Integrating Short- and Long-Run Decisions: Past Lessons & Future Prospects

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Objective

- To develop a comprehensive conceptual framework for microsimulating household and person decision-making in an integrated way over both the short- and long-run.
- Hopefully this framework is:
  - Behaviourally sound
  - Operationally implementable
  - Computationally efficient
  - Extensible

Some Building Blocks

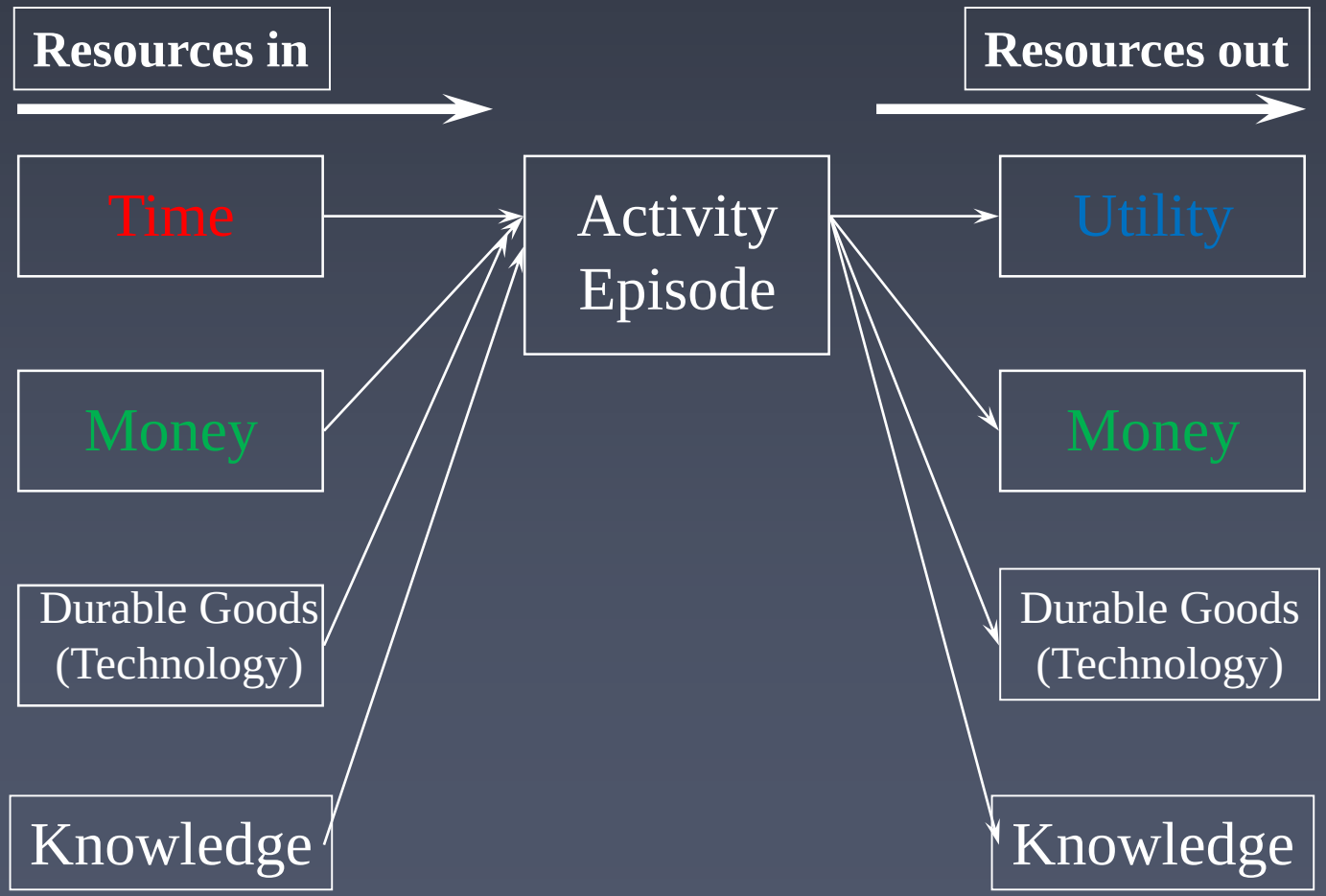
- Resources
- Projects
- Resource Management
- Resource Change Projects
- Stress

What do persons & households "do"?

- Persons & households respond to their environment (the state of "the World") and act into the World (and thereby affect its state) by making (and eventually executing) decisions with respect to the acquisition, allocation & usage of tangible household and personal resources:
  - Time
  - Money
  - Goods & Services (notably housing & cars)
  - Knowledge
- The resources available to an agent define the physical/technological/fiscal context within which all activity occurs.

Resource Flow for an Activity Episode

Activities both consume and generate resources.



Resource Flows & Stocks

FLOWS	STOCKS
Time	(No stock variable: time cannot be stored/saved)
Money	Equity/capital/savings
Utility	Well-being/satisfaction
Information	Knowledge/memory
Time usage of a good	Durable goods/technology/"tools" - Cars - Cottages - …

Budgets (Resource Management)

- Households and persons are constrained in their actions by time, money and other resource **budgets.**
  - In each time period, each person must spend each minute doing “something”.
  - In each time period all money available to the household must be spent (includes “spending” on savings).
  - Only one driver at a time can use a car (etc.).
- In the long-run, durable acquisition decisions (houses, cars), monetary budget tends to dominate.
- In short-run activity/travel decisions, time budget (and car availability constraints) tend to dominate.
- Both time & money constraints, however, are potentially operative within all time frames.

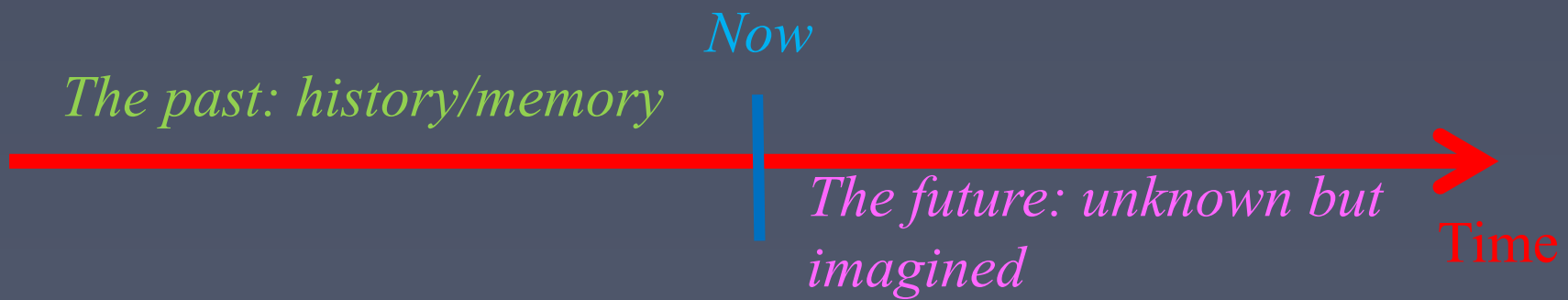
Time

- Time is continuous and “forward moving”.
- In practical applications we inevitably “aggregate” time into categories, one way or another, in particular into the short-run and the long-run.
- *Short-run decisions*: Decisions made given fixed resources (cars, income, place of residence, etc.).
- *Long-run decisions*: Decisions that change fixed resources (buy a new car, change job, etc.).

Acting in the "Now"

- All action, however, occurs in the "now", i.e., at some point in time that is the present moment at the time of the action (we cannot act in either the past or the future).
- We can remember the past.
- We can anticipate/envision the future.

Both can influence current decision-making



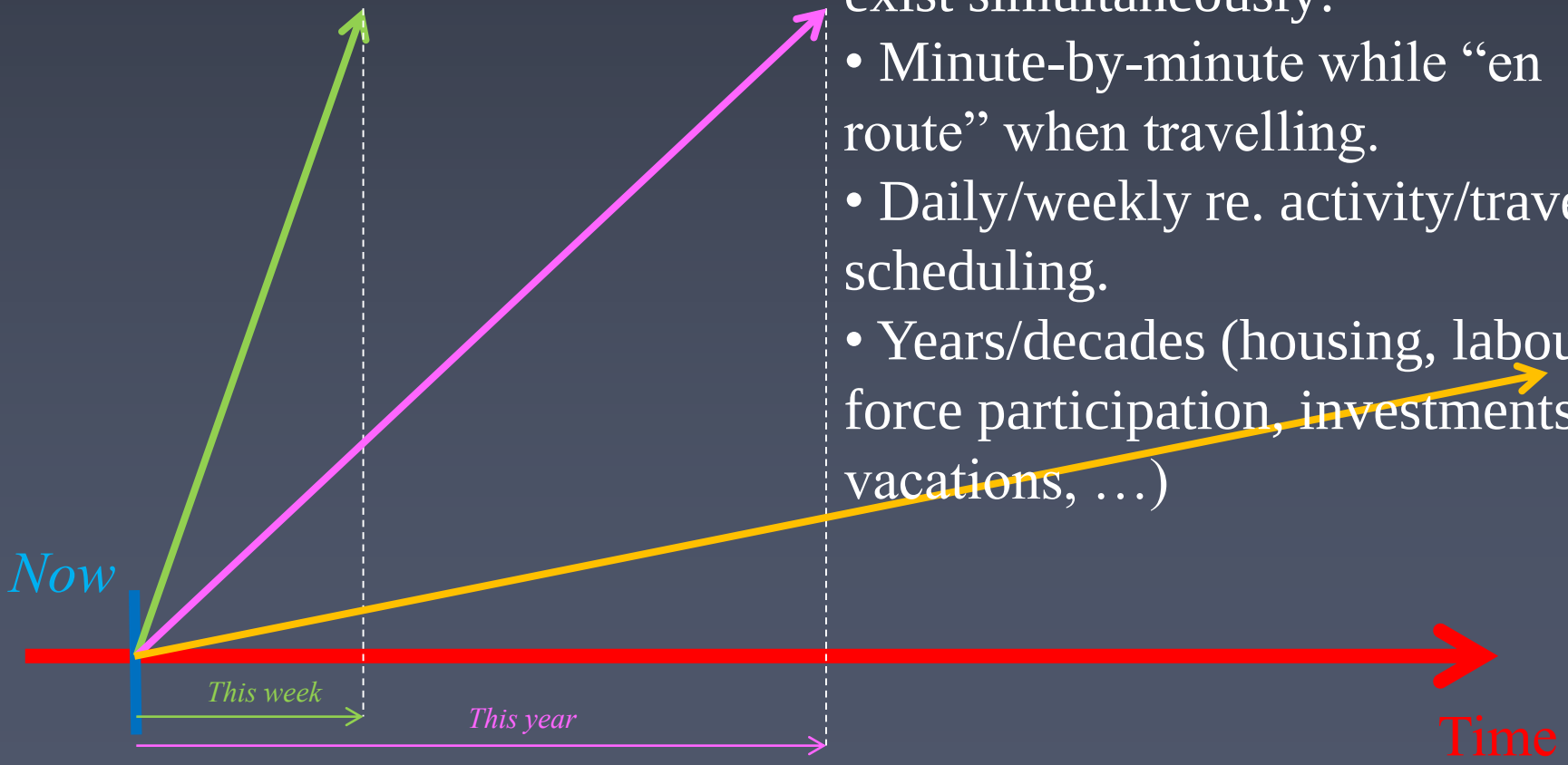
Long-Run Decisions

- Thus, long-run decisions are ones that do not occur on a "day-to-day" basis, but that do occur on "some day".
- The modelling challenge is to determine when such actions occur; i.e., at what point in time (under what circumstances) such a decision is "triggered".

Planning Horizons/Time Periods

Multiple planning periods clearly exist simultaneously:

- Minute-by-minute while "en route" when travelling.
- Daily/weekly re. activity/travel scheduling.
- Years/decades (housing, labour force participation, investments, vacations, …)



Temporal Modelling Issues

- How to deal with multiple planning periods?
- How does the past (day-to-day) experience influence current (day-to-day or longer-run) decisions?
- How do anticipations/expectations about the future influence current (day-to-day or longer-run) decisions?
- How to model the triggering of longer-run decisions?
- Time-driven or event-driven model?
- If time-driven, then:
  - What time step? (level of temporal aggregation)
  - Sequencing of decisions (what comes first?)
- If event-driven, then …

Projects

- Axhausen [1998] defines a **project** as a coordinated set of activities tied together by a common goal or outcome.
- In this conceptual model, the project is **the** fundamental organizing principle.
- It is argued that **all** activities (short- and long-run) are embedded within and generated by projects.
- Projects may have sub-projects, which can have sub-sub-projects, and so on.
- An activity is thus an “elemental” project which contains exactly one type of action.

Primary Projects (example)

However, specified, the set of projects contain the mechanisms required to generate all activity episodes of interest within the model system – including "long run" decisions.

- Community service
- Education
- Family
- Financial management
- Health care
- Mobility
- Personal maintenance
- Recreation (personal/household)
- Religious group
- Shelter
- Socializing (with non-household members)
- Sustenance
- Vacation
- Work

Projects & Decision-Making

- The key advantage of the project (as opposed to just speaking of various activities) is that each project **encapsulates** within itself all knowledge (decision rules, utility functions, etc.) required to determine what activity episodes "need" to be generated and undertaken to address the project's objectives within a given planning period (note that a project may be able to deal with more than one planning period at a time).
- In particular, these decisions can be made independently of the needs/decisions of other projects. E.g., the generation of the need to mow the lawn (shelter | home maintenance project) is independent of the need to play golf (recreation project).
- This facilitates:
  - Building individual activity episode generation models in a modular, extensible fashion.
  - Modelling logical interconnections between different types of activities within a given project (e.g., "business meetings", "return home from work for lunch", etc. within the work project).
  - Dealing with the complexity of overall behaviour within a manageable, practical computational framework.

Projects & Decision-Making, cont'd

- This encapsulation (in which each project only "knows about" its own activities) means that an **interface** must exist between projects so that time, money and other resource **requirements**, **constraints** and **allocations** can be communicated and determined.
- I.e., the feasibility of episodes being generated / "requested" by the projects must be determined, given available resources and competing demands for these resources.

Resource Manager

- The purpose of a *resource manager* is to facilitate the allocation of resources among competing activities.
- In particular, a resource manager controls the allocation of:
  - Time or money to activities.
  - Usage of a shared resource (e.g., cars)

Resource Manager Tasks

- Check for the feasibility of a proposed action given currently planned/committed actions and current resources available for all actions.
- Modify attributes of the desired action and/or previously accepted (scheduled) actions to make the desired action feasible.
- Reject the desired action if it is not (or can not be made to be) feasible.
- Return information concerning the plan and the outcome of the insertion process to the generating project.

Example Resource Managers

- Money budget manager:
  - Allocates household money to activities
  - Household-level manager
- (Daily/weekly) activity scheduler:
  - Allocates an individual's time to activities
  - Person-level manager
- Auto usage manager
  - Allocates time usage of household autos
  - Household-level manager
- ….

Operational in TASHA

Money Budget Manager (1)

Operating Budget, time period t:

$$H_t + M_t + \Sigma_p C_{pt} + S_t + D1_t + T_t = Y_t + SW1_t + ND1_t + TP_t$$

Expenditures in time period t:

H_t = Shelter costs (mortgage, operating, …)
M_t = Mobility costs (car payments, insurance, operating, …)
C_{pt} = Expenditures for project p
S_t = Payments to savings
$D1_t$ = Debt servicing charges
T_t = Taxes

Revenue in time period t:

Y_t = Household income
$SW1_t$ = Withdrawals from savings applied to operating expenses
$ND1_t$ = New debt applied to operating expenses
TP_t = Transfer payments (employment insurance, etc.)

Money Budget Manager (2)

Capital Budget in time period t:

$$SV_{t+1} = SV_t(1+i_t) + S_t - SW1_t - SW2_t + R1_t$$
$$TD_{t+1} = TD_t - D2_t + ND1_t + ND2_t$$
$$P_t = SW2_t + (R_t - R2_t) + ND2_t$$

SV_t = Total savings
i_t = Rate of return in period t
$SW2_t$ = Withdrawals from savings applied to a capital expenditure
$R1_t$ = Amount from sale of a capital good applied to savings
$R2_t$ = Amount from sale of a capital good applied to purchase of a new good
TD_t = Total debt
$D2_t$ = Debt principal reduction due to debt repayment
$ND2_t$ = New debt applied to a capital expenditure
P_t = Purchase price of a new capital good
R_t = Sale price of a capital good sold

Resource Change Projects

- Long-run *resource change projects* & their associated "generating" projects include:
  - Vehicle transactions (add, delete, trade a car): mobility project
  - Residential (re)location: shelter project
  - Labour force participation/job change: work project

Resource Change Process

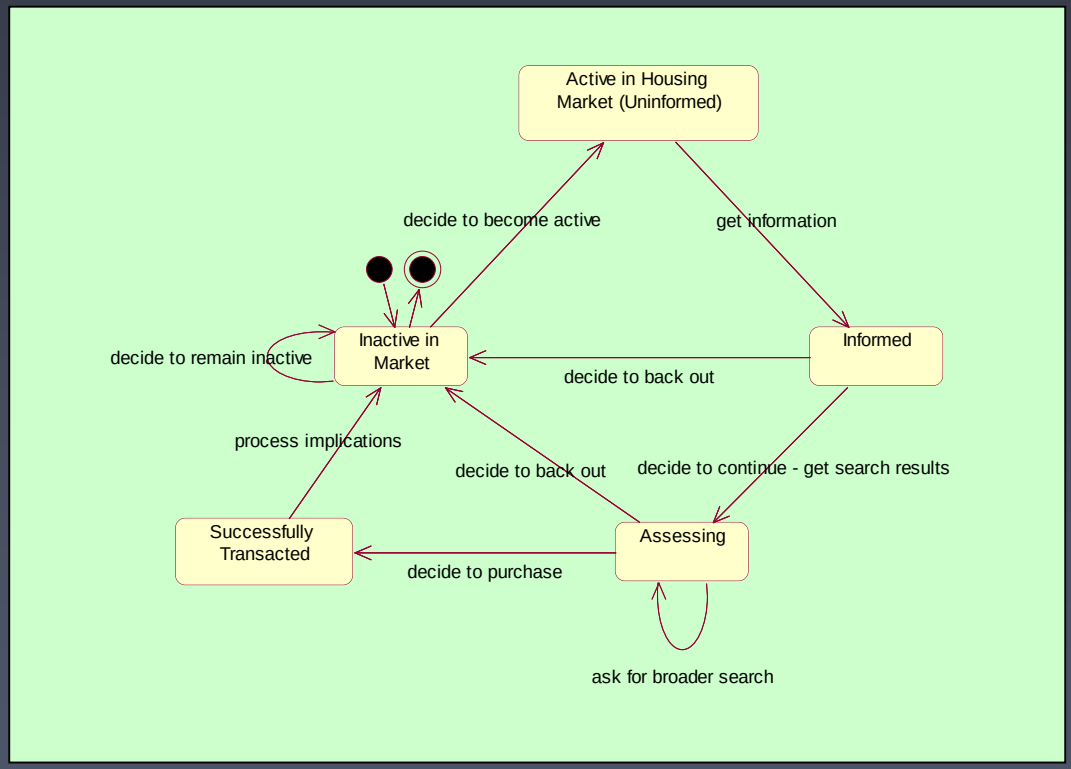
1. An agent “accepts” a project’s “recommendation” to become active in the given resource market (cars, houses, jobs) at time t.
2. The agent then enters a market process consisting of a set of activities: search, bidding and termination (change, no-change).
3. If the search is successful and a transaction occurs, then the new resource is added to the agent’s portfolio of resources (or replaces an existing resource), e.g.:
    1. Move to a new dwelling unit.
    2. Change jobs.
    3. Trade in an old car for a new one.
4. If the search is unsuccessful and a transaction does not occur, then the agent reverts to a “passive state” with the pre-existing resource portfolio.

Market Processes

Become Active in the Market

Constrained Search

Bidding & Search Termination



Stress

Stress is a concept that has been used to explain agent "state changes" (e.g., residential location change) since at least Rossi (1955).

Loosely (and somewhat simplistically):

Stress = (Expected/Desired State) – (Current State)

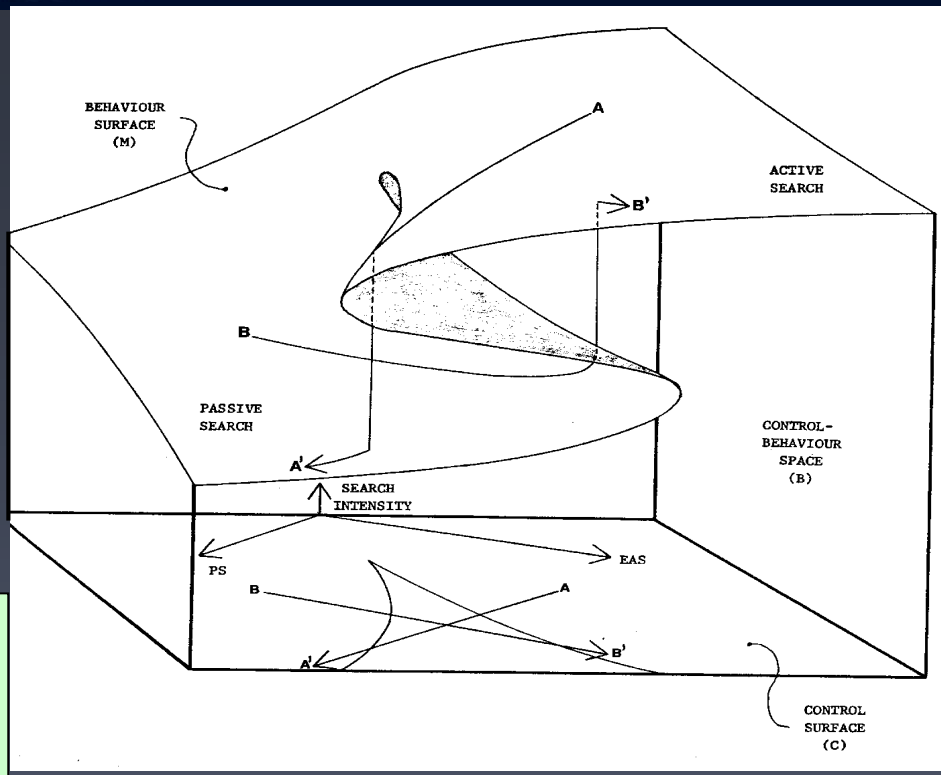
If Stress > τ (threshold value), then the agent may change state

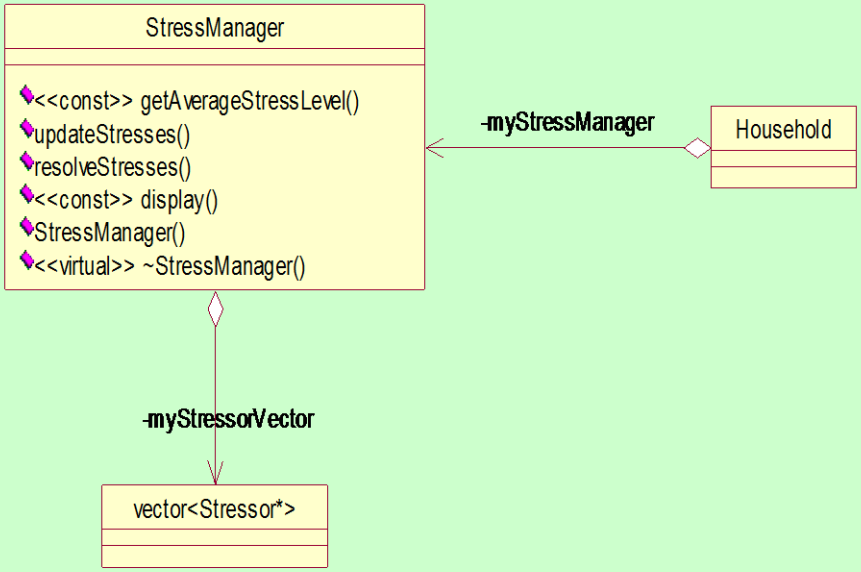
Stress, cont'd

For many resources (houses, cars, jobs, …) agents do not marginally adjust their state in response to marginal changes in circumstances. Many reasons for this exist:

- Marginal changes not possible
- Significant search & transaction costs exist
- Risk associated with alternative states
- Impacts on other aspects of the agent's state
- Imperfect information about alternative states
- Transactions require engaging in explicit market processes

Sarjeant's Cusp Catastrophe Model of Residential Stress & Search





Salvini's Stress Management Class

Example Stress-Based Models

- Residential mobility choice model:
  - Habib, M.A. and E.J. Miller (2009) "Reference-Dependent Residential Location Choice Model within a Relocation Context", *Transportation Research Record, Journal of the Transportation Research Board*, No. 2133, pp. 56-63.
  - Habib, M.A. and E.J. Miller (2008) "Microsimulating Residential Mobility and Spatial Search Behaviour: Estimation of Continuous Time Hazard and Discrete Time Panel Logit Models for Residential Mobility", pre-print CD, 87th Annual Meeting of the Transportation Research Board, Washington, D.C., January.
- Household auto transaction choice model:
  - Roorda, M.J., J.A. Carrasco and E.J. Miller (2009) "A Joint Model of Vehicle Transactions, Activity Scheduling and Mode Choice", *Transportation Research B*, 43(2) 217-229.

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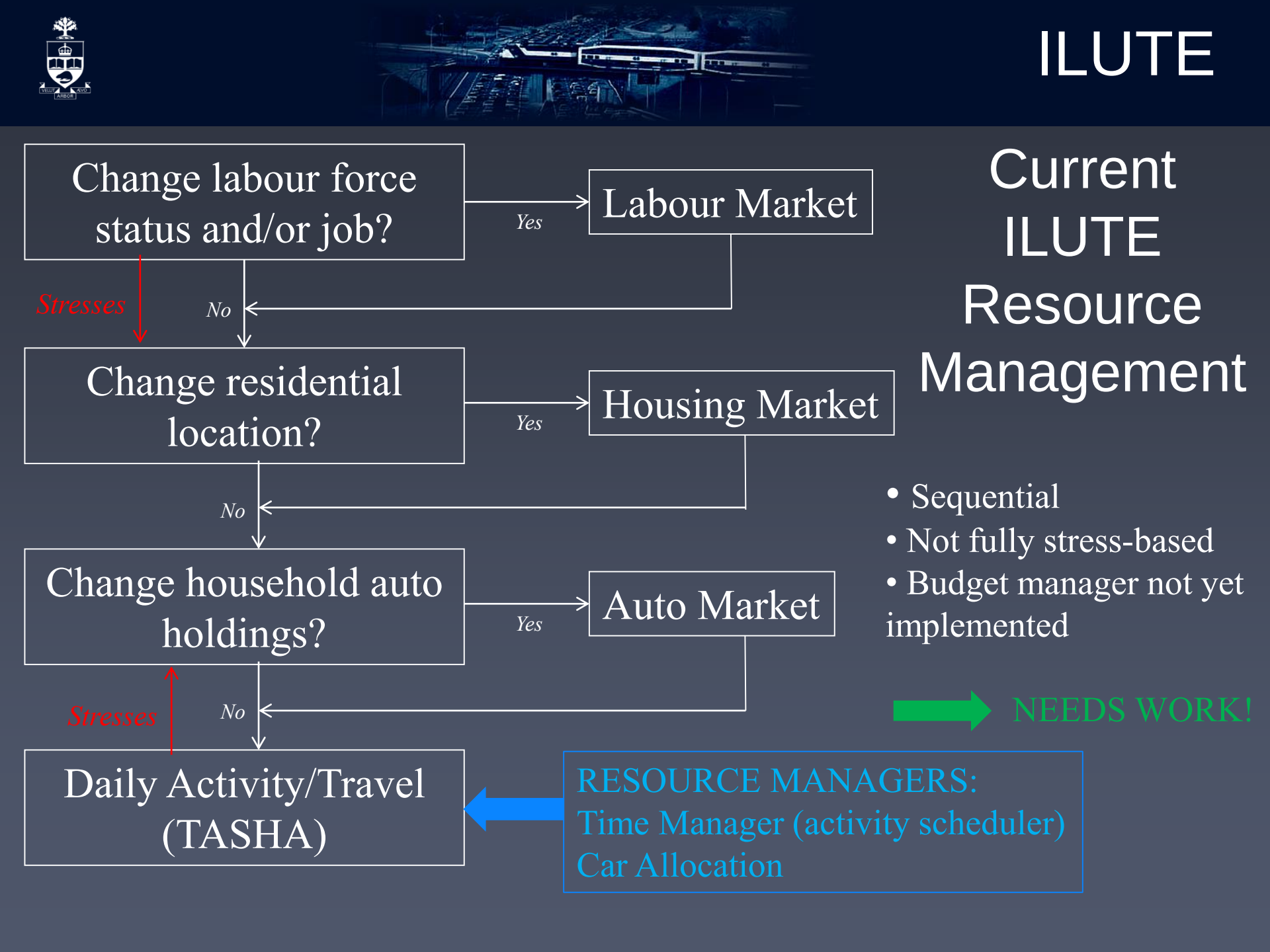


Current ILUTE Resource Management

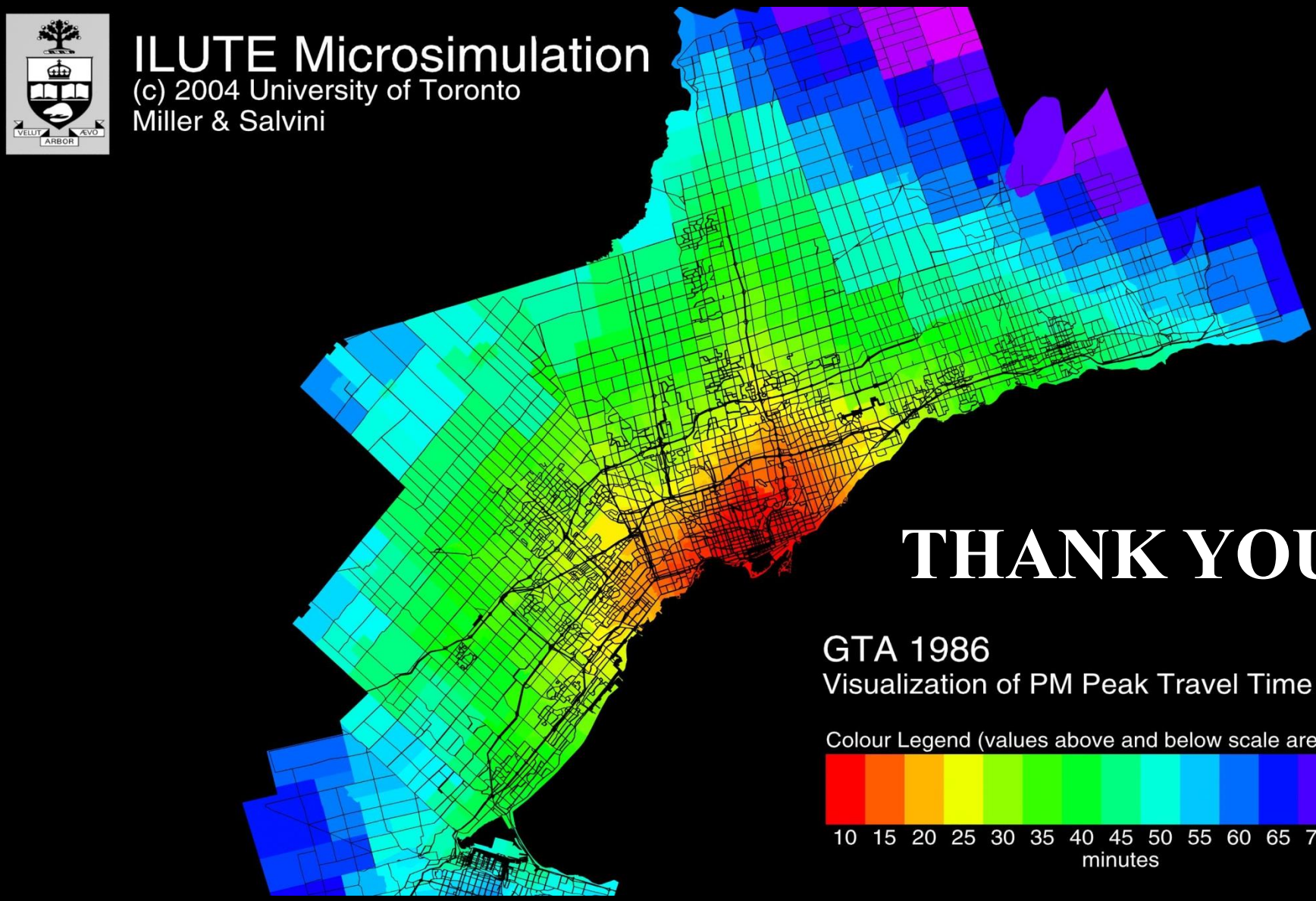
- Sequential
- Not fully stress-based
- Budget manager not yet implemented

NEEDS WORK!

RESOURCE MANAGERS:
Time Manager (activity scheduler)
Car Allocation

Key Research Questions

- How does the “day-to-day” experience accumulate to “trigger” long-run changes?
  - Most particularly, travel impacts on auto ownership & location choices.
- How to efficiently model the short- & long-run in the same model system?
- How to handle multiple stresses influencing multiple choices?


ILUTE Microsimulation
(c) 2004 University of Toronto
Miller & Salvini
THANK YOU!
GTA 1986
Visualization of PM Peak Travel Time to CBD
Colour Legend (values above and below scale are clipped):
10 15 20 25 30 35 40 45 50 55 60 65 70 75 80
minutes