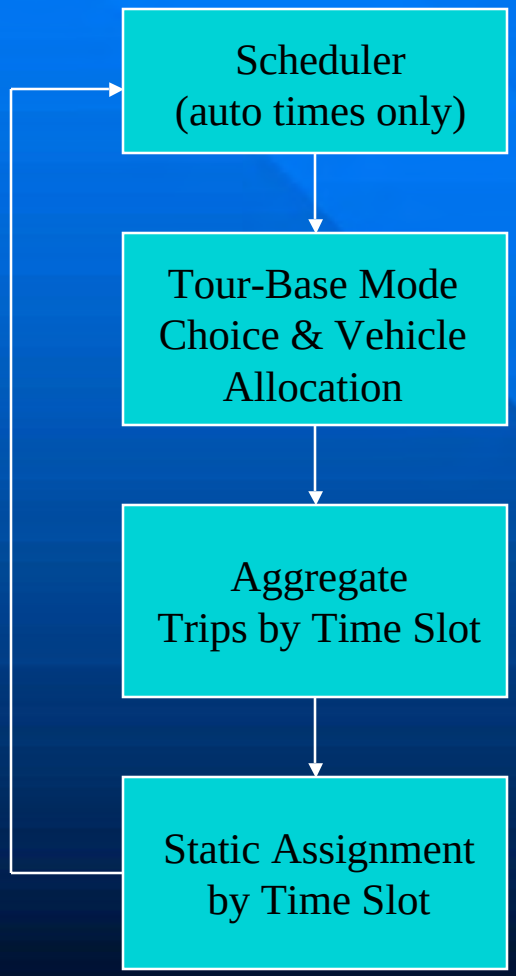


Treatment of Time

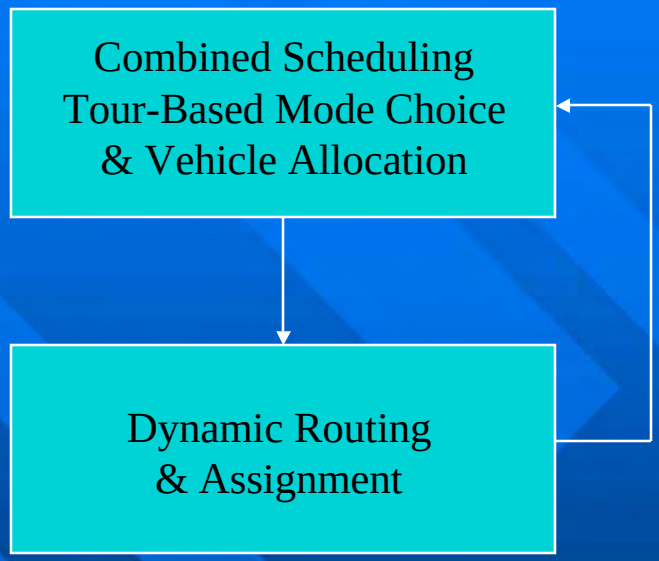
- For scheduling, 5 minute time increments
  - start times
  - durations/travel times
- For trip assignment, 4 time periods
  - 0600-0859
  - 0900-1459
  - 1500-1859
  - 1900-0559

  (EMME/2 currently used for trip assignment, but any network assignment/simulation model could, in principle, be used)

Current Model Structure



Eventual Model Structure



Construction of Schedules - Methodology

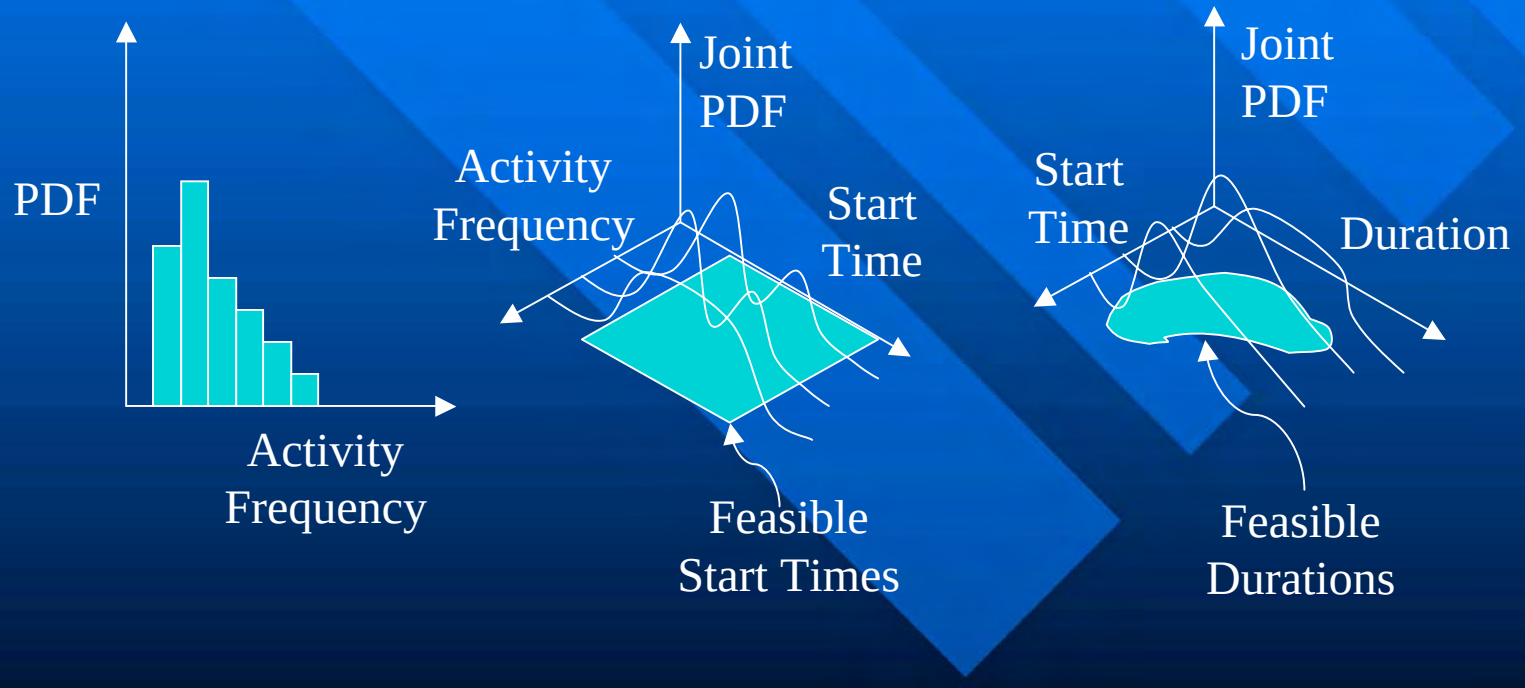
- Randomly generate activity episodes
  - Frequency, start time, duration, location
- Insert episodes into project agendas
- Construct person schedules
  - Insert episodes in order of priority
  - Joint episodes added simultaneously
  - Travel episodes added (assuming auto drive)
  - Trip chains emerge naturally
- Clean up the schedule
- Identify trip chains
- Run chain-based mode choice model

Activity Episode Frequency, Start Time and Duration Generation

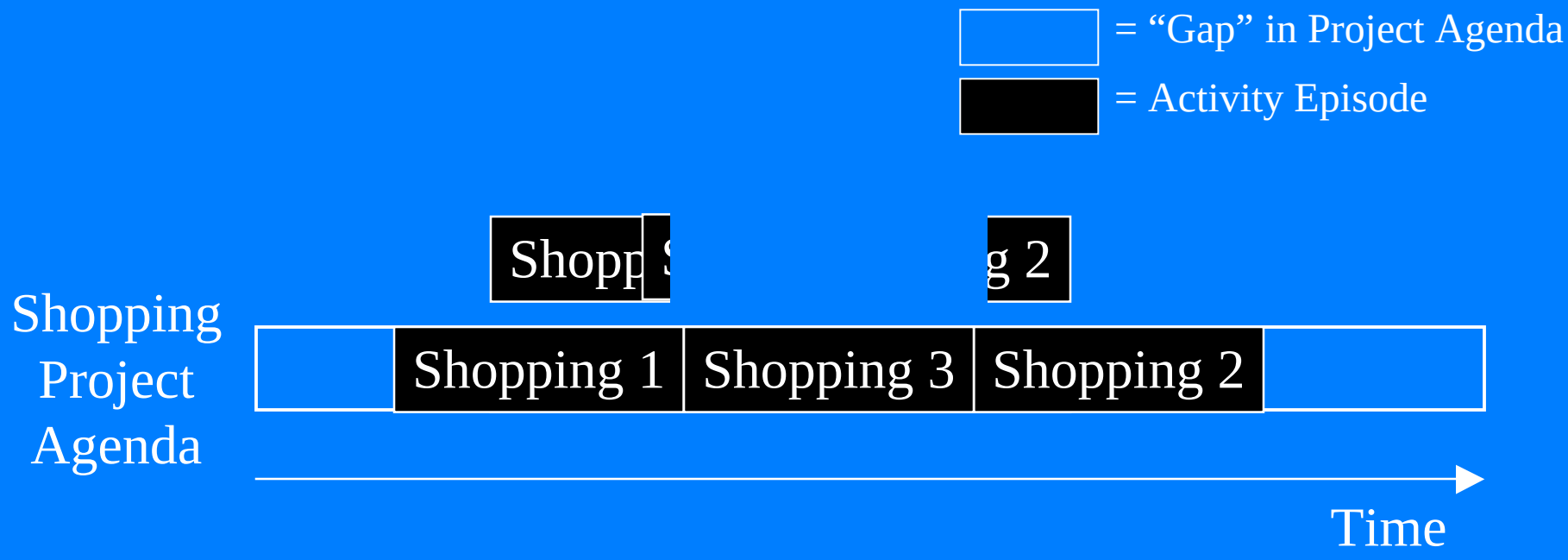
(a) Draw activity frequency from marginal PDF

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

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

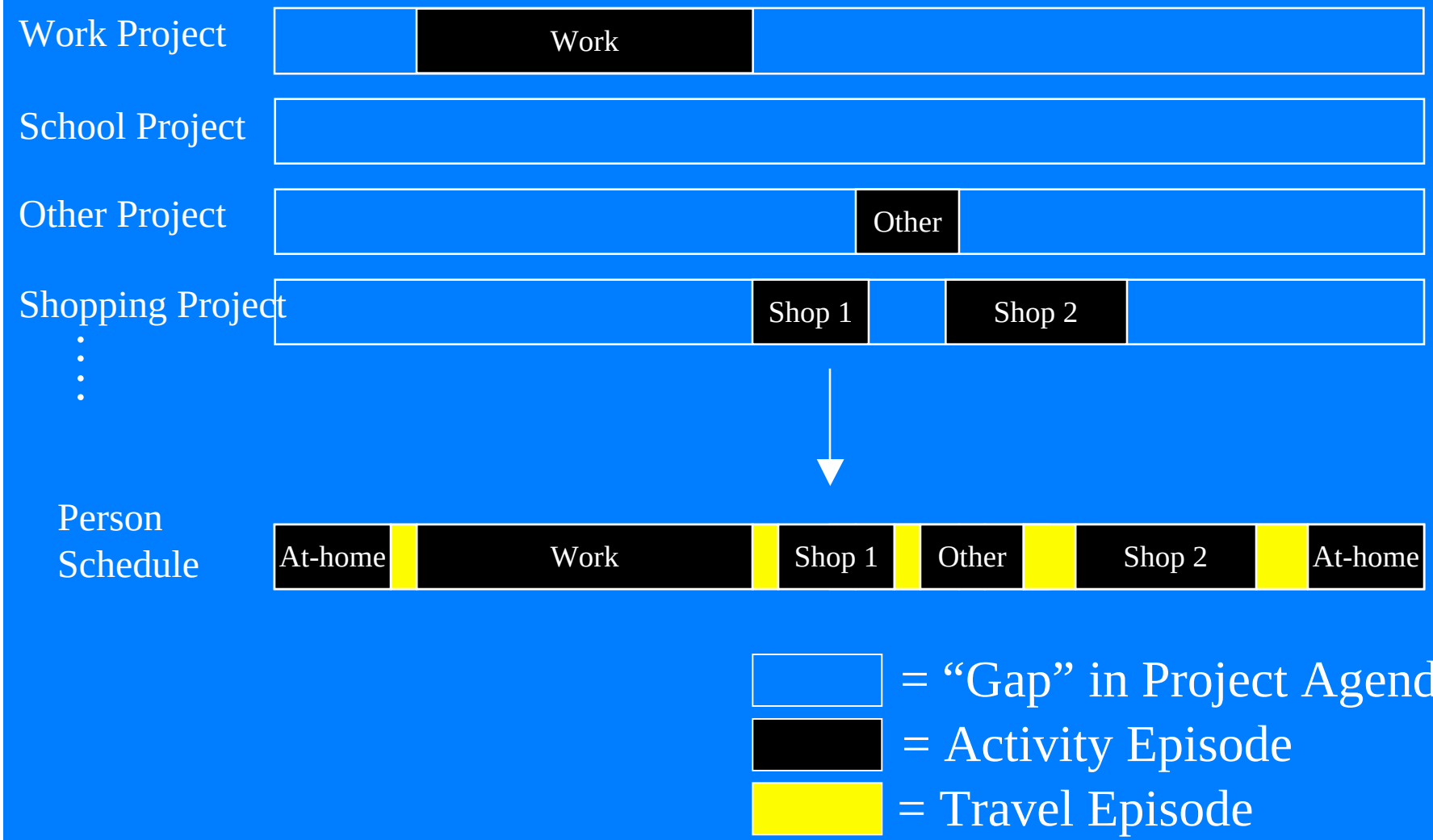


Inserting Activity Episodes Into the Project Agenda



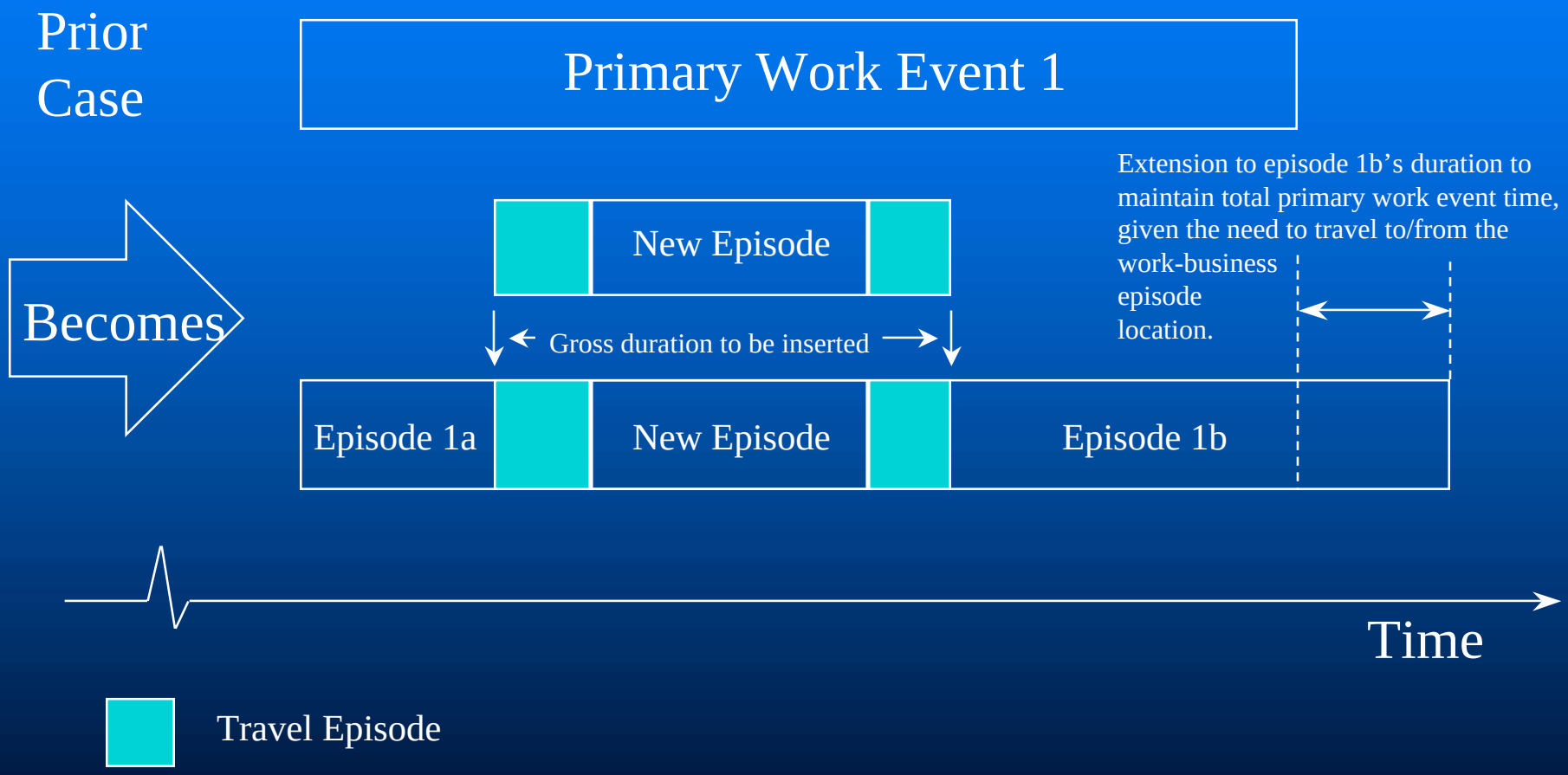
Shopping 1 – No conflict
Shopping 2 – Partial overlap with one episode
Shopping 3 – Insert between 2 episodes

Moving Activity Episodes from Project Agendas to the Person Schedule



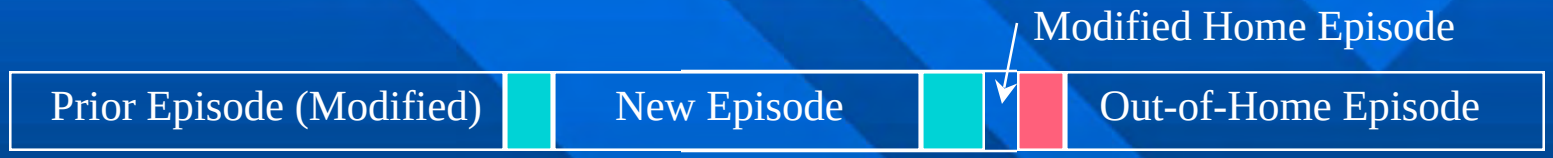
Inserting an Episode into a Schedule

Splitting a primary work episode with a work-business episode



Inserting a new Episode, Prior Location Different from Posterior Location

(a) Schedule prior to inserting new episode



(b) Schedule after inserting new episode

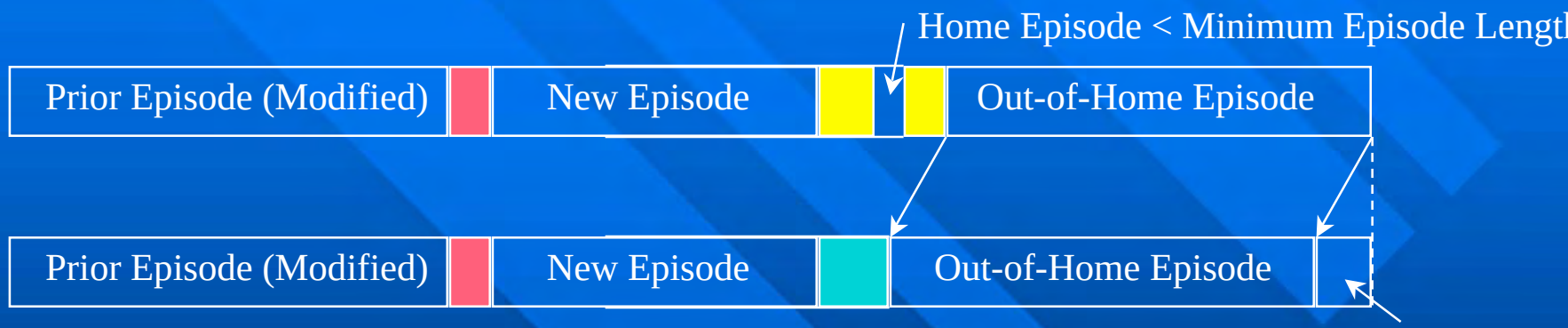
New Travel Episode

Existing travel episode deleted by new insertion

Existing Travel Episode

"Chaining" Episodes Together

(a) Schedule with residual home episode (from previous figure)



(b) Schedule after "chaining" episodes together

New Travel Episode

Existing travel episode deleted by "chaining" adjustments

Existing Travel Episode

Mode Choice Model

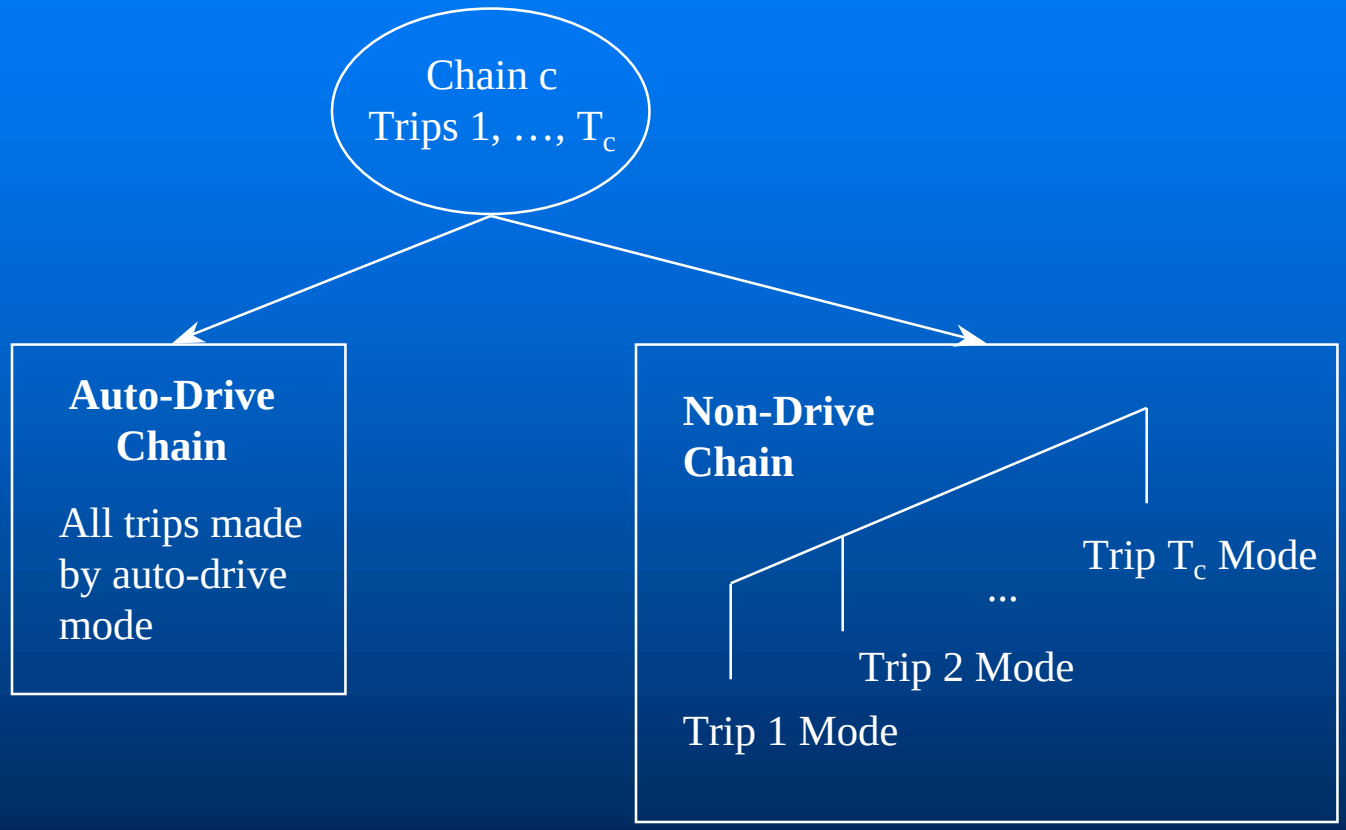
- Applied sequentially, based on the trip chains from the activity schedule model
- Chain-based
- Random utility formulation, with direct calculation of utilities

Papers documenting the model:

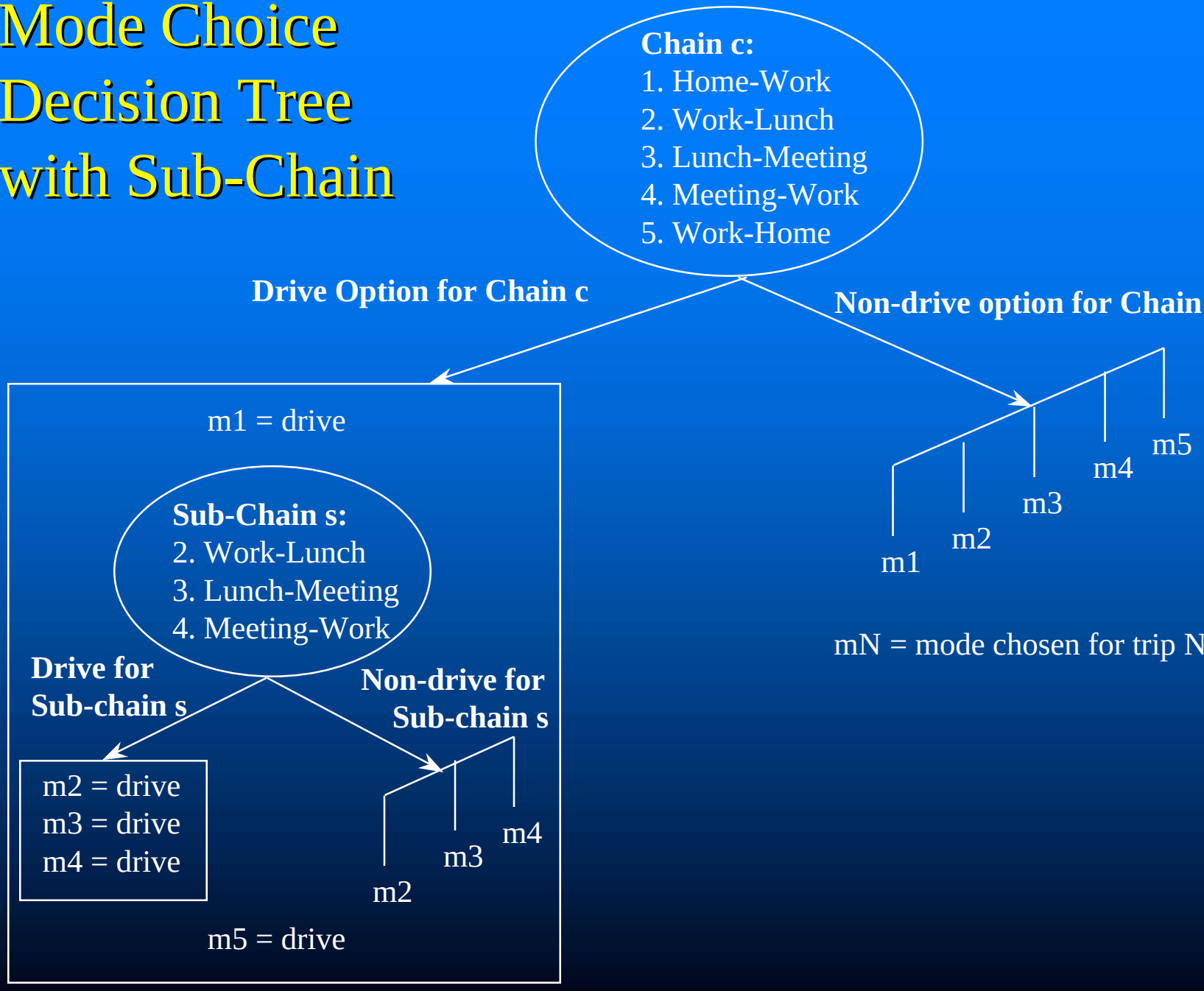
Miller, E.J., M.J. Roorda and J.A. Carrasco (2005) A Tour-Based Model of Travel Mode Choice. *Transportation*, Vol. 32, No. 4, 399-422.

Roorda, M.J., E.J.Miller and N. Kruchten (2006) Incorporating Within-Household Interactions into a Mode Choice Model Using a Genetic Algorithm for Parameter Estimation. forthcoming, *Transportation Research Records, Journal of the Transportation Research Board*.

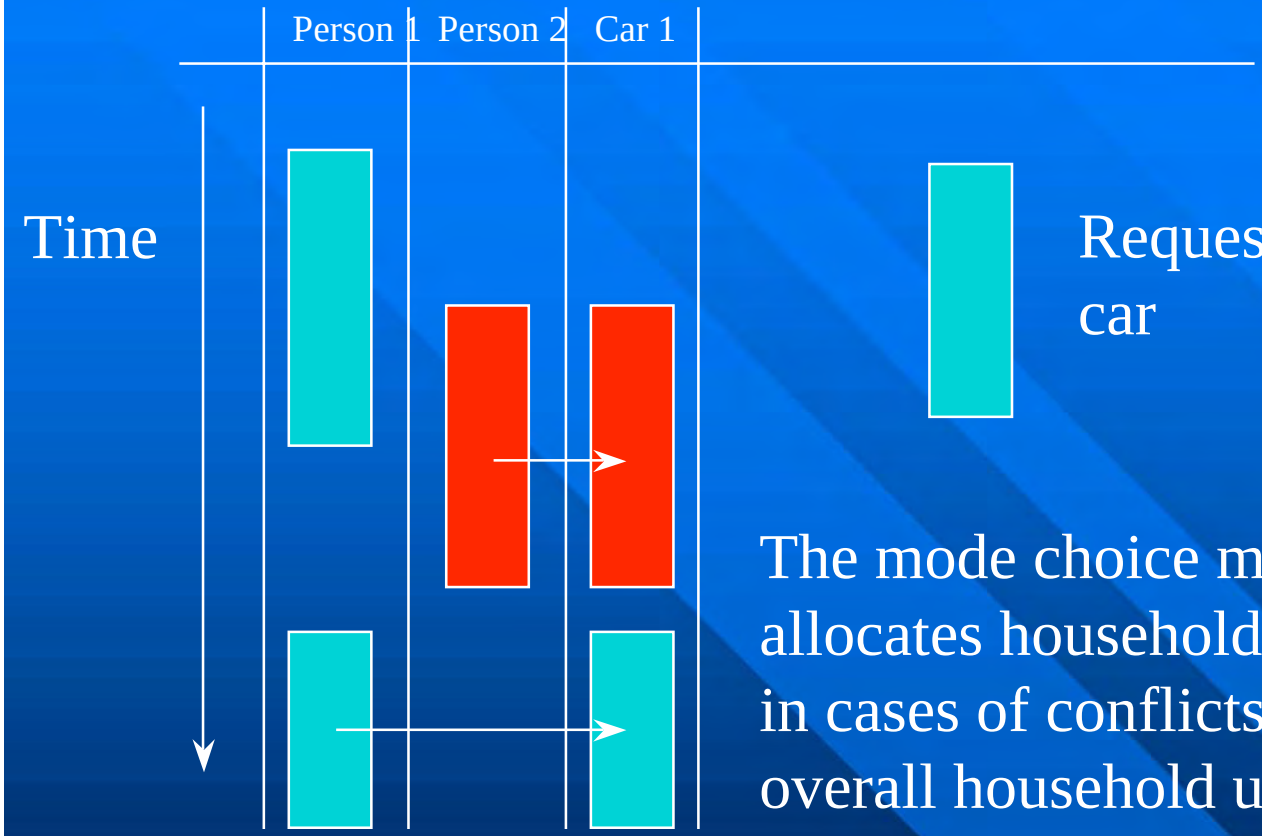
Mode Choice Model Structure



Mode Choice Decision Tree with Sub-Chain



Dynamic Vehicle Allocation



Request for car

The mode choice model dynamically allocates household vehicles to drivers in cases of conflicts, based on maximizing overall household utility.

Random Utility Formulation

- Utility of a trip t by mode m:

  $U_{mt} = V_{mt} + \varepsilon_{mt}$ $\quad m \in$ feasible modes

- Utility of a trip chain c with by a set of modes M:

  $U_{Mc} = \sum_t V_{mt} + \sum_t \varepsilon_{mt}$ $\quad M \in$ feasible mode combinations

- For simple chains M includes:
  - All-drive chains
  - All-bicycle chains
  - Non Personal Vehicle (NPV) chains

Random Utility Formulation

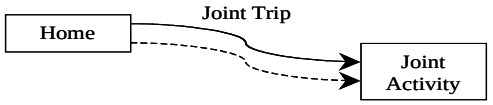
- Standard RUM Assumption:

$$U_{M^*c} \geq U_{Mc} \qquad \forall\ M, M^* \in \text{feasible mode sets};\ M^* \neq M$$

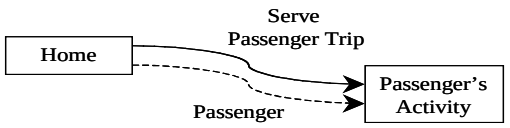
- In our microsimulation framework we:
  - Randomly simulate error terms
  - Directly compare utilities for individual trip chains
  - Explicitly choose the maximum utility set of modes
- Replicate many times to result in probability that a set of modes is chosen for that trip chain

Within-Household Ridesharing

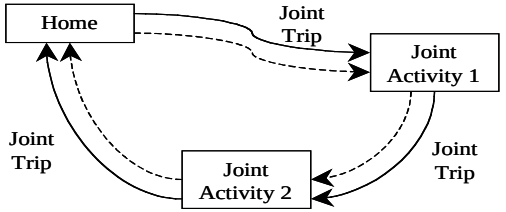
Joint Trip - A joint trip is a trip in which more than one household member travel together to or from a joint activity. This can either be a rideshare trip (by car), taking transit together, walking together, etc.



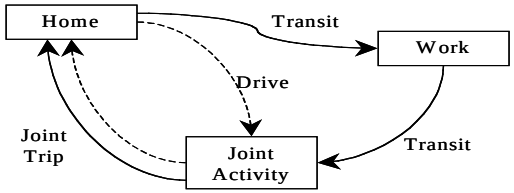
Serve Passenger Trip - A trip made by one member of a household for the purpose of transporting another member to their desired activity. A serve passenger trip may include a passenger (e.g. the trip to drop someone off), or may not include a passenger (e.g. the return trip home after dropping someone off).



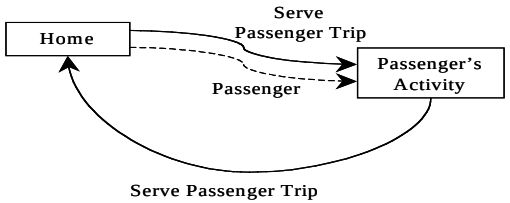
Pure Joint Tour – A joint tour is a tour in which more than one household member travel together to or from at least one joint activity. A pure joint tour occurs when all of the activities on the tours of multiple household members are joint activities. These household members travel together to and from joint activities, and all of these household members make the same trips on the entire tour, at the same times to the same locations. Mode choice for pure joint tours is assumed to be a joint decision, simultaneously determined for all joint activity participants.



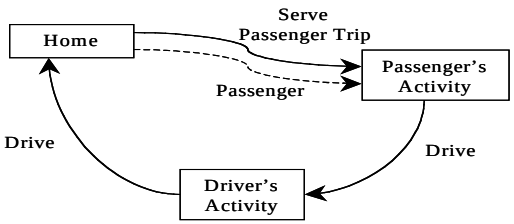
Partial Joint Tour - A partial joint tour is possible when some but not all of the activities on the tours of multiple household members are joint activities. A partial joint tour occurs when some but not all of the trips in each of these household members' tours, accessing or egressing from the joint activity, are at the same time, have the same origin and destination, and are by a shared mode.



Pure Serve Passenger Tour - A tour made by one household member solely for the purpose of picking up or dropping off another household member. No activities other than "dropping off" or "picking up" are conducted on a pure serve passenger tour.



En route Serve Passenger Tour - A tour made by one household member that includes at least one serve passenger trip, but also includes other activities before or after the serve passenger trip. For example, a tour in which a parent drops off a child at school on the way to work would be considered an en route serve passenger tour.



Tour-Based Mode Choice Model Parameter Estimates

Parameter	Description	Coeff-icient	Lik. Ratio
c-tr_n_dr	Mode specific constant for transit all-way	-0.166	18.46
c-walk	Mode specific constant for walk	-0.304	28.96
c-ridesh	Mode specific constant for rideshare (for joint trips)	0.835	72.40
c-pass	Mode specific constant for auto passenger	-2.385	527.0
atime	Auto in-vehicle travel time (min)	-0.075	167.2
tivtt	Transit in-vehicle travel time (min)	-0.029	94.7
twalk	Walk travel time including walk access to/from transit (min)	-0.064	1263.5
twait	Transit wait time (min)	-0.145	267.8
travelcost	Travel cost ($1996 Canadian)	-0.065	28.7
pkcost	Parking cost ($1996 Canadian)	-0.302	314.2
dpurp_shop_d	=1 if trip purpose = shopping (drive mode); = 0 otherwise	0.993	174.0
dpurp_sch_d	=1 if trip purpose = school (drive mode); = 0 otherwise	-1.181	302.1
dpurp_oth_d	=1 if trip purpose = other (drive mode); = 0 otherwise	0.593	116.7
dest_pd1_w	=1 for walk trips destined for downtown Toronto; = 0 otherwise	0.897	114.3
intrazonal_t	=1 for an intrazonal trip for transit all-way mode; = 0 otherwise	-2.962	299.9
adjzone_t	=1 for an adjacent zone for transit all-way mode; = 0 otherwise	-1.016	142.2
age11_15_p	=1 if age 11-15 (passenger mode); =0 otherwise	0.954	61.3
Etrip_par	Scaled variance for the trip specific error term	1	
Num Observations		19335	
Num Parameters		17	
Log Likelihood L(â)		-5035.87	
Log Likelihood No Parameters L(0)		-17434.8	
-2[L(0)-L(â)]		24797.8	
rho^2		0.7112	
Adjusted rho^2		0.7102	
Number of Observations in which observed mode never chosen		166	

Model Prediction Success Tables

Table 2.8 Prediction Success Table for the Estimated Model (Trips)

	Predicted Mode					
Observed Mode	Drive	Transit	Walk	Rideshare	Passenger	Total
Drive	11054	448	139	0	59	11699
Transit	487	2313	216	28	73	3117
Walk	122	252	863	2	60	1299
Rideshare	0	0	3	2814	14	2831
Passenger	109	125	70	0	81	385
Total	11771	3139	1291	2844	287	19331

Table 2.9: Prediction Success Table for the Estimated Model (% of Total Trips)

	Predicted Mode					
Observed Mode	Drive	Transit	Walk	Rideshare	Passenger	Total
Drive	57.2%	2.3%	0.7%	0.0%	0.3%	60.5%
Transit	2.5%	12.0%	1.1%	0.1%	0.4%	16.1%
Walk	0.6%	1.3%	4.5%	0.0%	0.3%	6.7%
Rideshare	0.0%	0.0%	0.0%	14.6%	0.1%	14.6%
Passenger	0.6%	0.6%	0.4%	0.0%	0.4%	2.0%
Total	60.9%	16.2%	6.7%	14.7%	1.5%	100.0%

Table 2.10: Prediction Success Table for the Estimated Model (% of Observed Mode)

	Predicted Mode					
Observed Mode	Drive	Transit	Walk	Rideshare	Passenger	Total
Drive	94.5%	3.8%	1.2%	0.0%	0.5%	100.0%
Transit	15.6%	74.2%	6.9%	0.9%	2.3%	100.0%
Walk	9.4%	19.4%	66.5%	0.2%	4.6%	100.0%
Rideshare	0.0%	0.0%	0.1%	99.4%	0.5%	100.0%
Passenger	28.3%	32.5%	18.1%	0.0%	21.0%	100.0%
Total	60.9%	16.2%	6.7%	14.7%	1.5%	100.0%

Location Choice

- Locations are unknown for all episodes except usual place of work and school
- Currently simple (logit) location destination choice models are used based on home or work location
- Must do better!
- Carrasco looking at spatial aspects of social networks

TASHA Validation

The predictive performance of the TASHA model has been tested by means of:

- ***Verification*** of the its ability to reproduce 1996 base year activity schedules.
- ***Validation*** of its ability to predict observed 2001 activity schedule.

Some Summary Statistics

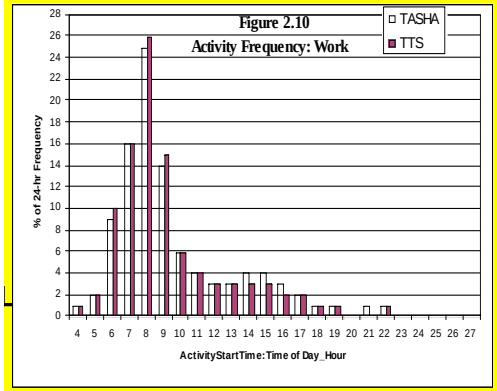
1996 Test:

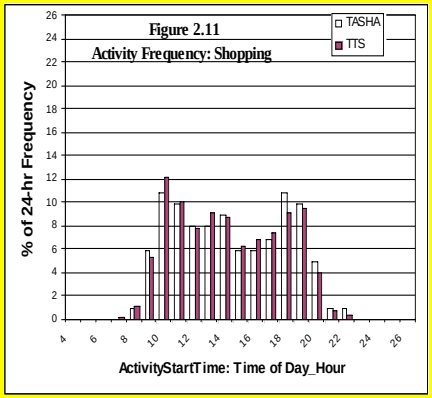
Activity	TASHA-Total Freq	TASHA-% Freq	TTS- Total Freq	TTS - % Freq	TASHA-AvgDist-km	TTS-AvgDist-km
Home	182113	45.53	187254	45.2	8.68	8.54
Shopping	32929	8.23	35679	8.61	5.67	4.83
Others	59671	14.92	64290	15.52	7.74	7.39
School	29425	7.36	30500	7.36	6.51	5.05
Work	95838	23.96	96574	23.31	12.76	12.04
Total	**399976**		**414297**			

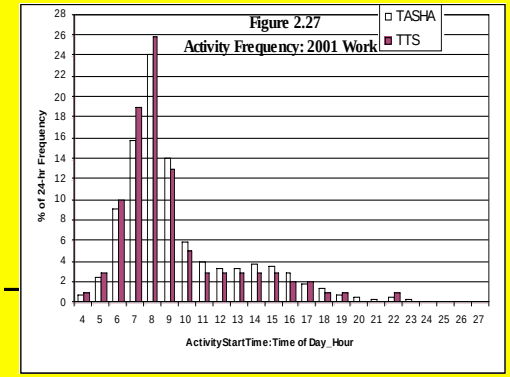
2001 Test:

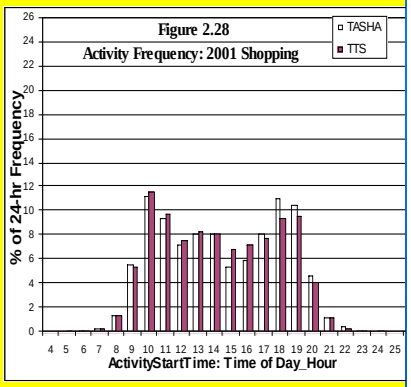
Activity	TASHA-Total Freq	TASHA-% Freq	TTS- Total Freq	TTS - % Freq	TASHA-AvgDist-km	TTS-AvgDist-km
Home	266345	45.48	286125	45.19	9.21	9.21
Marketing	46414	7.93	54550	8.62	5.87	5.47
Others	84914	14.5	100452	15.86	7.97	8.93
School	42518	7.26	44190	6.98	6.42	5.45
Work	145388	24.83	147860	23.35	13.56	13.04
Total	**585579**		**633177**			

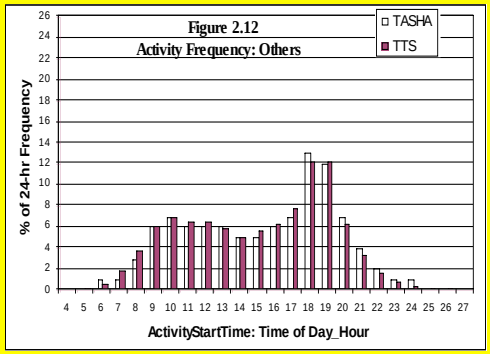
1996 & 2001 Validation: Activity Episode Frequency by Time of Day

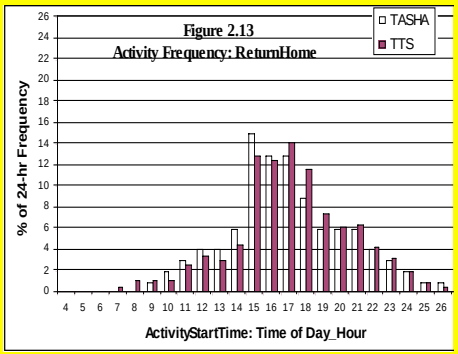


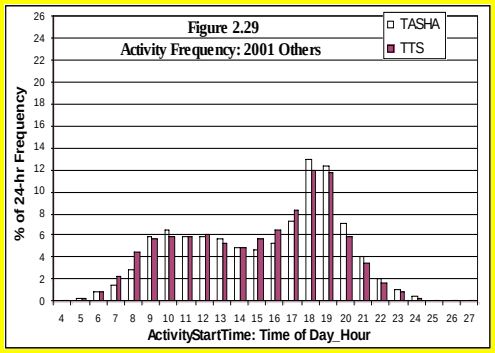


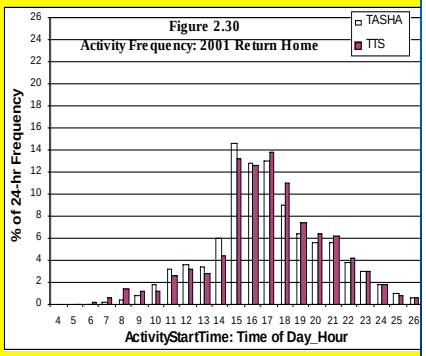


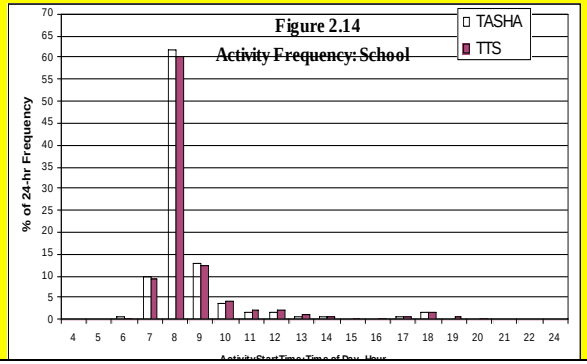


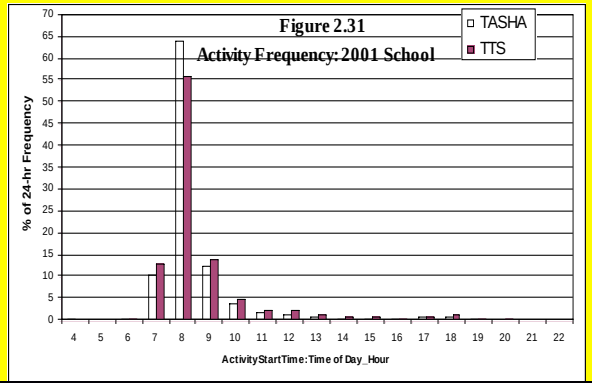




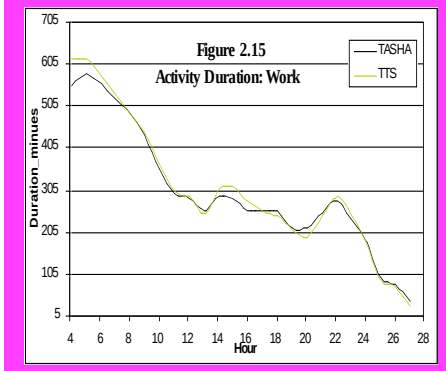


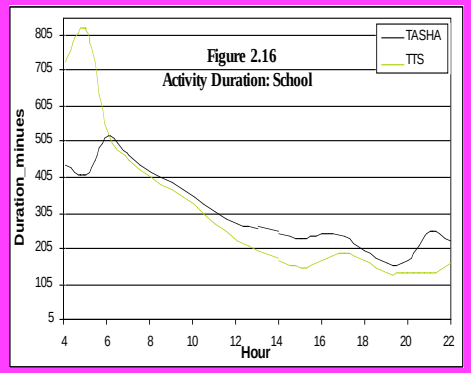


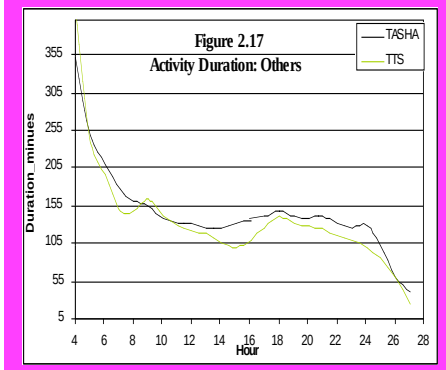


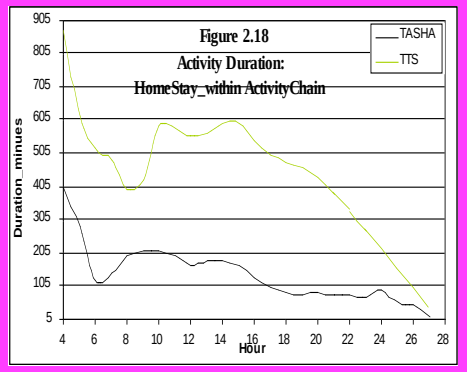


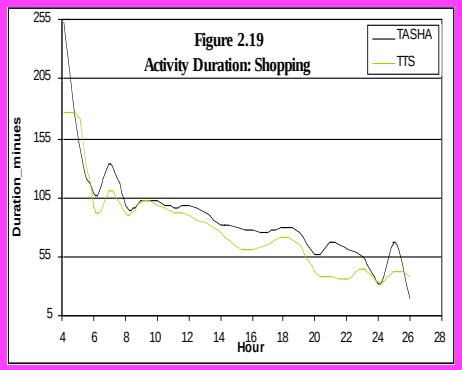
1996 & 2001 Validation: Activity Episode Durations by Time of Day

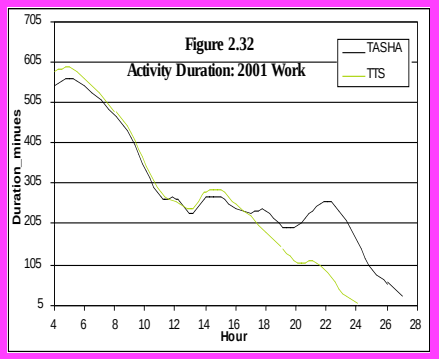


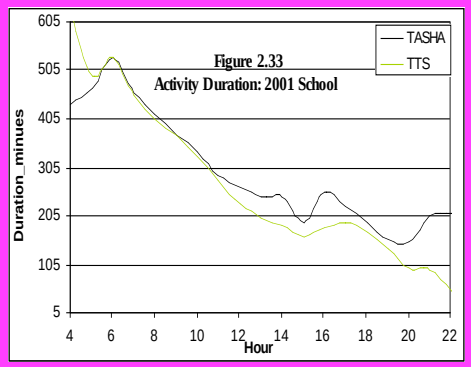


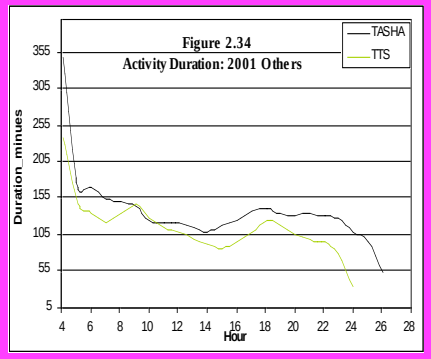


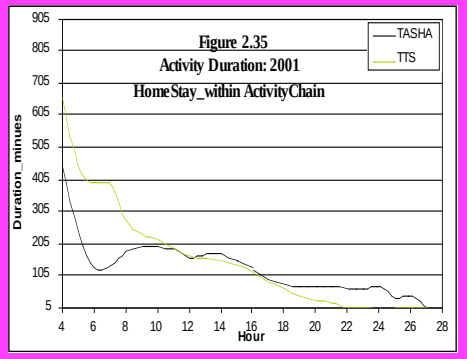


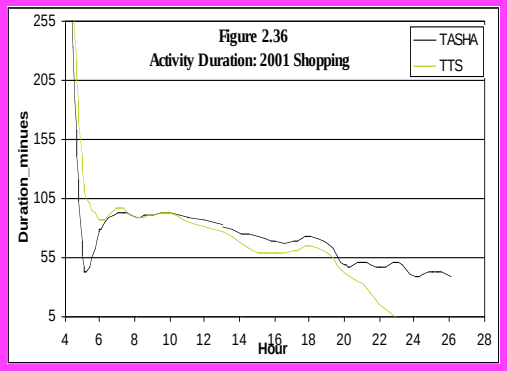












Next Steps

- The validated model will be used to test the impacts on GTA travel behaviour of a variety of land use and transport network options (about to start)
- Develop improved models of non-work/school activity location choice
- Develop schedule- & policy-sensitive models of activity episode generation (underway)
- Tie TASHA to a model of household auto ownership (underway)
- Integrate mode choice model within the scheduler
- Extend to a full week?
- Incorporate panel survey results

Panel Survey

We have recently completed a 3-year panel survey to gather detailed information about household activity scheduling behaviour.

Approx. 270 households (Wave 1) in each of Toronto & Quebec City.

Wave 1 (2002-03):

- 1 week activities per person 16+ years old.
- CHASE survey method in Toronto; paper diary in Q.C.

Wave 2(2003-04):

- 2-day paper activity diary + SP experiments

Wave 3 (2004-06):

- 2-day paper activity diary
- Routine, skeleton schedule" gathered prior to diary

"TASHA/2" will incorporate many findings from this survey.

Thank you!
Any questions?