Activity-Based Models: What, Why and How

Institute for Transport Studies, University of Leeds
August 6, 2013

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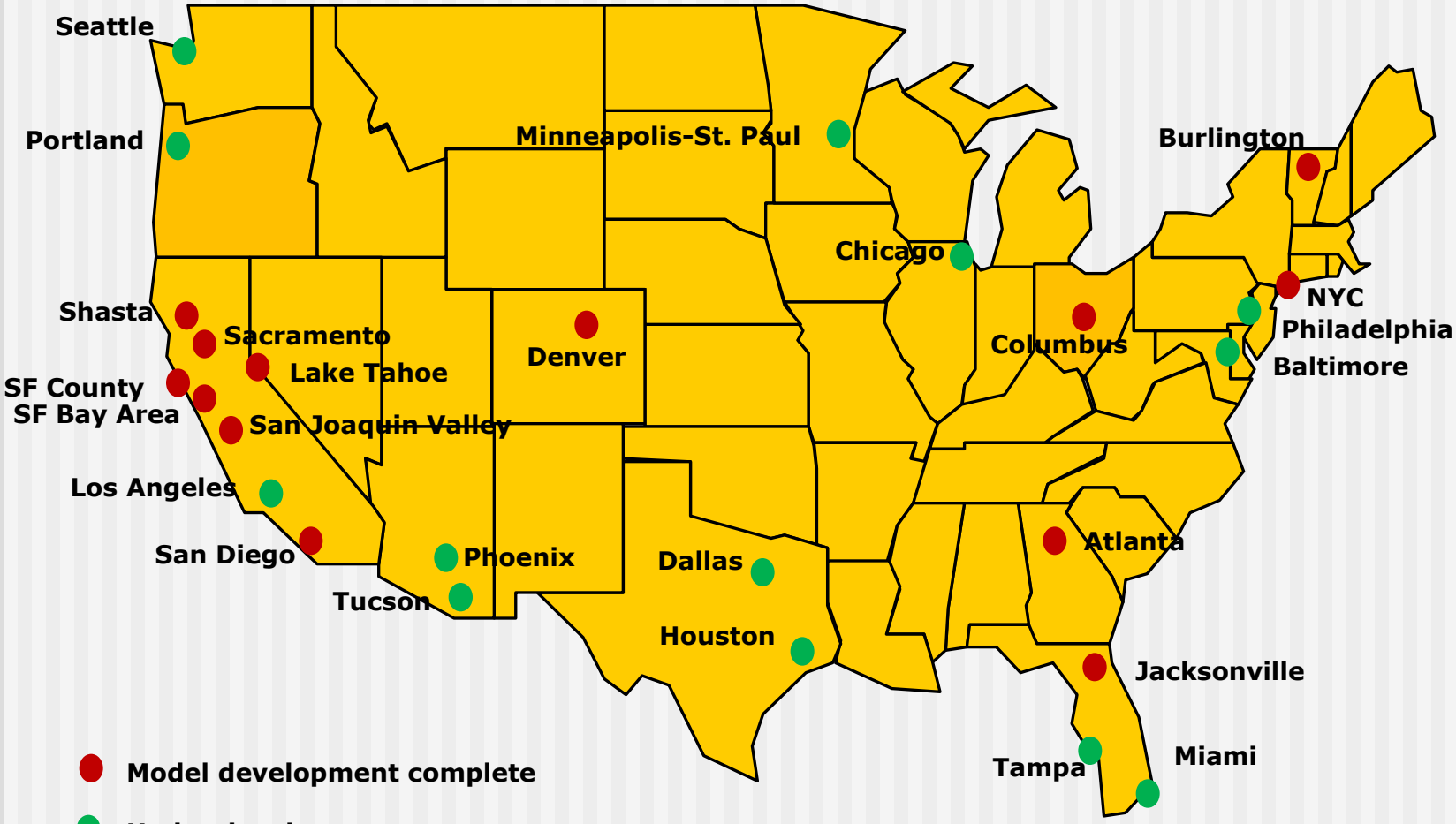
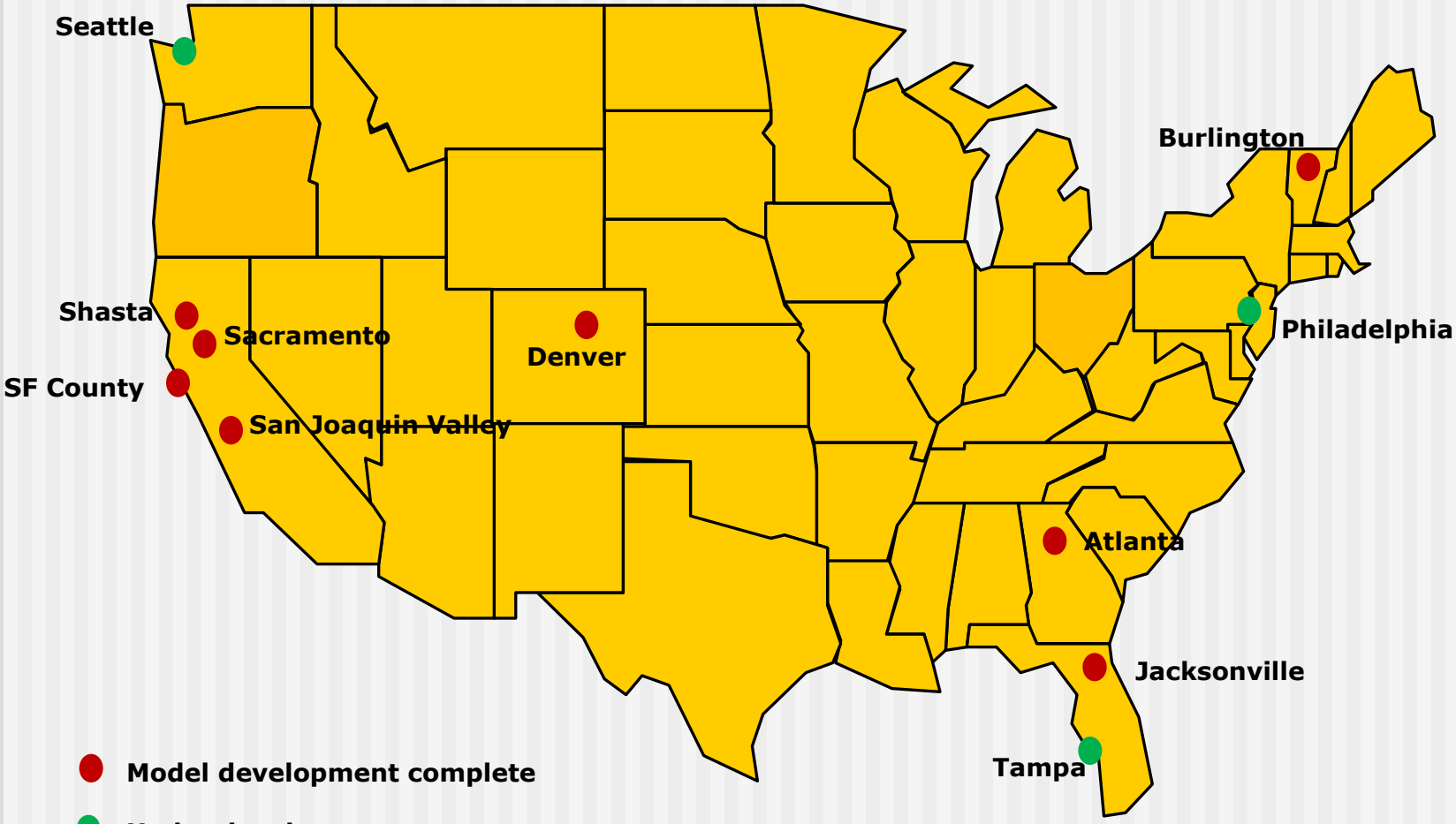
AB Models in the U.S.

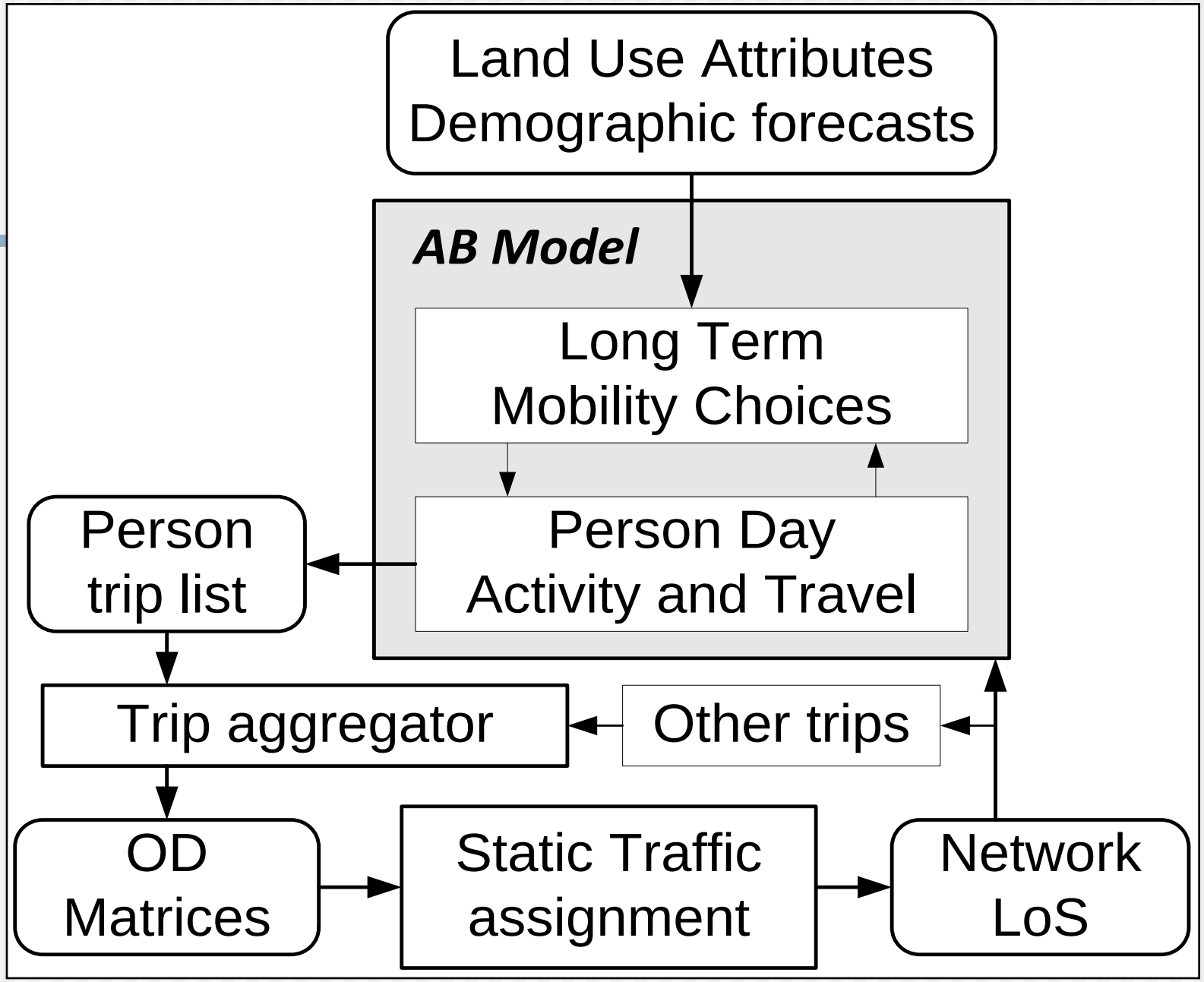


AB Models in the U.S.



Copenhagen ACTUM Project

- funded by the Danish Strategic Research Council
- led by Danish Technical University
- involves several universities and collaborators, including Leeds
- to develop an advanced activity-based model (COMPAS—Copenhagen Model for Person-Activity Scheduling)


Land Use Attributes
Demographic forecasts
AB Model
Long Term
Mobility Choices
Person Day
Activity and Travel
Person
trip list
Trip aggregator
Other trips
OD
Matrices
Static Traffic
assignment
Network
LoS

Outline:
How AB models are designed to achieve the desired benefits

- Microsimulate an entire day for each person
- Model household interactions explicitly
- Use a fine-grained representation of space

A closer look at two model components

- Person Day Activity Pattern
- Primary Family Priority Time

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Why microsimulate?

- use personal and household characteristics to explain choices
- measure policy impacts on flexibly defined population subsegments
- represent how choices for a day constrain travel choices
- capture effects of time and cost on a day's activity participation choices
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- include chained and non-home based trips realistically
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- (Need to consistently use all features for estimation and application)

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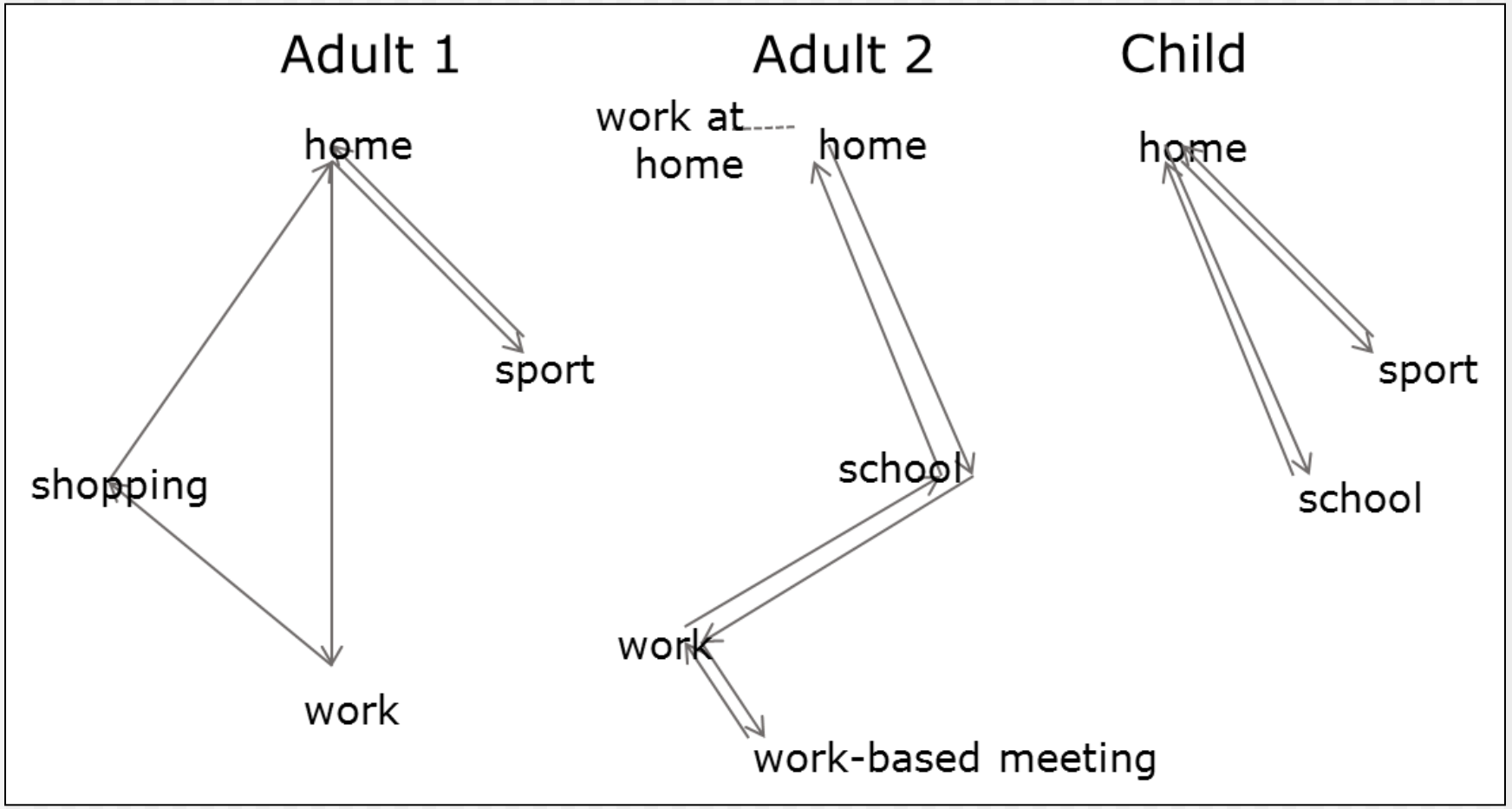
How?
Generate a synthetic population…

Household
Household income
Residence parcel id

Person
person type
age in years
gender
worker type
student type

…and use those characteristics in choice models that generate a schedule for each household.



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How?
Aggregate results in any way desired.

Household
Vehicles available
Household income
Residence parcel id

Person
person type
age in years
gender
worker type
usual work parcel id
student type
usual school parcel id
transit pass?
paid parking at workplace?

Tour
parent tour id
number of subtours
prim.dest.purpose
time leave tour origin
time larrive tour dest
time leave tour dest
time arrive tour origin
tour origin parcel
tour dest parcel
tour main mode
tour mode path type

Trip
tour half
trip# within half tour
trip origin purpose
trip dest purpose
trip origin parcel
trip dest parcel
trip mode
trip mode path type
trip driver or passenger
trip deparute time
trip arrival time
trip dest activity end time
network travel time
network travel cost
network travel distance

Household Day
PFPT participation
PFPT start time
PFPT duration

Person Day
Minutes worked at home

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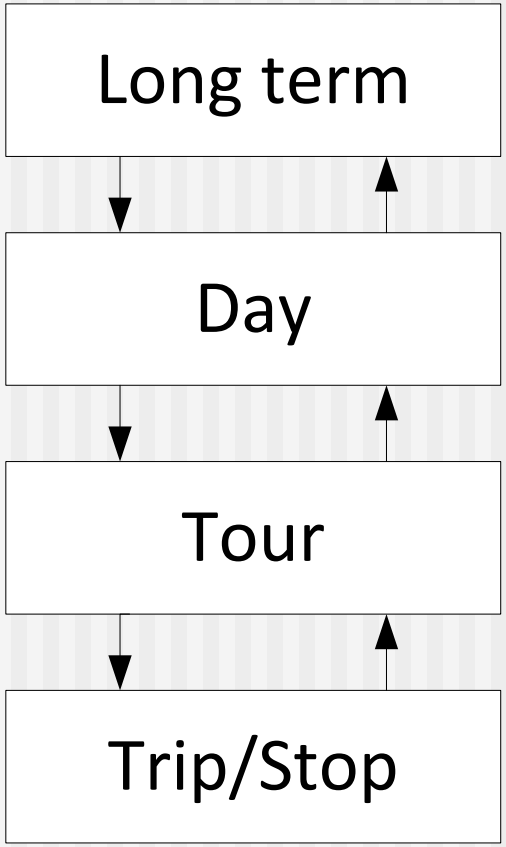
How?
An integrated system of choice models



Downward integration

Upward integration

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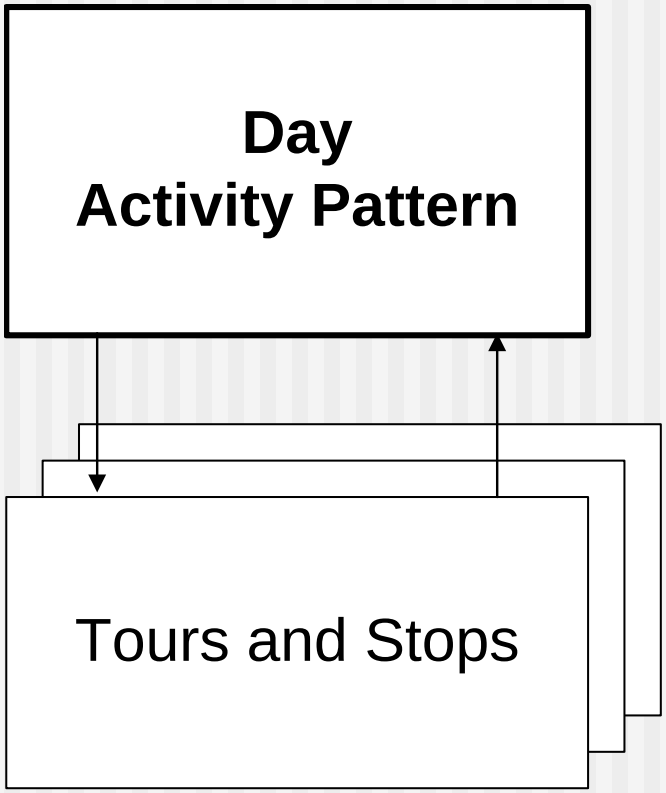
How?
Person Day Activity Pattern Model



- Model simultaneously
  - Presence of tour purposes
  - Presence of intermediate stop purposes
- Chosen combinations depend on
  - Personal characteristics
  - Household characteristics
  - Accessibility

Why microsimulate?

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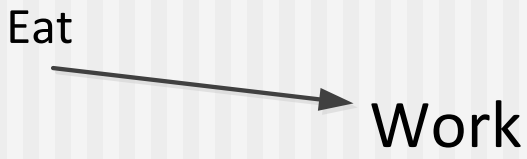
How?
Construct a trip chain for each half tour.

Work

Home

Start with known tour outcomes
--purpose
--destination
--main tour mode
--arrival and departure time periods
Model stops on each half tour

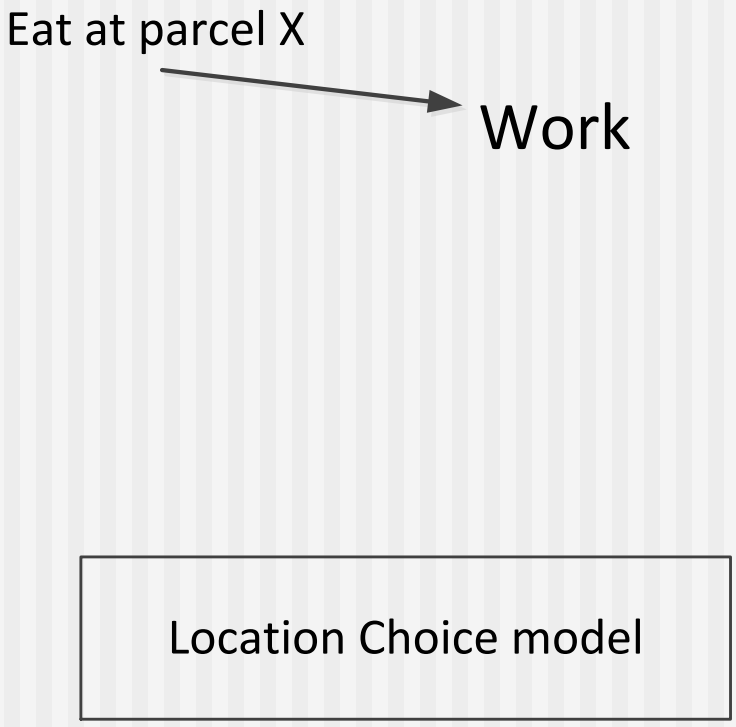
Generate a stop for some purpose (or not) ….



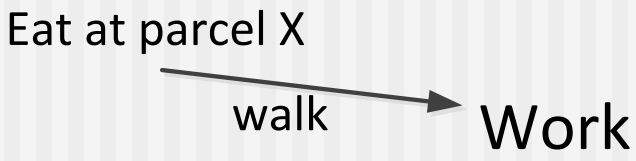
Home

Stop Generation model

…then the stop location…



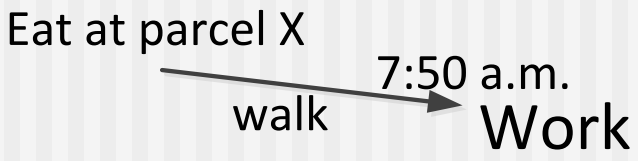
…then the trip mode…



Home

Mode Choice model

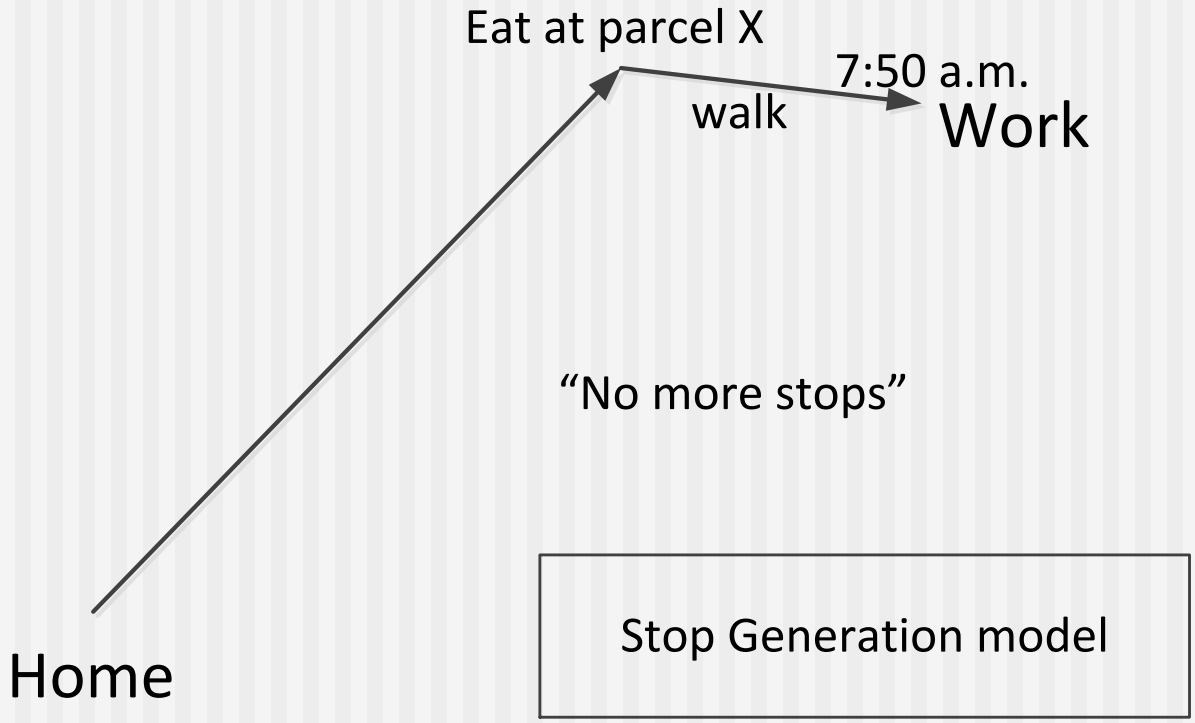
…and the arrival time.



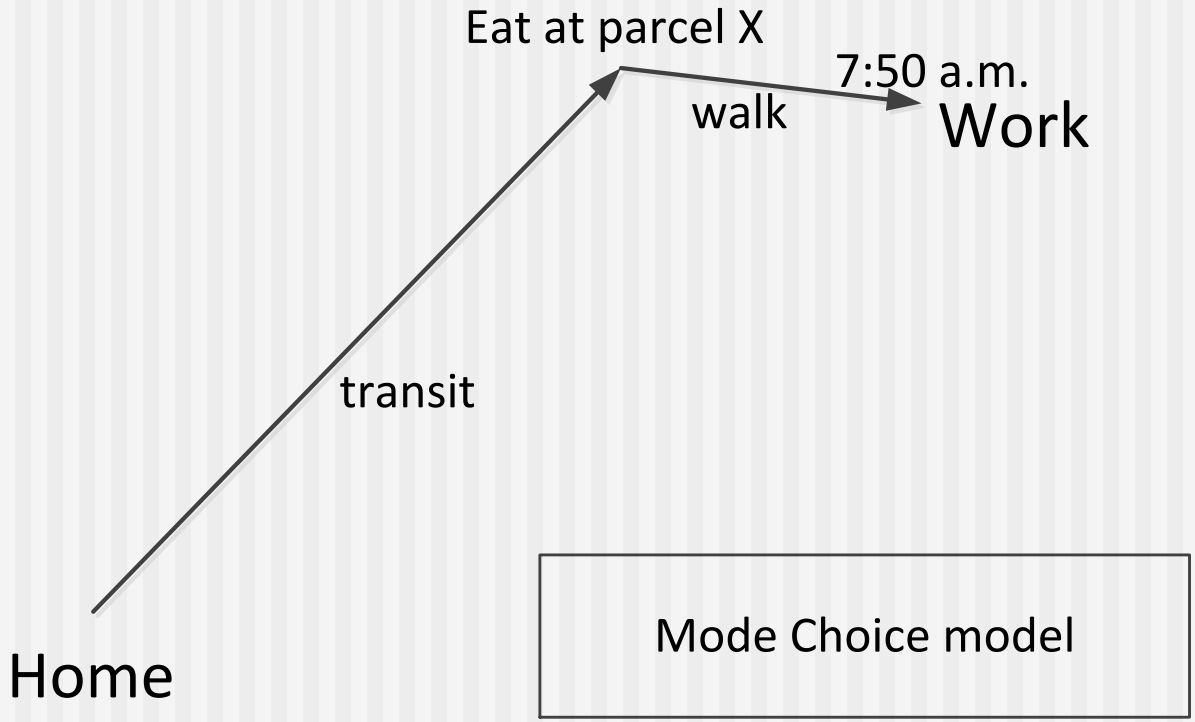
Home

Arrival Time Choice model

Generate another stop? (not this time)

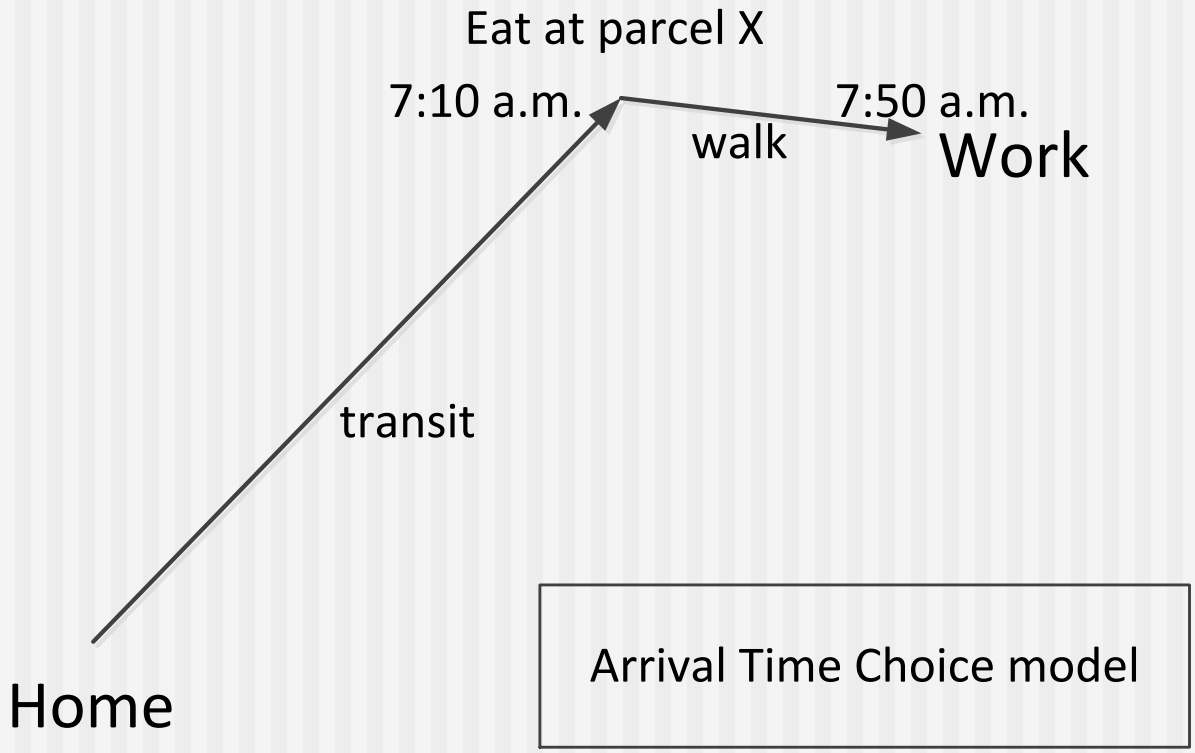


For the ‘last’ trip in the half tour model mode choice…



…and arrival time.

Then repeat for the second half tour



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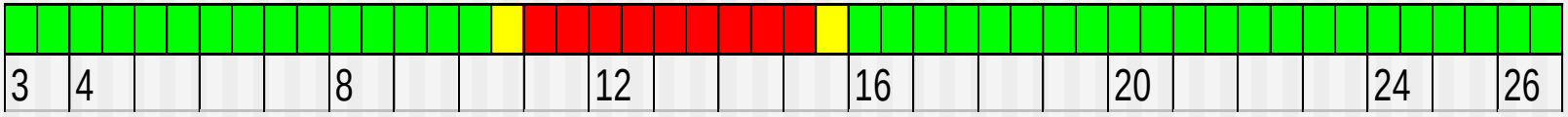
How?
Time of day choice models for tours and intermediate stops

- Arrival and duration shift variables
- Example effects
  - People shift travel to periods with shorter travel time
  - part time employees more likely to arrive at work later and have shorter work day

Likely outcome for FT employee

Likely outcome for PT employee



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How? Rigorous time window accounting

- When something is scheduled its time span is occupied
- Tight schedules affect choices
  - Hard constraints: infeasible alternatives are ruled out
  - Soft constraints: feasible alternatives causing tight schedules are less attractive

Simulation Event	Occupied time spans
Work tour scheduled	**7:53 AM to 4:47 PM**
No stop on way to work scheduled	**7:04 AM** to 4:47 PM
Stop on way home scheduled	7:04 AM to **5:30 PM**
No other stop on way home scheduled	7:04 AM to **6:05 PM**
Tour to eat out scheduled	7:04 AM to 6:05 PM **7:30 PM to 9:15 PM**
No stop on way to eat out scheduled	7:04 AM to 6:05 PM **7:15 PM** to 9:15 PM
No stop on way home scheduled	7:04 AM to 6:05 PM 7:15 PM to **9:30 PM**

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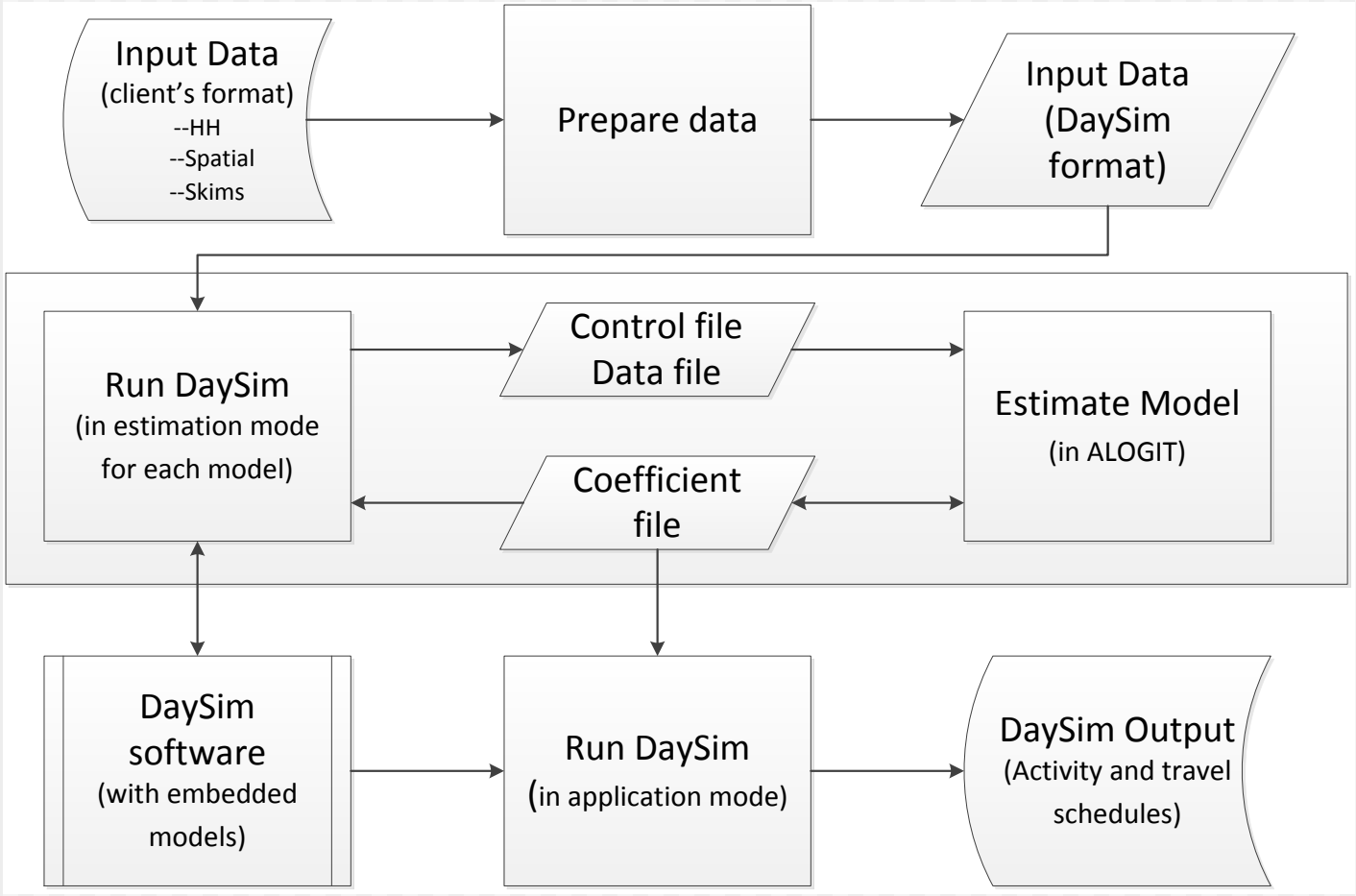
How?
Software code that supports model estimation and application



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How AB models are designed to achieve the desired benefits

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- Model household interactions explicitly
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Why model household interactions explicitly?

- Yields coherent travel choices among household members

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- At-home family activities correlate with travel choices

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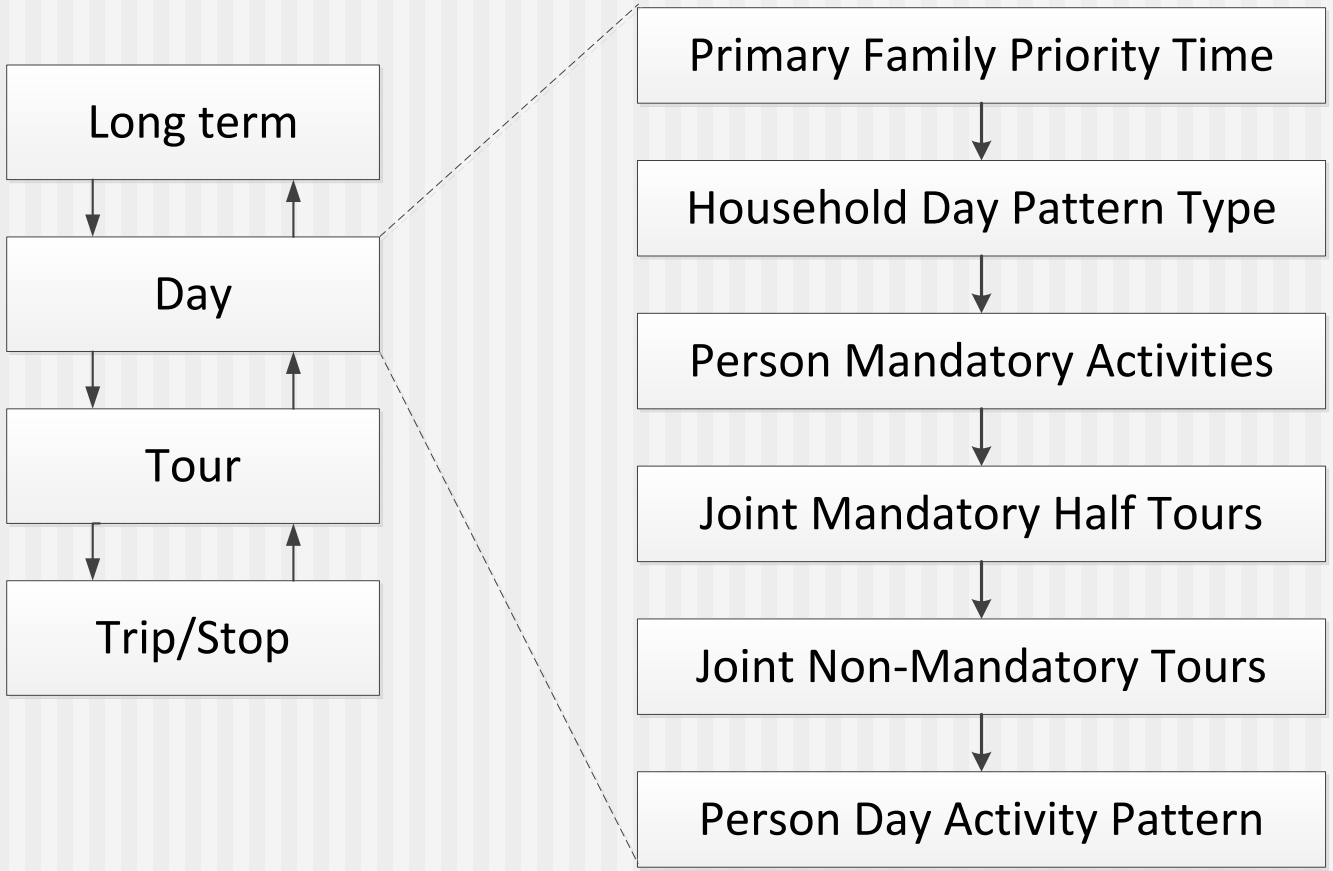
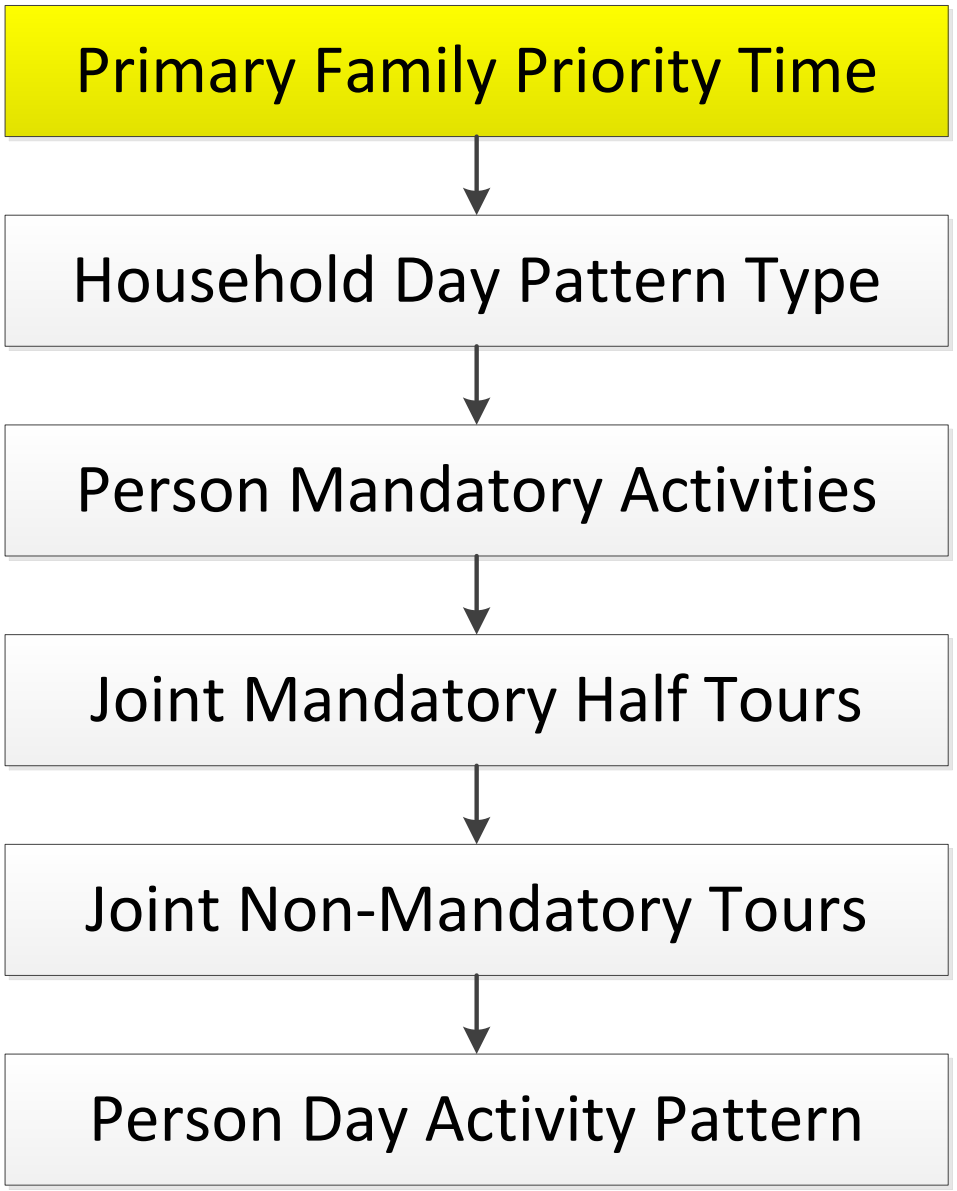
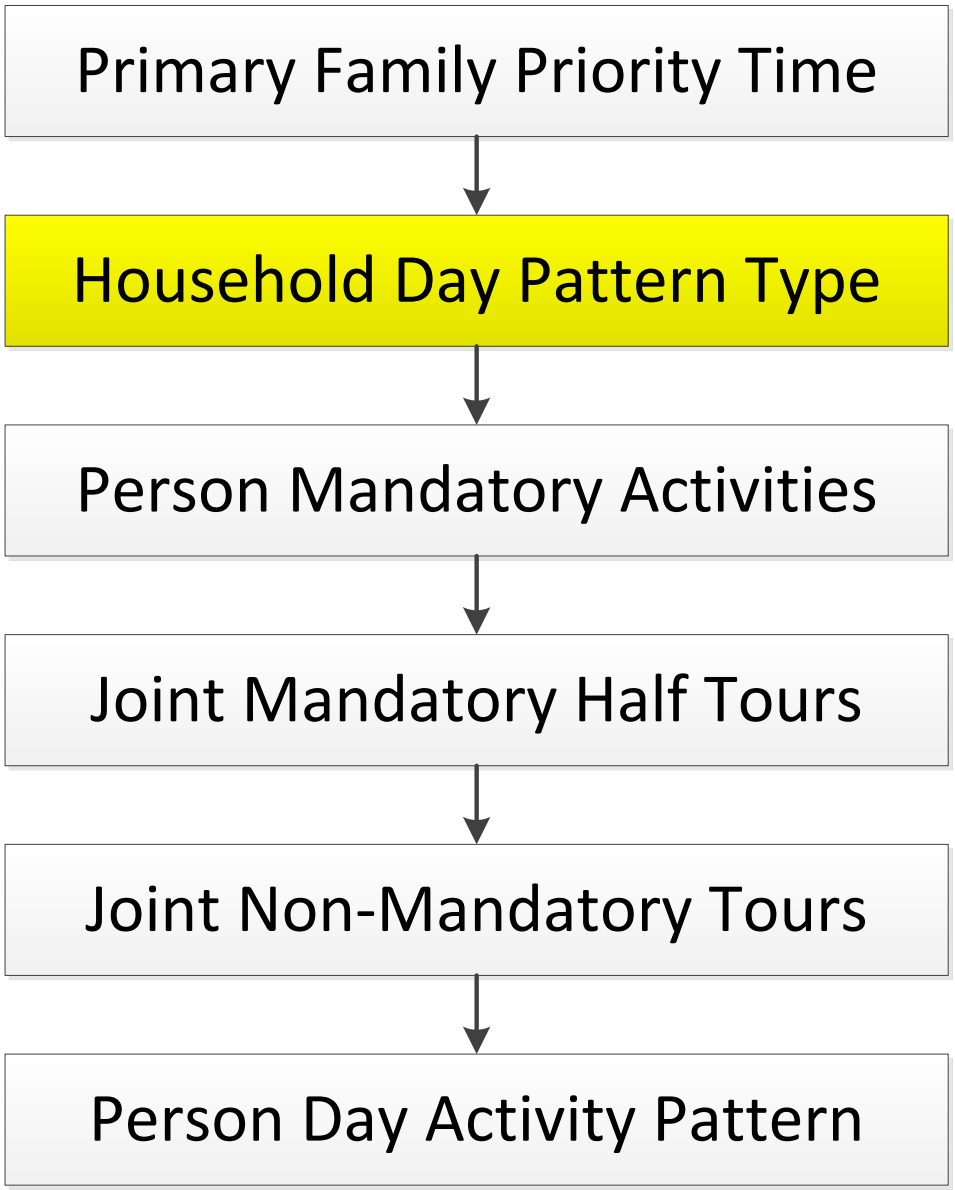
- Can represent joint activity and travel
- Joint travel impacts responsiveness to transport policies
- At-home family activities correlate with travel choices
- Joint decisions constrain and influence individual choices

How?
Household Day Activity Pattern

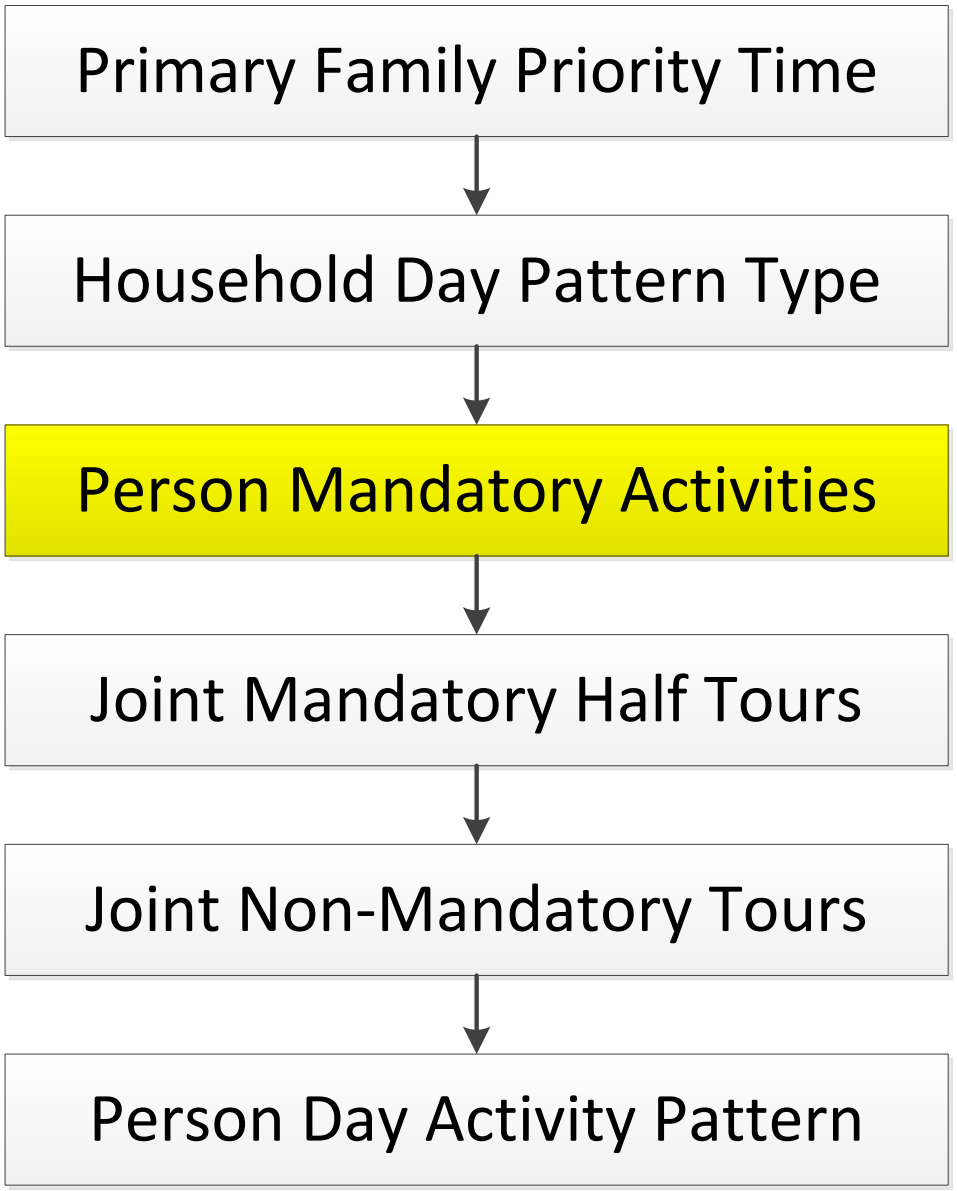




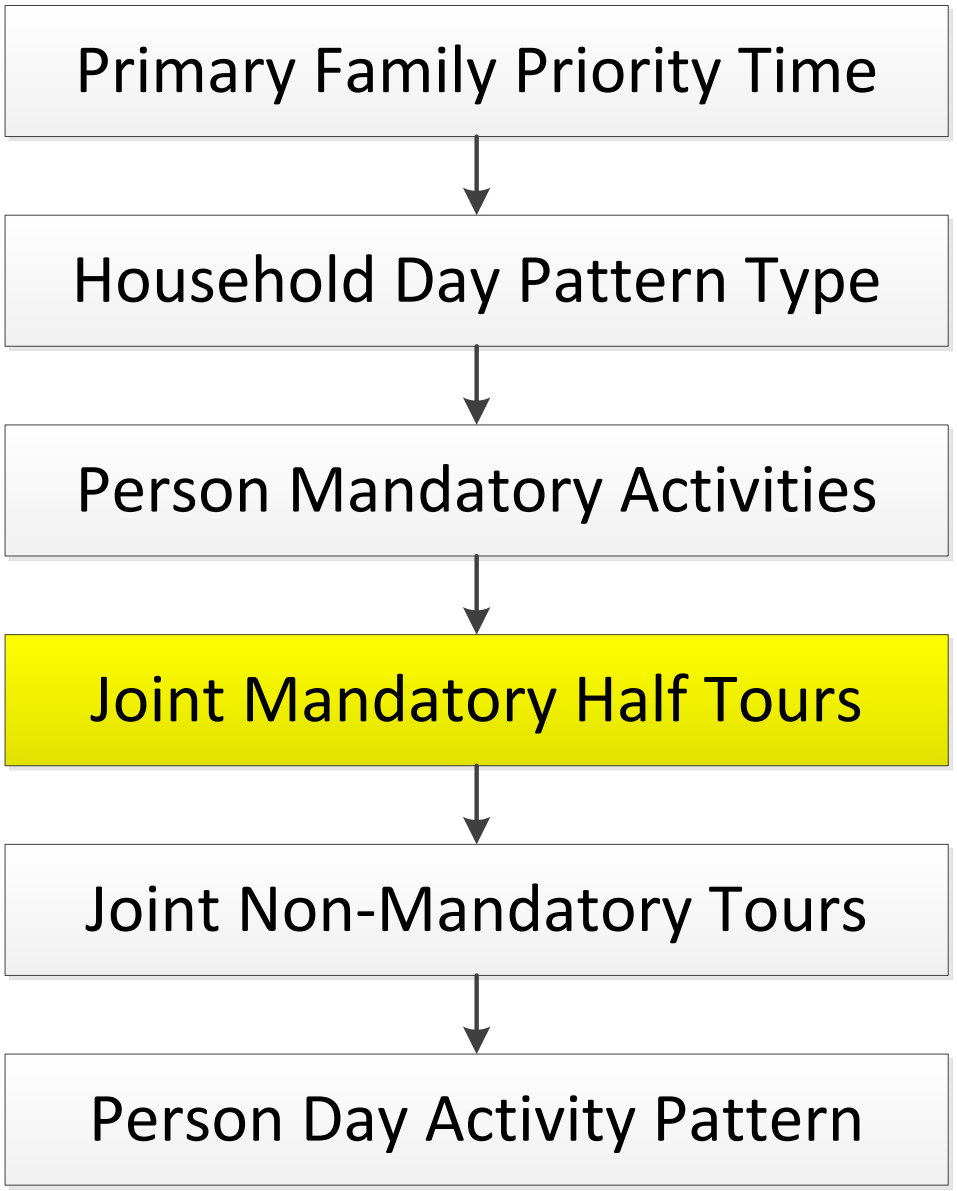
- Vuk et al (2013)
- Participation Model
  - Shared at-home activity
- Schedule Model
  - Start minute and duration minutes



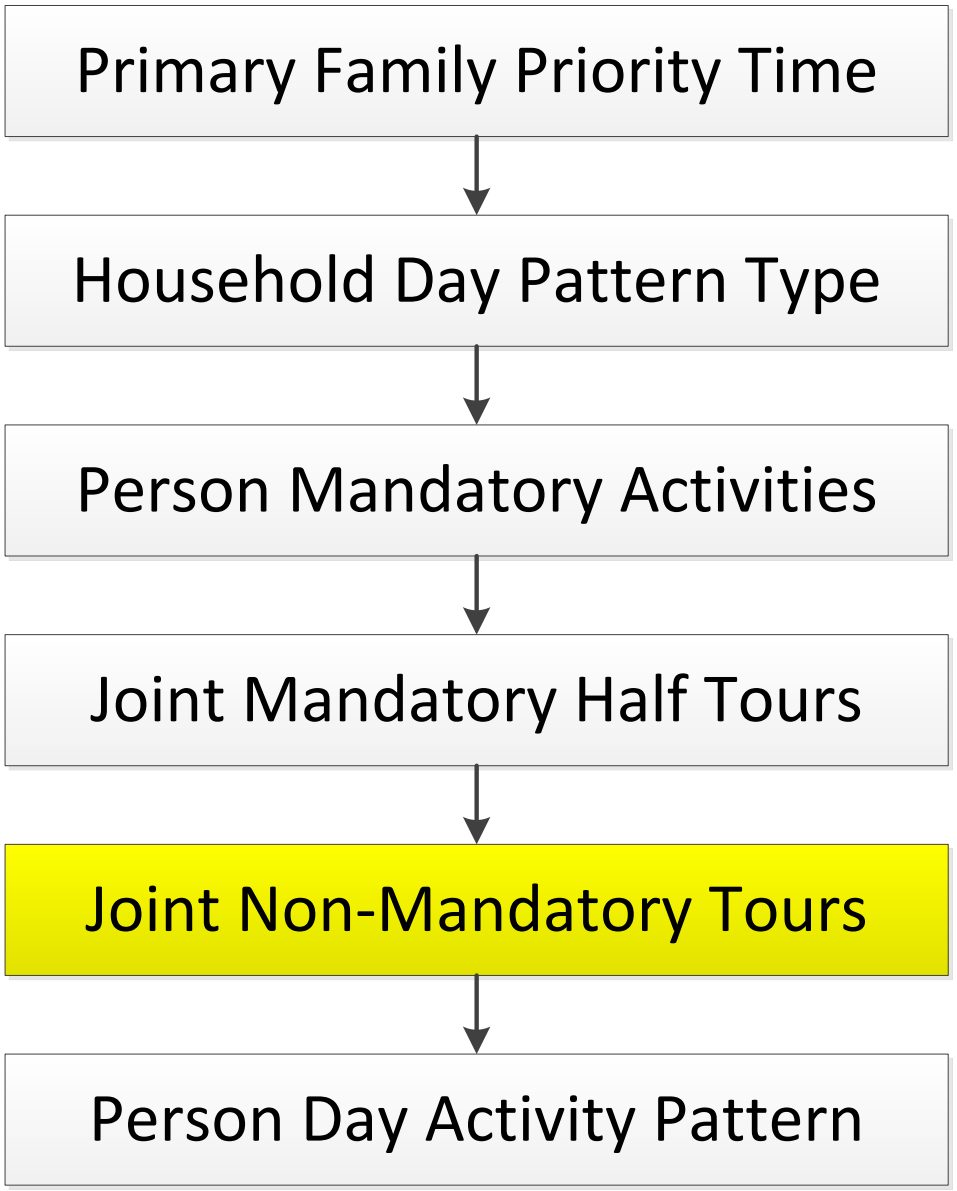
- Based on Bradley & Vovsha (2005)
- Joint for up to five HH members
- Up to three pattern type alternatives per person



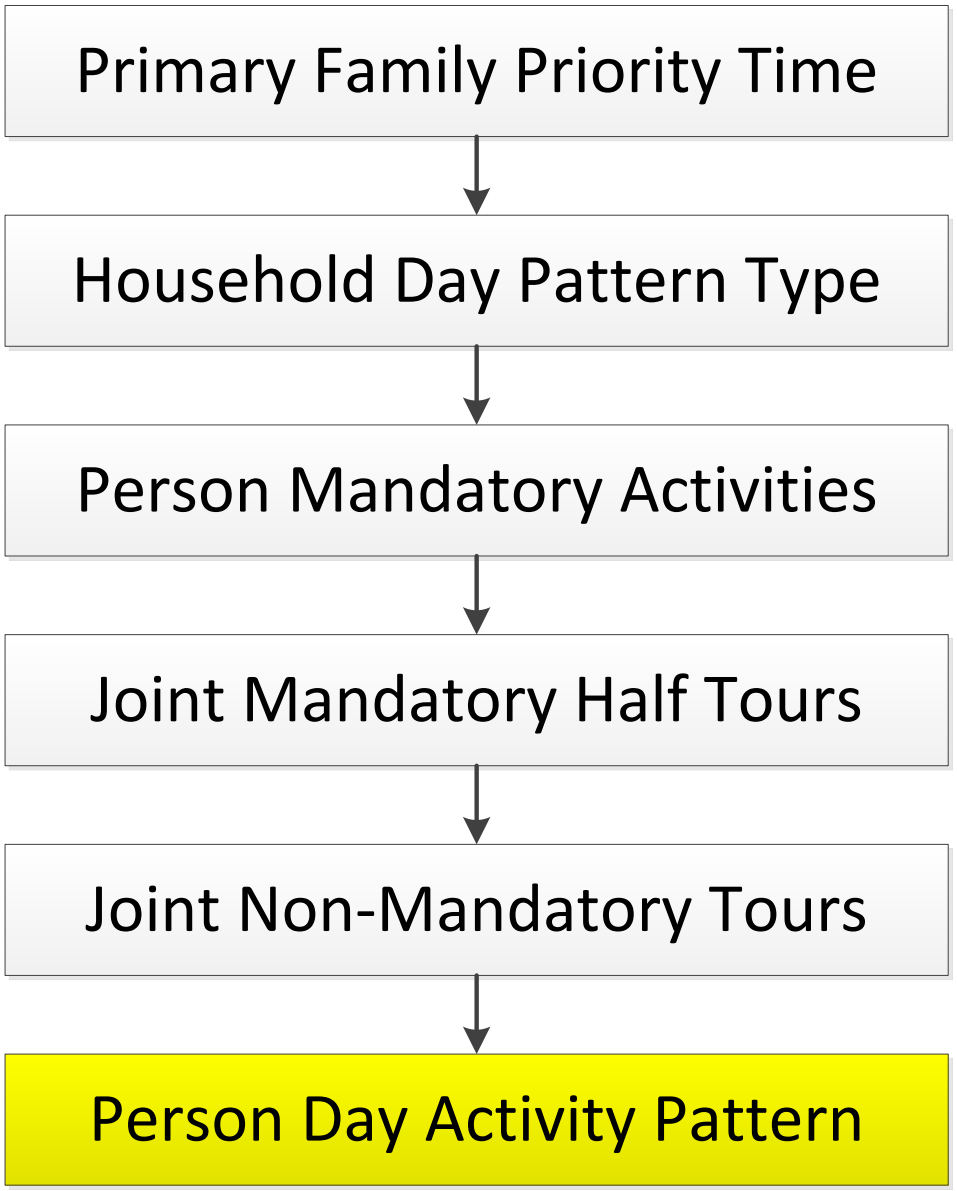
- Work at Home Model
- Mandatory Tour Generation Model
- Mandatory Stop Presence Model



- Shared travel to work and school
- Joint Half Tour Generation Model
  - Fully joint or partially joint
- Participation Model
  - Jointly for up to five persons



- Shared travel for non-mandatory activity
- Joint Tour Generation Model
- Participation Model
  - Jointly for up to five persons



- Person Day Pattern Model
  - Presence in day of…
    - tour purposes
    - intermediate stop purposes
- Tour Generation Model
  - Exact number of tours for each purpose

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Why use a fine-grained representation of space?

- measure attractiveness better for location choice
- capture neighborhood effects on location choices
- include the impact of true walk distances in travel choices
- model short intra-zonal travel choices better
- represent transit alternatives more accurately in mode choice
- Handle bicycle and walk modes as effectively as cars and transit

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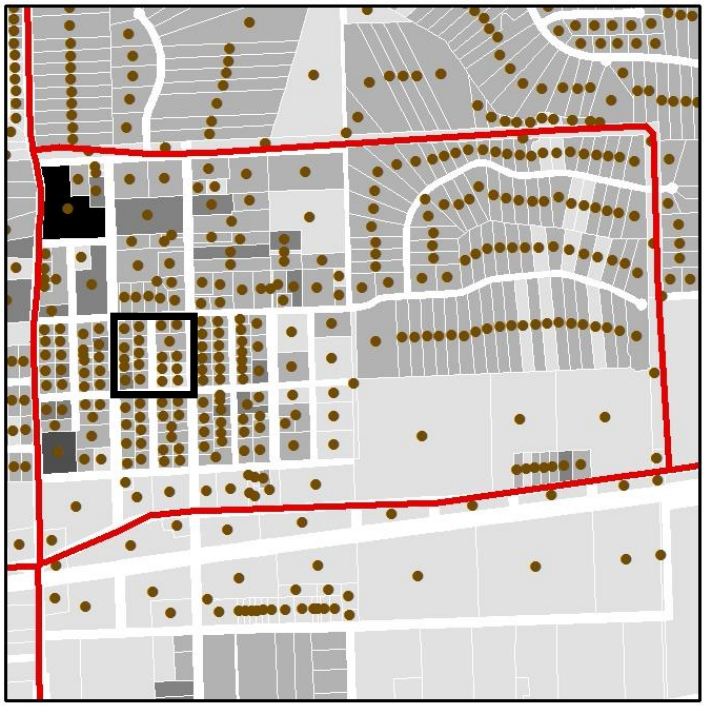
How?
Use parcels or microzones for destination choice.

- Parcel attributes include:
  - Location
  - Area
  - Housing units
  - Enrollment by school type
  - Employment by sector
  - Transportation network access
  - Urban form measures
  - Offstreet parking



Ex. TAZs, microzones and parcels

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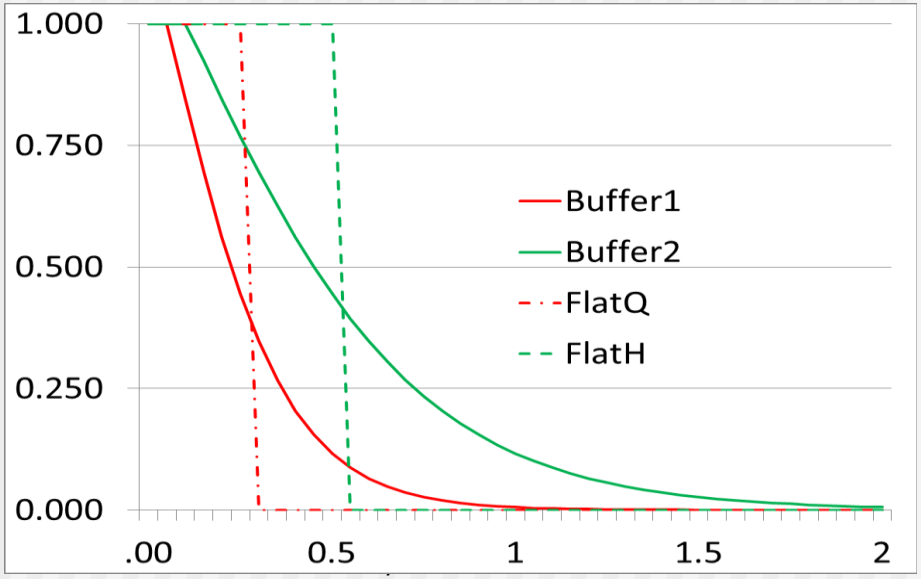
How?
Measure attributes in neighborhood of parcel or microzone centroid

- Attributes buffered
  - Housing units
  - Employment by sector
  - School enrollment
  - Street intersections by type (dead end, 3-way, 4-way)

Distance decay weighting function



Meal Tour Destination Choice Model (PSRC)

Attribute	Parcel size effect (relative to base)	Neighborhood effect (coefficient)
Food employment	1.000	0.261
Retail employment		0.010
Service employment		-0.190
Total employment	Tiny	
Households	Tiny	

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How?
Use all-streets network to measure impedance for short trips

- Associate each parcel (or microzone) and transit stop with its nearest node
- Calculate shortest network paths between all node pairs less than 2-3 miles apart
- Use for impedance calculations
  - instead of zone-to-zone impedance for walk and short bike trips
  - for transit walk access and egress times
  - rescale zone-to-zone auto impedance for short trips
- Use for weighting in the parcel (or microzone) buffer calculations

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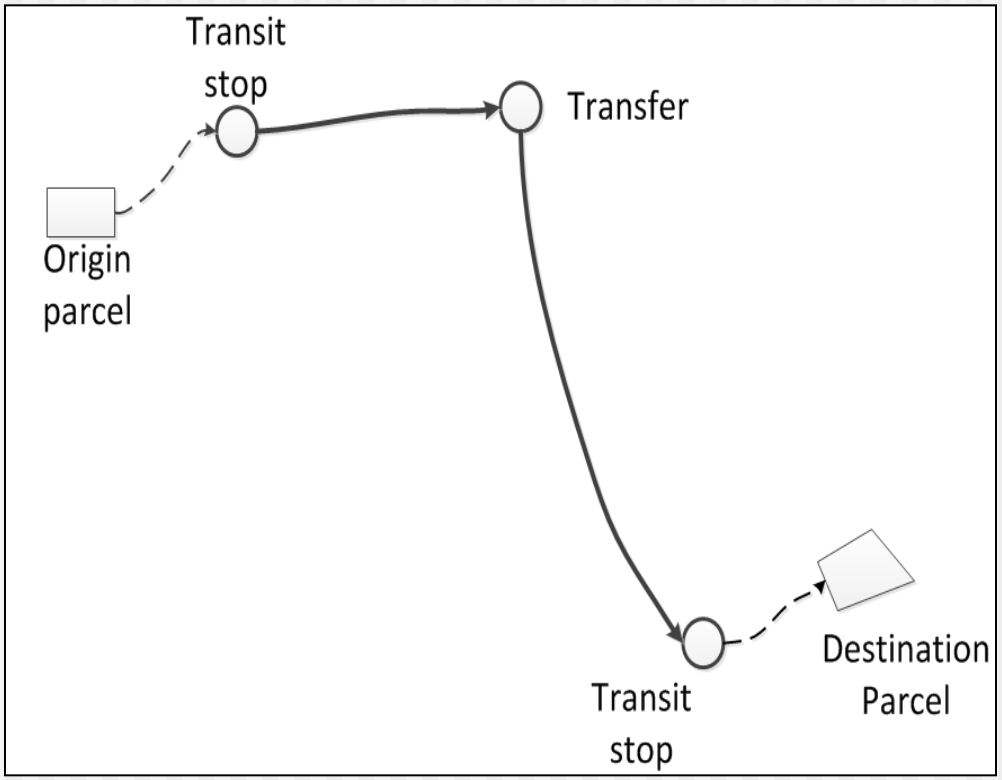
How?
measure transit impedance using stop areas instead of zones

- Walk access and egress impedance: parcel-to-stop using Enhanced short distance calculation
- Transit impedance from boarding stop to alighting stop
- AB model chooses best combination of transit stops



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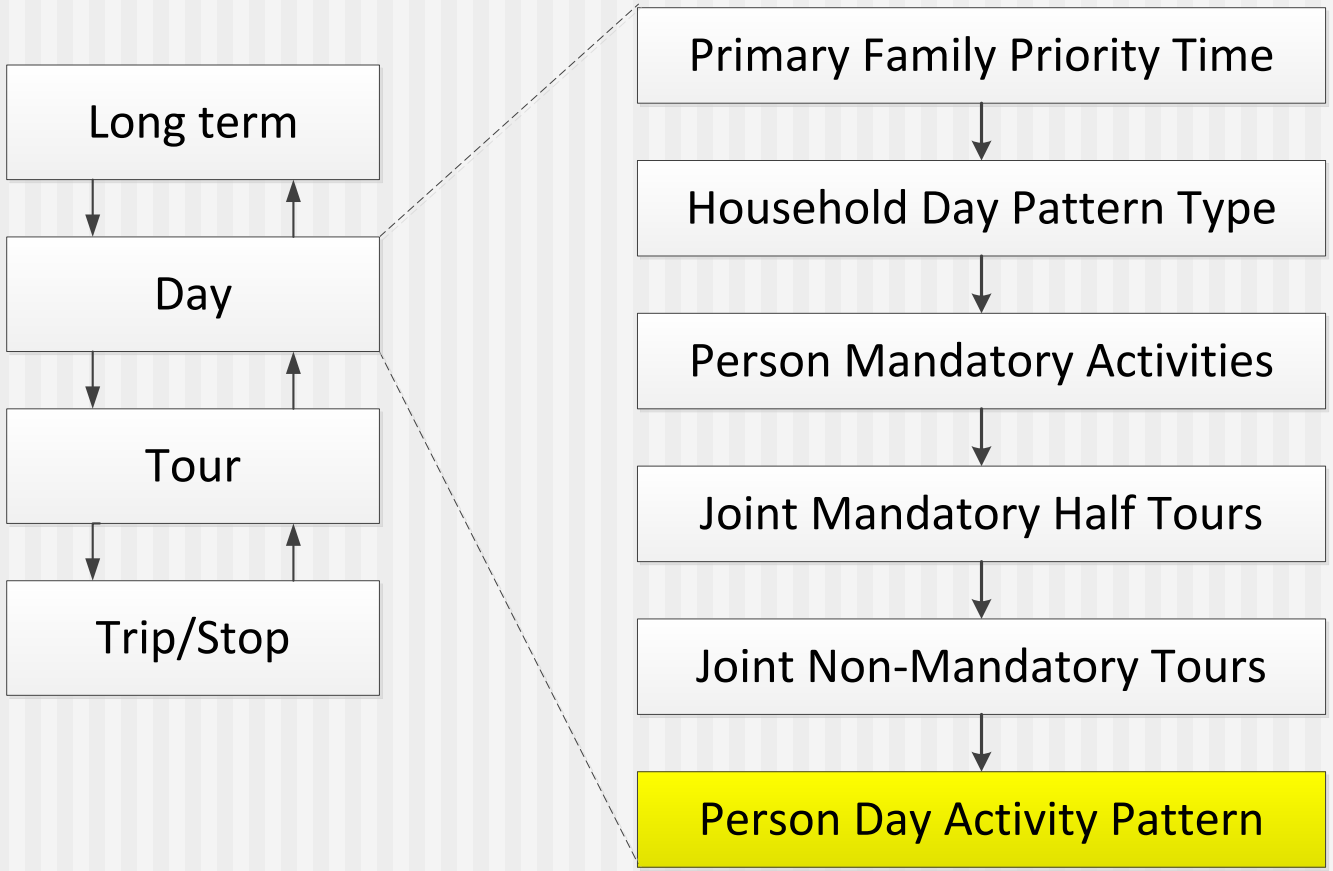
How?
Bicycle route choice model (a newly emerging capability)

- Route choice model
  - use all-streets network
  - with bicycle-specific attributes for disaggregate bike route choice model
    - Link type (wide cycle track, narrow cycle track, lane, etc)
    - Cumulative elevation gain
    - Motorized volumes and speeds (or proxies)
    - Bicycle intersection provisions (eg: automatic signal activation; green wave signal timing)
    - Number of stops and turns
- Use route choice logsum in mode choice model

A closer look at two model components

- Person Day Activity Pattern
- Primary Family Priority Time

Person Day Activity Pattern



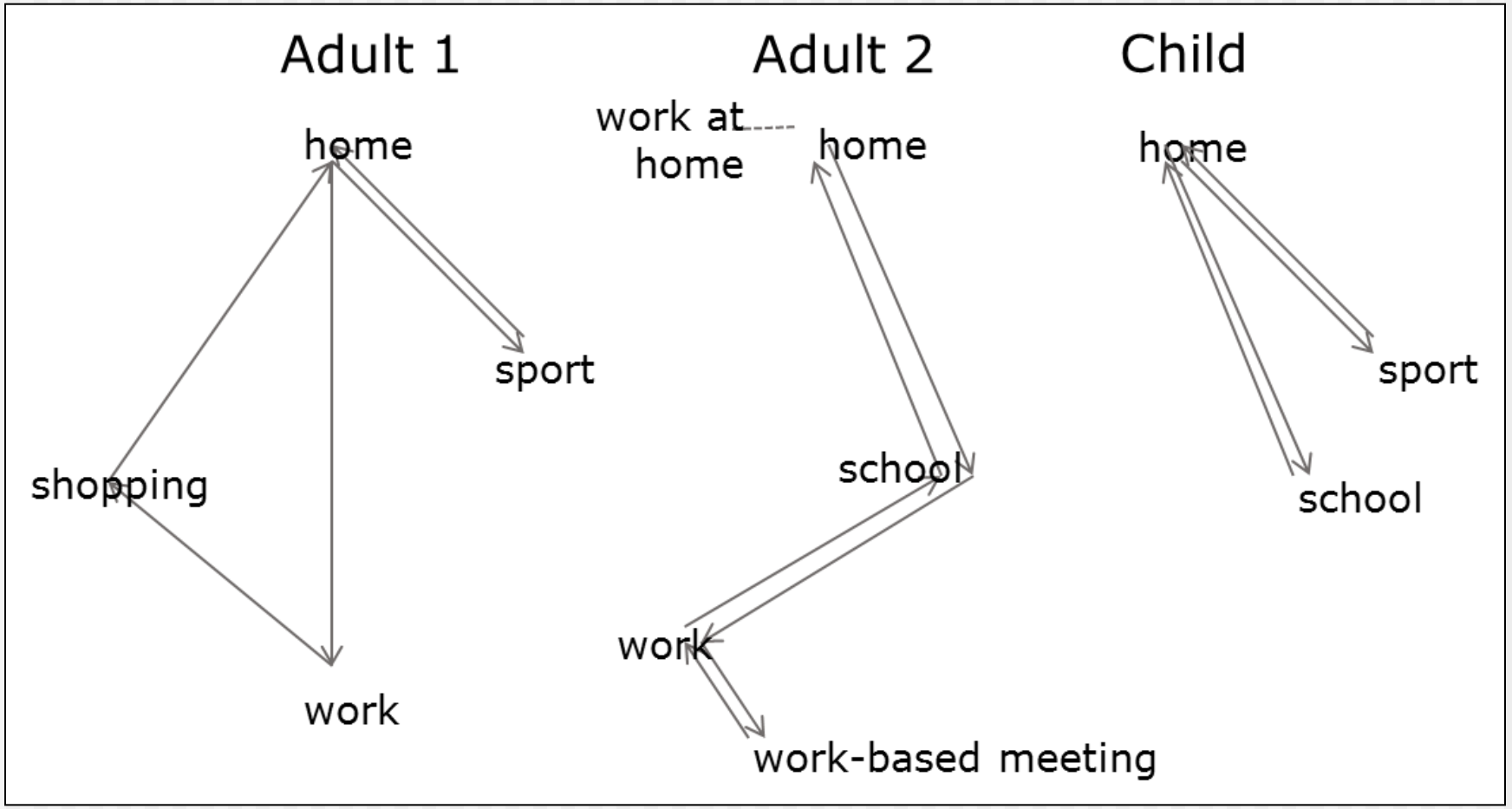
Person Day Pattern

- Presence or absence in day of…
  - tours for each purpose
  - intermediate stops for each purpose
- Purposes:
  - Work, business, school
  - Escort, personal business, shop, meal, social, recreation, medical

Choice Set (Seattle) has 3051 alternatives

- Include combinations of:
  - 7 binary tour purpose variables
  - 7 binary stop purpose variables
  - This would yield 2^14 = 16384 alternatives
- Remove extremely rare combinations:
  - Number of tour purposes > 3
  - Number of stop purposes > 4
  - Number tour purposes plus number stop purposes > 5
- Allows interactions between tours, stops and purposes to be modeled explicitly

Example Household Day

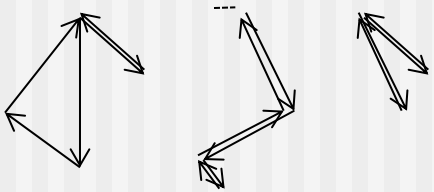


Conditioning Values: Household and Persons

Household	
Vehicles available	1
Household income	150K
Residence parcel id	11111

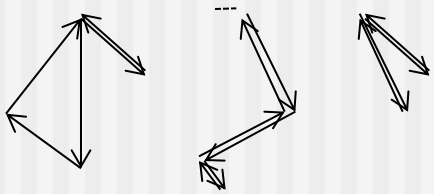
Person	Adult 1	Adult 2	Child
person type	FT Worker	PT Worker	Child 5-15
age in years	41	40	12
gender	Male	Female	Female
worker type	FT	PT	null
usual work parcel id	22222	33333	null
student type	nonstudent	nonstudent	Student
usual school parcel id	null	null	44444
transit pass	No	No	No
paid parking at workplace	No	No	null

Conditioning Values: Household Day



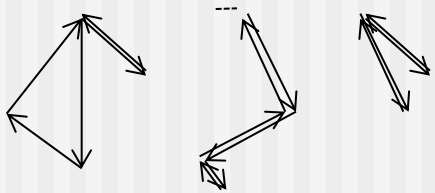
HouseholdId	10
JointTours	1
PartialHalfTours	2
FullHalfTours	0
StartingMinuteSharedHomeStay	18:00
DurationMinutesSharedHomeStay	50
PrimaryPriorityTimeFlag	TRUE

Conditioning Values: Joint Tour



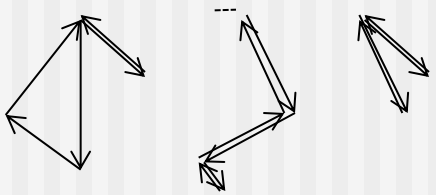
HouseholdId	10
Sequence	1
MainPurpose	Social
Participants	2
PersonSequence1	1
TourSequence1	2
PersonSequence2	3
TourSequence2	2
PersonSequence3	
TourSequence3	
PersonSequence4	
TourSequence4	
PersonSequence5	
TourSequence5	

Conditioning Values: Person Days



	Adult 1	Adult 2	Child
HouseholdId	10	10	10
PersonSequence	1	2	3
HomeBasedTours	TRUE	TRUE	TRUE
WorkBasedTours			
UsualWorkplaceTours	1	1	0
WorkTours	1	1	0
BusinessTours	0	0	0
SchoolTours	0	0	1
EscortTours			
PersonalBusinessTours			
ShoppingTours			
SocialTours	TRUE		TRUE
BusinessStops	0	TRUE	0
SchoolStops	0	0	0
EscortStops			
PersonalBusinessStops			
ShoppingStops			
SocialStops			
WorkAtHomeDuration	0	120	0
PatternType	Mandatory	Mandatory	Mandatory

Modeled Outcomes: Person Days



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ShoppingTours	0	0	0
SocialTours	TRUE	0	TRUE
BusinessStops	0	TRUE	0
SchoolStops	0	0	0
EscortStops	0	0	0
PersonalBusinessStops	0	0	0
ShoppingStops	TRUE	0	0
SocialStops	0	0	0
WorkAtHomeDuration	0	120	0
PatternType	Mandatory	Mandatory	Mandatory

Summary Estimation Results

Number observations	17353
Number alternatives	3051
Estimated Coefficients	**364**
Likelihood (0)	-120337
Likelihood (C)	-61203
Likelihood (Final)	-50180
Rho-Squared (w.r.t. C)	**.180**
Rho-Squared (w.r.t. 0)	.583

Utility Term Categories

Category	Example
Activity Purpose Presence	Dummy for Full Time Worker with shopping **tour(s) and/or stop(s)**
Tour Purpose Presence	Mixed use density for pattern with **one or more tours** of any purpose
Stop Purpose Presence	Constant for presence of **one or more** social **stops**
Ln(# tour purposes)	**Log(number tour purposes)** for a retired person
Ln(# stop purposes)	**Log(number stop purposes)** for female with children under 5
Tour and Stop Combos	Constant for pattern with one or more work tours and one or more escort stops

Estimated Coefficients

	Activity Purpose Presence*	Tour Purpose Presence	Stop Purpose Presence	Ln(# tour purposes)	Ln(# stop purposes)	Tour and Stop Combos
Constants		7	7			116
Person characteristics	71	1	2	13	13	
Household characteristics	77	1	1	11	11	
Neighborhood characteristics		2	2	2	2	
Day				2	2	
Logsums						10
Nuisance**	7					

*Activity purpose is present if there is at least one tour or intermediate stop with that purpose
**For diaries completed by a proxy

Logsums on **work days**

	Patterns with additional tour purpose(s)		Patterns with intermediate stops	
	Tour Coeff	(T stat)	Stop Coeff	(T stat)
Work tour mode choice logsum	-0.014	(-0.66)	0.036	(2.13)
At-home mode-destination logsum	0.042	(2.17)	0.033	(2.30)

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Logsums on **school days**

	Patterns with additional tour purpose(s)		Patterns with intermediate stops	
	Tour Coeff	(T stat)	Stop Coeff	(T stat)
School tour mode choice logsum	-0.014	(-0.19)	0.627	(7.74)
At-home mode-destination logsum	0.090	(3.84)	-0.007	(-0.37)

Logsums on **school days**

	Patterns with additional tour purpose(s)		Patterns with intermediate stops	
	Tour Coeff	(T stat)	Stop Coeff	(T stat)
School tour mode choice logsum	-0.014	(-0.19)	0.627	(7.74)
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Logsums on **on-tour non-commute days**

	Patterns with additional tour purpose(s) Tour Coeff (T stat)	Patterns with intermediate stops Stop Coeff (T stat)
At-home mode-destination logsum	0.077 (4.61)	0.000 (0.02)

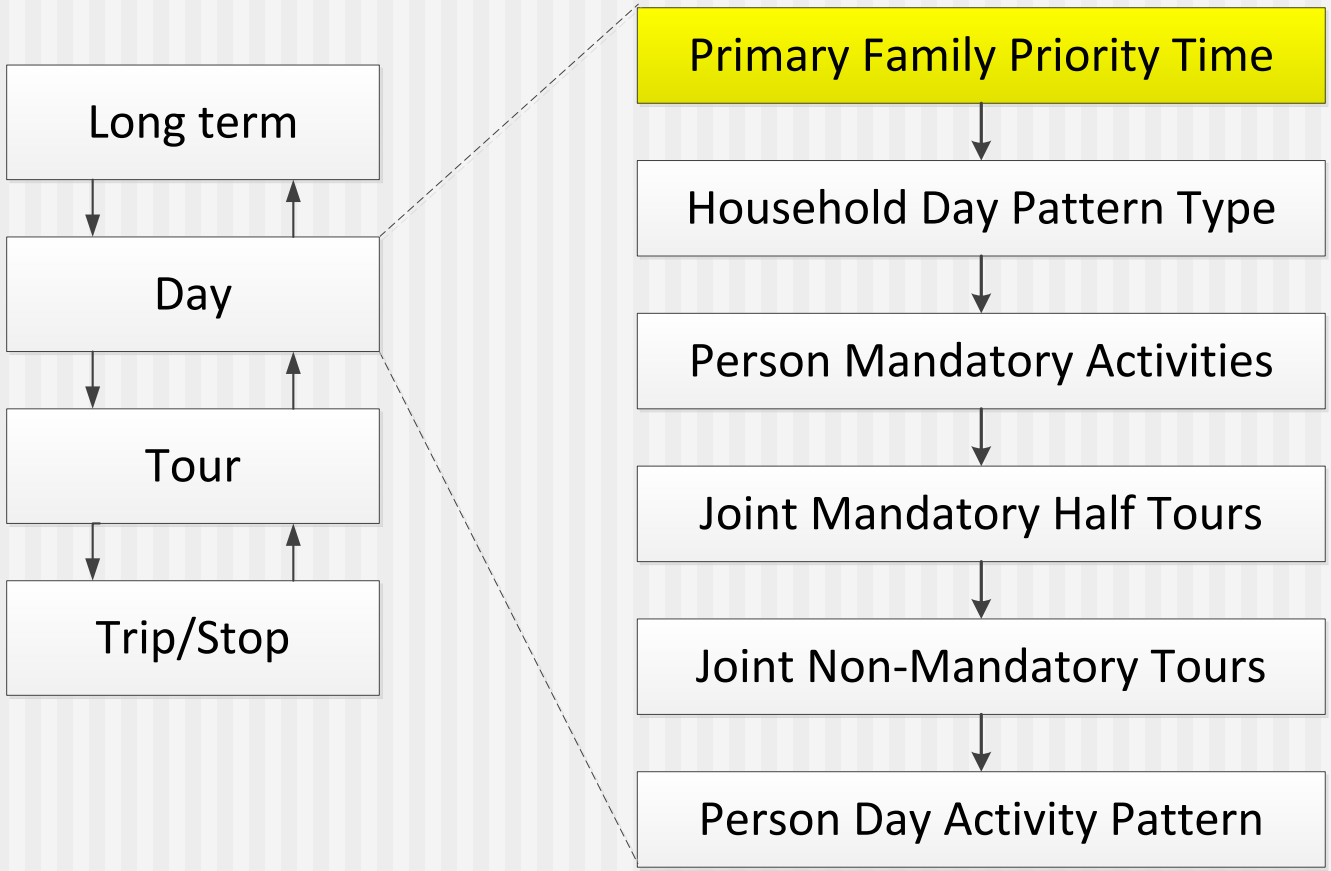
Logsums on **on-tour non-commute days**

	Patterns with additional tour purpose(s)		Patterns with intermediate stops	
	Tour Coeff	(T stat)	Stop Coeff	(T stat)
At-home mode-destination logsum	0.077	(4.61)	0.000	(0.02)

A closer look at two model components

- Person Day Activity Pattern
- Primary Family Priority Time

Primary Family Priority Time (Vuk, et al, 2013, Copenhagen)



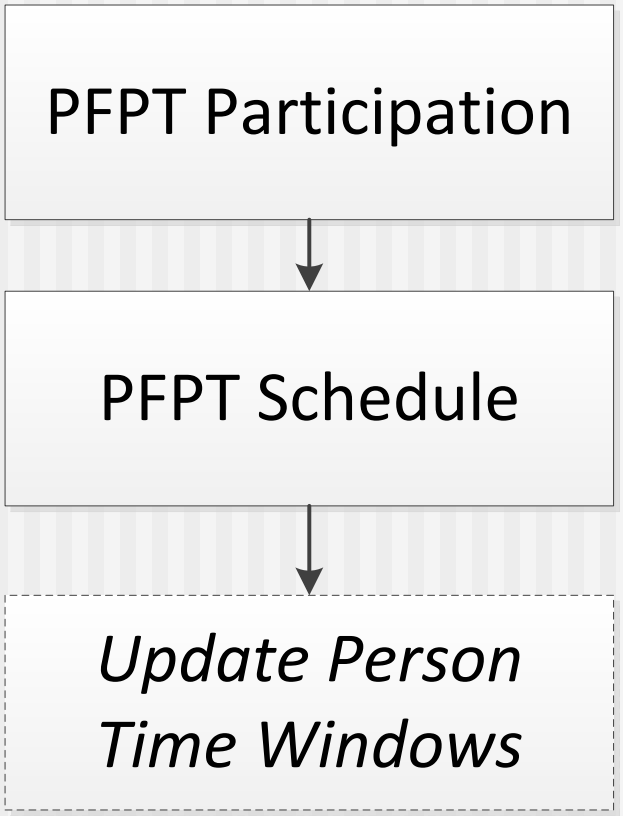
PFPT Definition

- Shared at-home activity
- All members of household
- At least 20 minutes
- Purpose other then work, school, commerce

Rationale for PFPT model

- family life implies that family members might like to spend time together
  - and to prioritise this time, i.e. schedule other activities around it
  - e.g. work schedules
  - seems particularly important in Denmark

PFPT Implementation



- Participation Model
  - Binary choice
- Schedule Model
  - Start time and duration
- The updated time windows constrain subsequent choices

Copenhagen data

- Travel survey data has been collected for 20+ years
  - diary of travel by one person per household in a weekday
- extended survey was needed to include whole household
  - asked about activities at home with other household members
  - 2209 persons in 801 households

PFPT Participation Summary Statistics

Number observations	644
Degrees of freedom	14
Rho squared (w.r.t. 0)	0.499
Rho squared (w.r.t. constants)	0.446

Dummy Variables

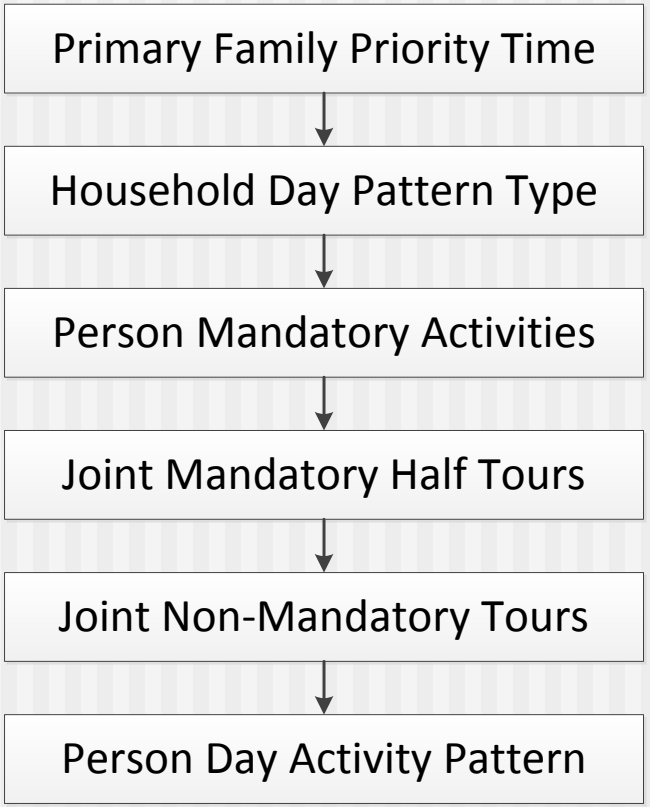
Variable (PFPT alternative)	Coeff	T Stat
Constant	-1.691	-4.00
HH size 3	-1.128	-3.20
HH size 4+	-1.409	-3.58
Pre-school children	1.087	3.41
One adult + school children	1.116	2.88
Two adults, both working	1.780	4.15
Two adults, one with high education	3.513	10.68
Two adults, one car	-0.434	-1.53
Two adults, 2+ cars	-0.847	-1.89
HH income 3-600,000 DKK	0.613	1.52
HH income 6-900,000 DKK	0.334	0.76
HH income over 900,000 DKK	-0.170	-0.35

Logsums—accessibility to workplaces increases likelihood of PFPT

Variable (PFPT alternative)	Coeff	T Stat
Work tour mode choice logsums for up to two workers	0.122	1.44
At-home mode-dest logsum for nonworking household	-0.002	-0.07

PFPT Effects in Subsequent Model Components

- **Time window constraints**—travel activities can't occur during time reserved for PFPT
- PFPT households more likely to **travel together to work and school**
- PFPT households more likely to conduct **joint tours for shopping and social purposes**



Outline:
How AB models are designed to achieve the desired benefits

- Microsimulate an entire day for each person
- Model household interactions explicitly
- Use a fine-grained representation of space

A closer look at two model components

- Person Day Activity Pattern
- Primary Family Priority Time

Collaborators in US AB Model Development

- Mark Bradley
- Resource Systems Group (Vermont)
  - Joe Castiglione
  - others
- DKS Associates (Sacramento)
  - John Gibb
  - John Long
- Public agency clients

Collaborators in Copenhagen (DTU Actum Research Project)

- Goran Vuk (Danish Road Directorate)
- Christian Overgård Hansen (DTU)
- Andrew Daly and Stephane Hess (Leeds University)
- Resource Systems Group

Questions?