EVOLUTION OF MODELING METHODS AND SOFTWARE FROM THE PAST TO THE PRESENT

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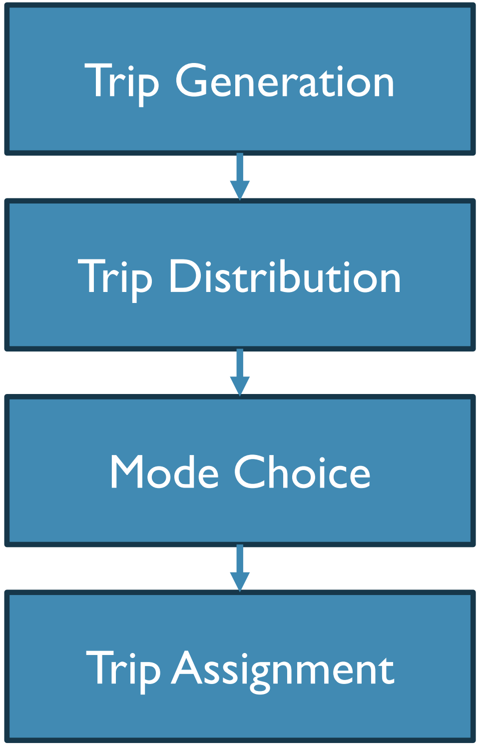
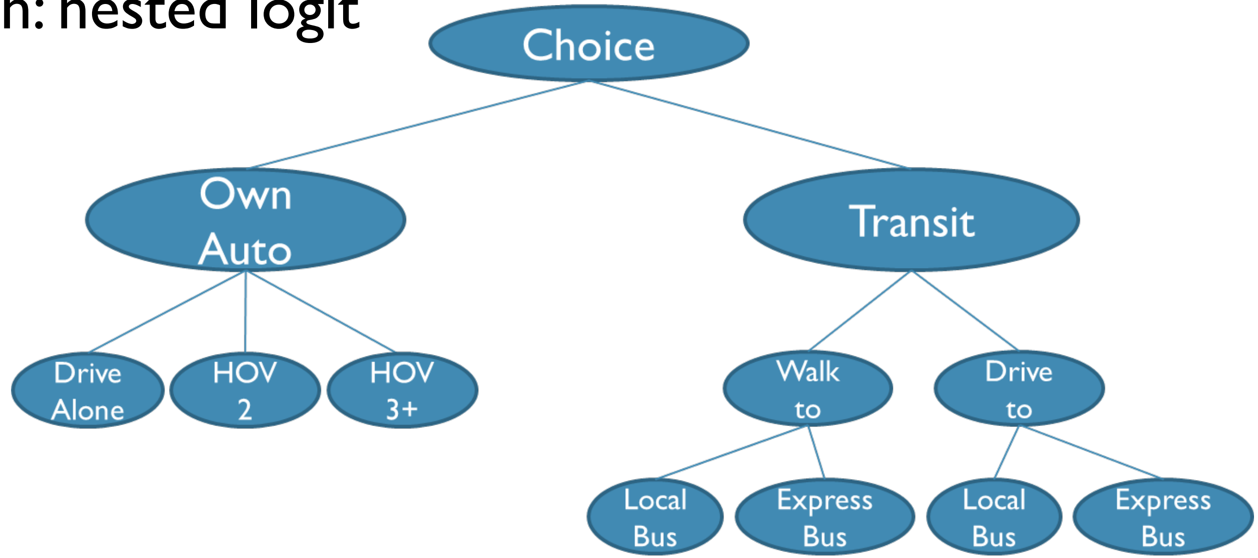
IN THE BEGINNING…

- There was UTPS – FHWA's mainframe software (1970s)
  - Standard "Four-Step" model:
  - Trip Generation
    - Cross-classification
    - Regression
  - Trip Distribution
    - Gravity
  - Mode Choice
    - Multinomial Logit
  - Trip Assignment
    - Frank-Wolfe User Equilibrium



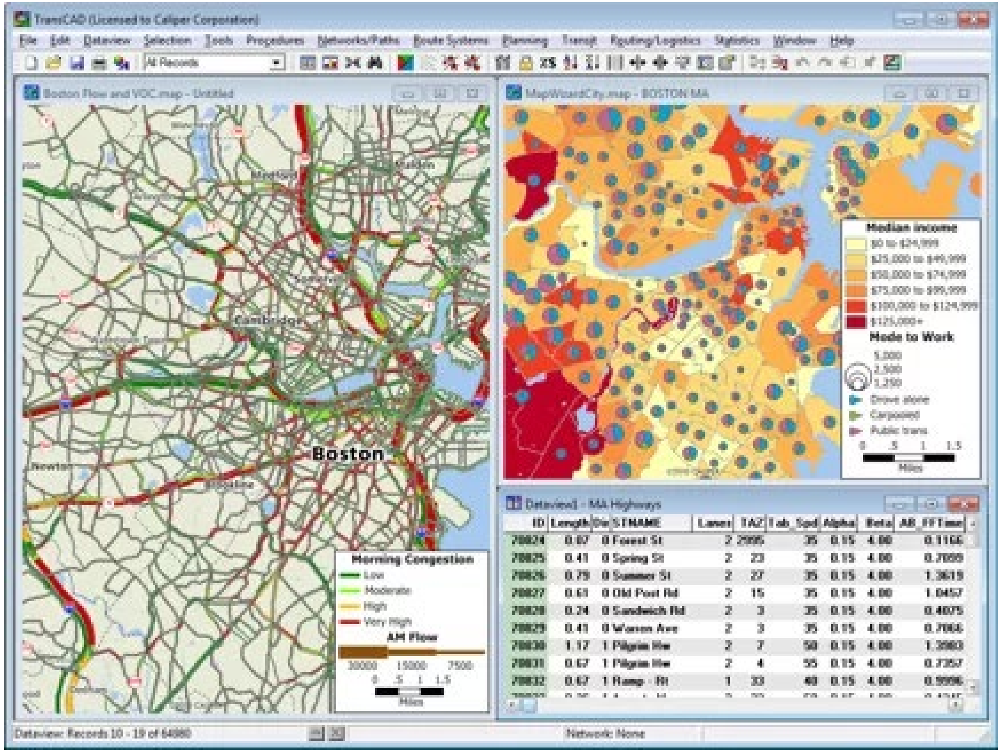
IN THE 1980's

- MINUTP and TRANPLAN for PCs
- Some customization of the four-step model
- Main innovation: nested logit



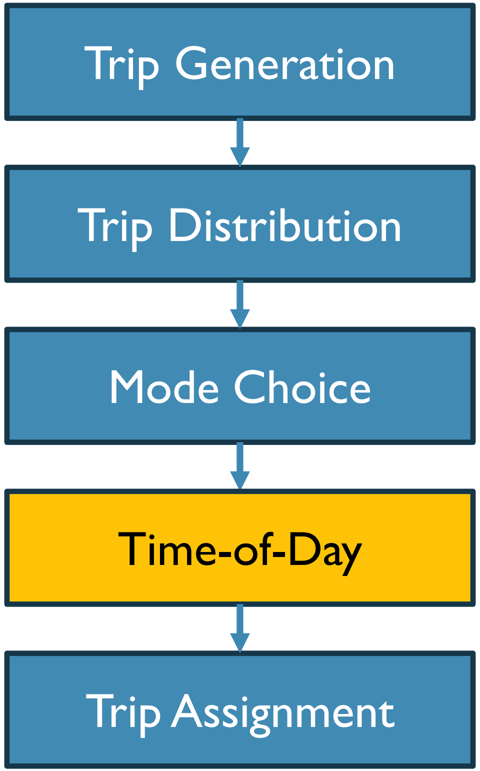
IN THE 1990's

- TransCAD for Windows
- GIS integration
  - "True Shape" road networks replace stick networks



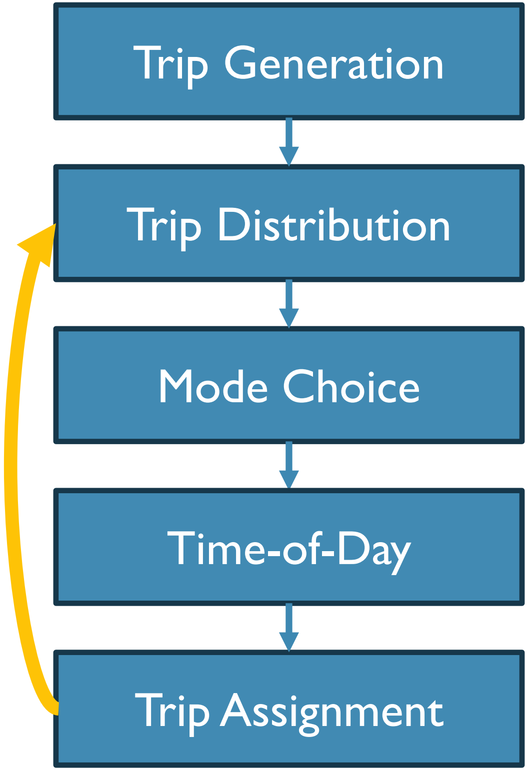
TIME-OF-DAY

- Air quality conformity led to focus on speeds
- Speeds vary by time-of-day
- Models began to represent demand by time-of-day
- Most commonly trips split into time periods just before assignment in PA to OD conversion



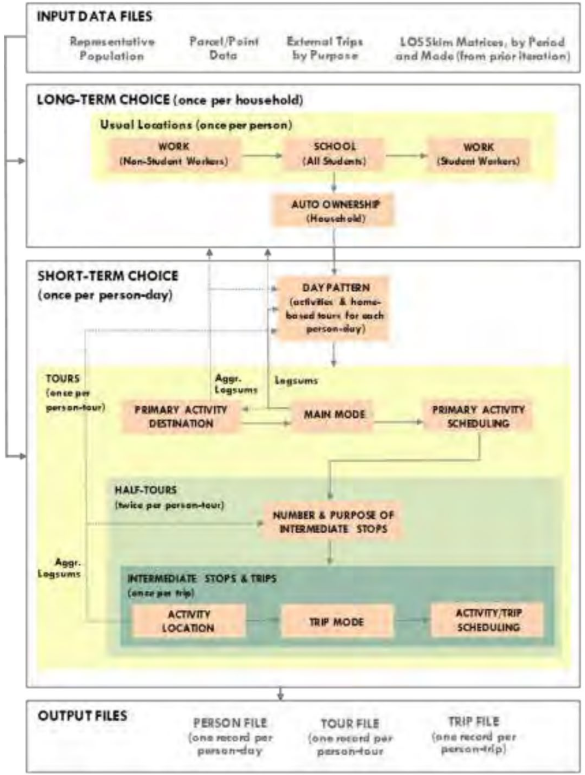
FEEDBACK

- Air quality conformity also led to concerns about the consistency of travel times assumed in trip distribution and resulting from trip assignment
- Travel times were ‘fed back’ and the model looped until convergence



ACTIVITY-BASED MODELS

- Born out of academic desire to address inconsistencies in traditional models
- Began to be adopted as useful for land use effects, walk/bike planning, time sensitive pricing/policies, equity analyses
- People as basic unit of analysis (synthetic population)
- Discrete choice models with many variables
- Monte Carlo simulation
- Relational database

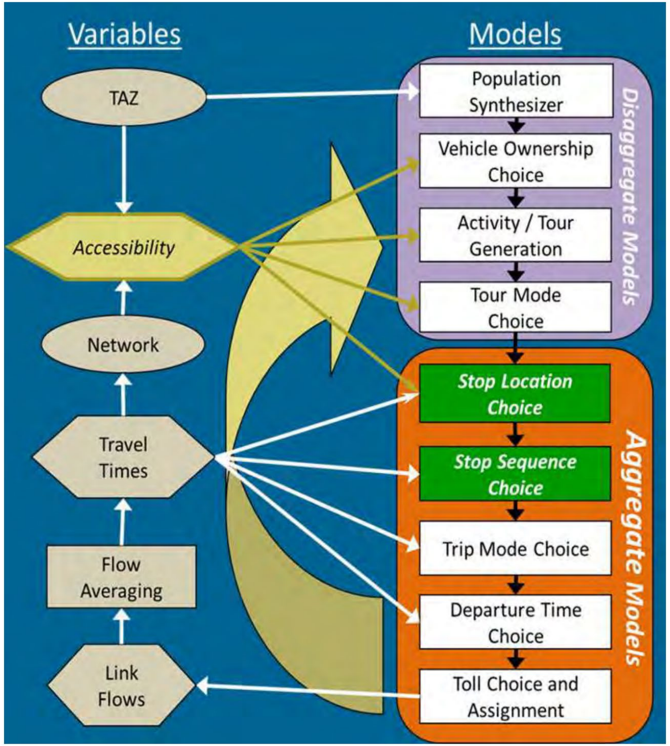


ACTIVITY-BASED MODELS

- Limited adoption, mostly by very large MPOs
  - Many of which also maintain & use trip-based model
- Require large surveys
- Costly development
- Long runtimes

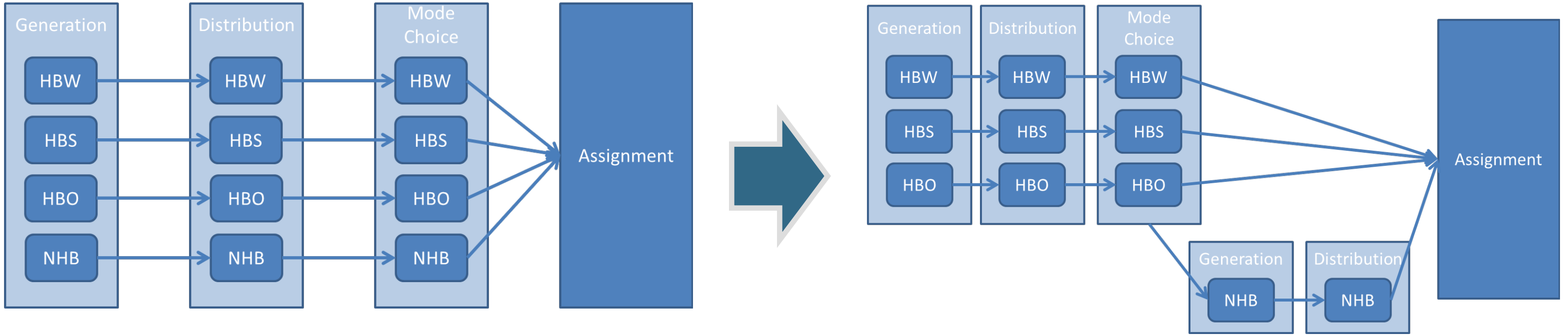
HYBRID MODELS

- Developed after activity-based, as an attempt to compromise between theoretical and practical concerns
- Discrete choice models like activity-based, but no Monte Carlo simulation
  - Mode choice often before destination choice
- Some use of persons; some use of trip matrices



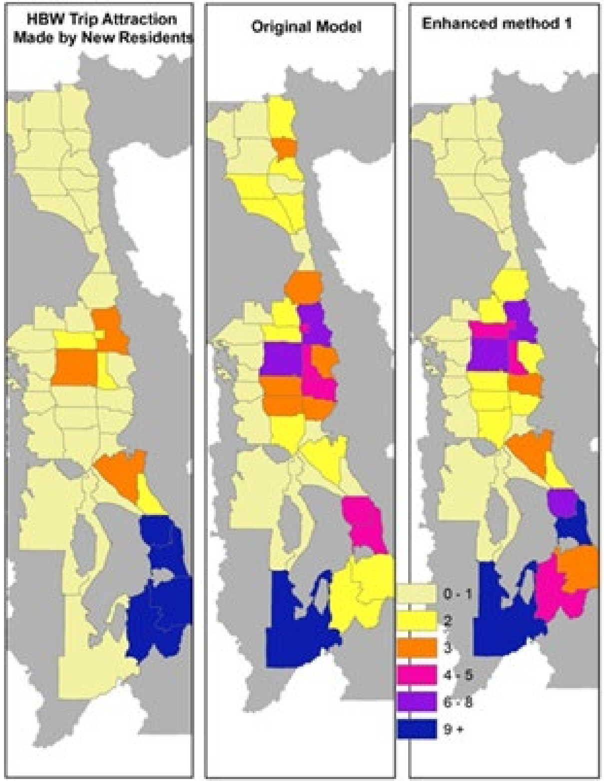
LINKING NON-HOME-BASED TRIPS (TMIP METHOD)

- After and conditional on HB trip models
  - NHB trips generated separately by mode based on HB trip destinations by mode (~Markov transition probabilities)



LINKING NHB TRIPS

- Linking NHB to HB trips provides consistency between modes and destinations chosen
- In the original/traditional Salt Lake City model adding population down in Provo (S) added NHBW trips in Ogden (N) – linking trips fixes this



NHB TRIP GENERATION **BY MODE**

- **Example:** Nonwork Tour Non-home-based SOV

term	estimated_as	estimate	std.error	statistic	p.value
N_HB_OD_Long_hov	N_HB_OD_All_hov	0.0209	0.0037	5.6162	0
N_HB_OD_Short_hov	N_HB_OD_All_hov	0.0209	0.0037	5.6162	0
N_HB_OD_Long_sov	N_HB_OD_All_sov	0.1034	0.0041	25.021	0
N_HB_OD_Short_sov	N_HB_OD_All_sov	0.1034	0.0041	25.021	0
N_HB_OME_All_hov	N_HB_OME_All_hov	0.0026	0.0034	0.7798	0.4355
N_HB_OMED_All_hov	N_HB_OME_All_hov	0.0026	0.0034	0.7798	0.4355
N_HB_OME_All_sov	N_HB_OME_All_sov	0.0292	0.0044	6.6661	0
N_HB_OMED_All_sov	N_HB_OME_All_sov	0.0292	0.0044	6.6661	0

  - All HB trip types (on Nonwork tours) by auto modes generate NHB SOV trips
  - No HB trips by non-auto modes generate NHB SOV trips
    - You have to have taken a car with you make a NHB trip by SOV.

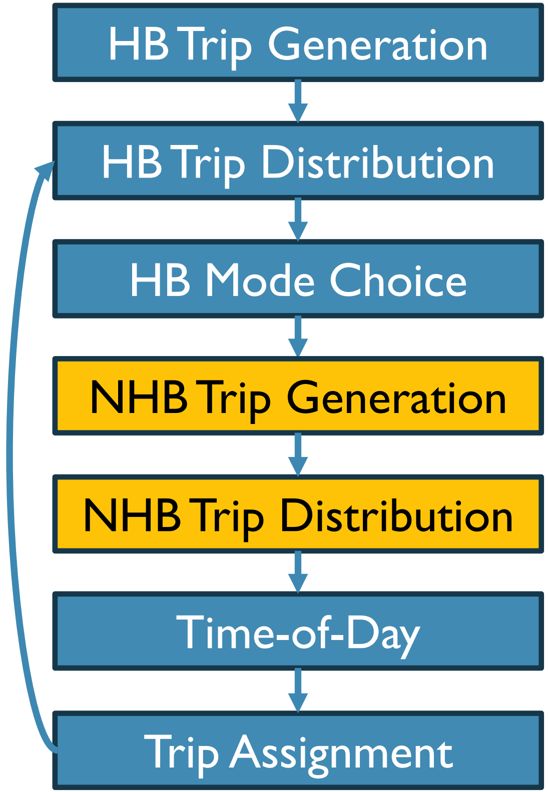
NHB TRIP GENERATION BY MODE

- **Example**:
  Nonwork Tour
  Non-home-based
  Maintenance / Eat
  WALK
  - NHB walk trips can be made by many more modes – because they don't require having a vehicle with you
  - Note how likely auto-pay HB trips are to generate NHB walk trips

term	estimated_as	estimate	std.error	statistic	p.value
N_HB_K12_All_t	N_HB_K12_All_t	0.0813	0.0472	1.7235	0.0848
N_HB_OD_Long_auto_pay	N_HB_O_All_auto_pay	0.5896	0.0225	26.237	0
N_HB_OD_Short_auto_pay	N_HB_O_All_auto_pay	0.5896	0.0225	26.237	0
N_HB_OME_All_auto_pay	N_HB_O_All_auto_pay	0.5896	0.0225	26.237	0
N_HB_OMED_All_auto_pay	N_HB_O_All_auto_pay	0.5896	0.0225	26.237	0
N_HB_OD_Long_hov	N_HB_OD_All_hov	0.0062	0.0028	2.238	0.0252
N_HB_OD_Short_hov	N_HB_OD_All_hov	0.0062	0.0028	2.238	0.0252
N_HB_OD_Long_t	N_HB_OD_All_t	0.0681	0.0218	3.1296	0.0018
N_HB_OD_Short_t	N_HB_OD_All_t	0.0681	0.0218	3.1296	0.0018
N_HB_OD_Long_walk	N_HB_OD_Long_walk	0.0398	0.0082	4.831	0
N_HB_OD_Short_sov	N_HB_OD_Short_sov	0.0129	0.0055	2.3628	0.0181
N_HB_OD_Short_walk	N_HB_OD_Short_walk	0.0131	0.004	3.261	0.0011
N_HB_OME_All_bike	N_HB_OME_All_bike	0.1197	0.0477	2.5095	0.0121
N_HB_OME_All_hov	N_HB_OME_All_hov	0.0075	0.0026	2.8264	0.0047
N_HB_OME_All_sov	N_HB_OME_All_sov	0.0251	0.0034	7.3015	0
N_HB_OME_All_t	N_HB_OME_All_t	0.0695	0.0276	2.5216	0.0117
N_HB_OME_All_walk	N_HB_OME_All_walk	0.1767	0.0089	19.884	0
N_HB_OMED_All_walk	N_HB_OME_All_walk	0.1767	0.0089	19.884	0
N_HB_OMED_All_hov	N_HB_OMED_All_hov	0.0168	0.0091	1.8509	0.0642

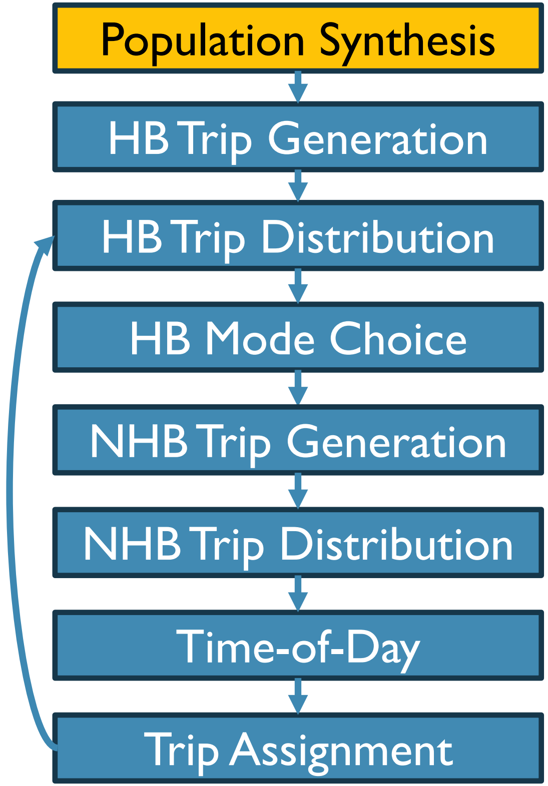
LINKING NHB TRIPS TO HB TRIPS

- This relatively simple shift makes the model's trip tables consistent with tours
- The rest of what makes a model a hybrid is generally improvements to the individual modeling steps



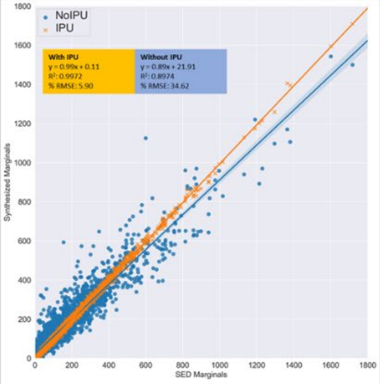
POPULATION SYNTHESIS

- Creates linked lists of individual persons and households with the same aggregate characteristics as the real population as described by the Census

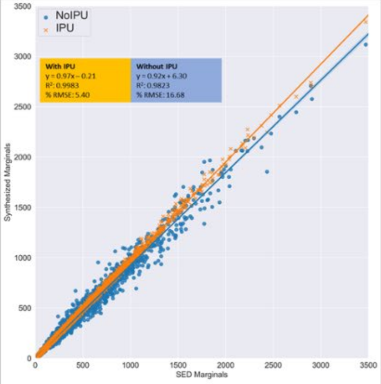


POPULATION SYNTHESIS

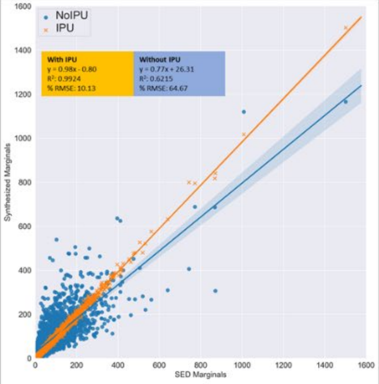
- TransCAD's Iterative Proportional Updating (IPU)
  - Household and Person level controls
  - Support for controls at multiple levels of geography
  - Extremely fast, ~ 2 minutes – run during model run
- Person level attributes show benefit of IPU over IPF



Synthesized vs SED Marginals by TAZ: Kids

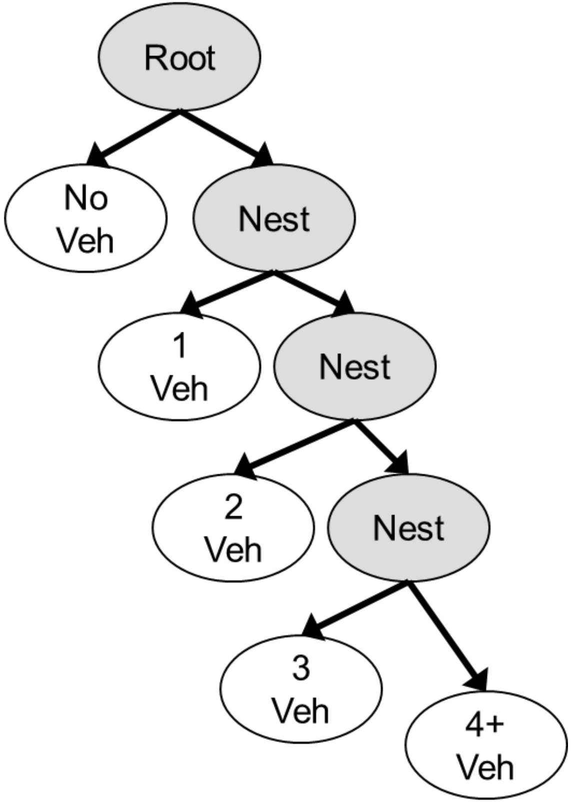


Synthesized vs SED Marginals by TAZ: Adults Under 65



Synthesized vs SED Marginals by TAZ: Seniors

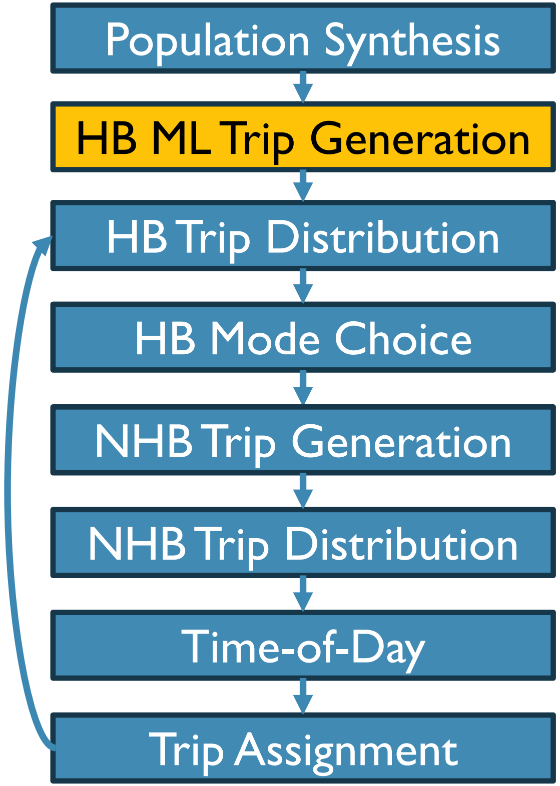
AUTOMOBILE AVAILABILITY



- Each household chooses how many vehicles to own / lease
- No aggregation bias
- Vehicle ownership levels respond to
  - Demographics (household size, income, number of workers, seniors, etc.)
  - Transit Availability
  - Urban Design Factors (network density and intersection approach density ~ pedestrian environment / grid vs. cul-de-sac design)

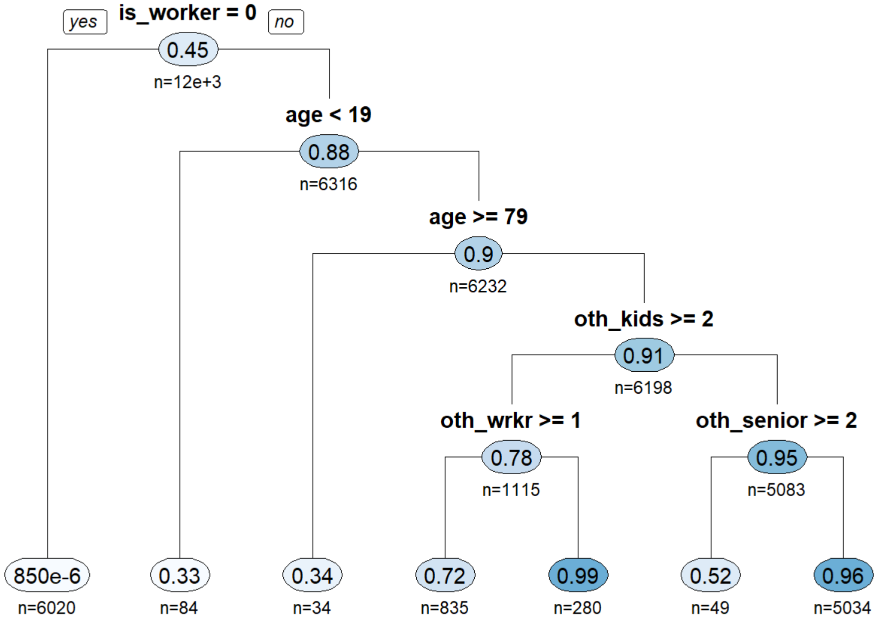
DISAGGREGATE ML TRIP GENERATION

- Individual people decide how many HB trips / tours to make
- Many different model forms
  - Cross-classification
  - GLM (up to and including zero-inflated negative binomial)
  - Logit (ordered logit)
  - Decision Trees (machine learning)
- Machine learning outperforms traditional statistical models



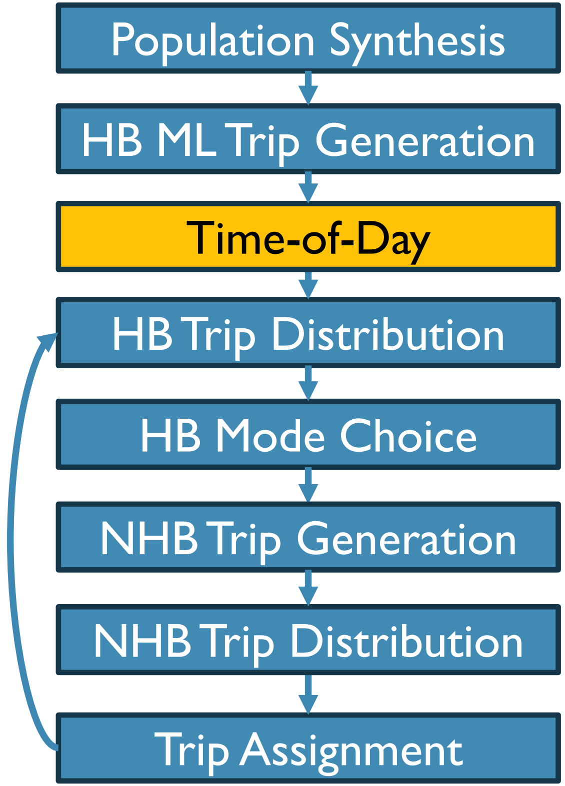
DECISION TREES FOR TRIP GENERATION

- Advantages of ANOVA-based decision trees
  - Sensitivity
    - **Age**
    - **Neighborhood / Accessibility**
    - Income
    - Vehicle ownership
    - Household composition
  - Nonlinear effects
  - Full survey support
    - No empty cells like with cross-class



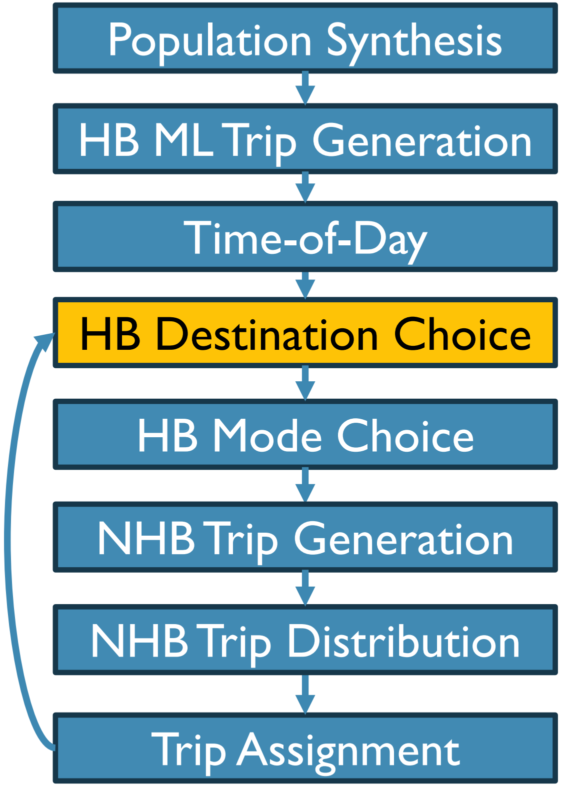
DISTRIBUTION BY TIME-OF-DAY

- Moving Time-of-Day up means trip distribution for each time of day is based on travel times at that time of day



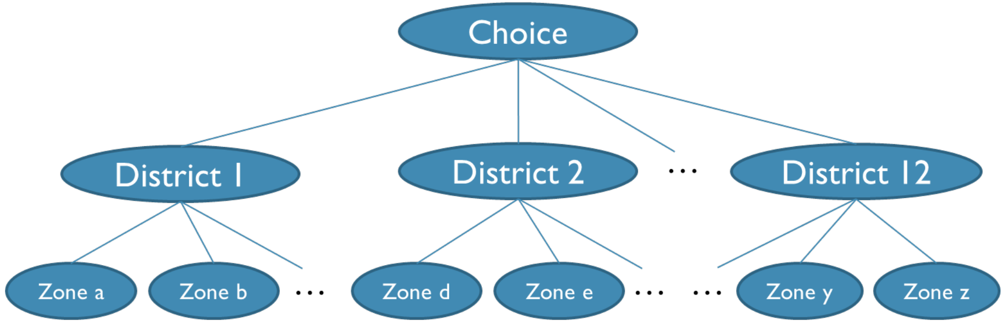
DESTINATION CHOICE

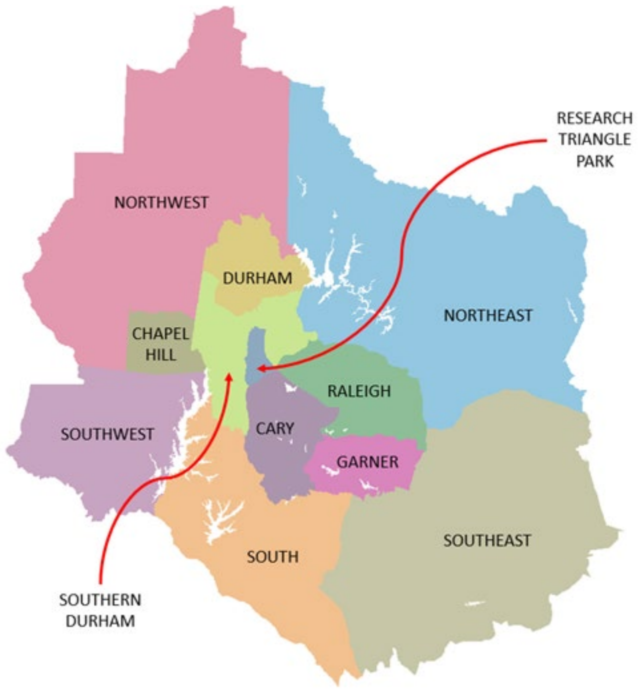
- Trip distribution is the largest source of error in travel models
- Destination choice models improve over gravity by taking more factors into account in determining where people go
  - Accessibilities
  - Bias constants
  - Psychological barriers



NESTED DESTINATION CHOICE

- **First**, travelers choose a destination district
- **Second**, travelers choose the exact zone
- Allows much better representation of travel in multinucleated regions

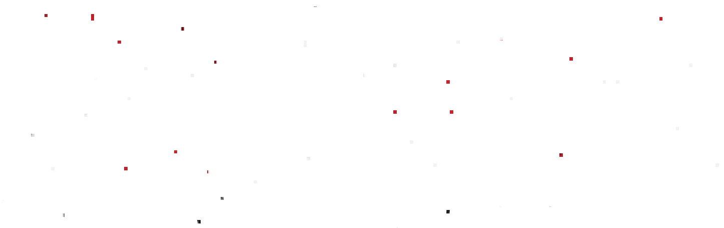




BIG DATA

- Destination choice models can now be calibrated with big data
- Traditional household surveys typically have observations in less than 1% of the cells in an origin-destination (OD) matrix
- Big data often has observations of 20% of the cells in an OD matrix

CAN YOU RECOGNIZE THE PATTERN FROM ~1%?



HOW ABOUT BASED ON ~20%?

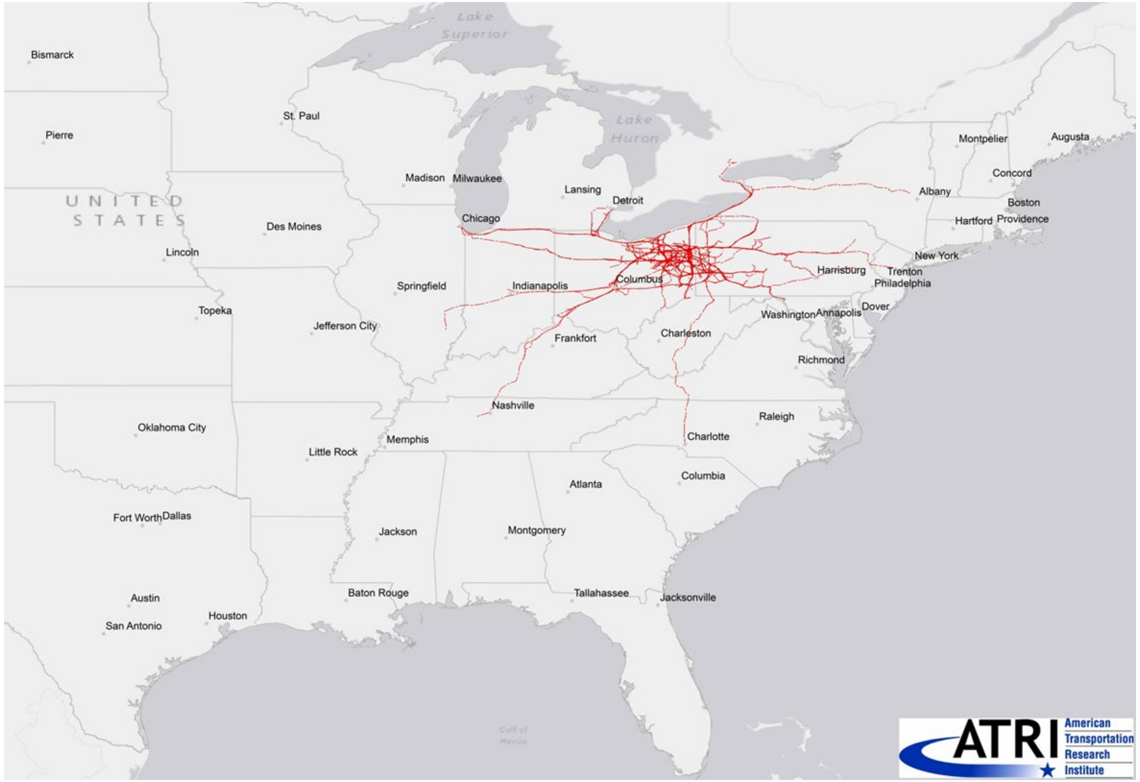
BIG DATA ALLOWS US TO SEE THE BIG PICTURE

ATPA

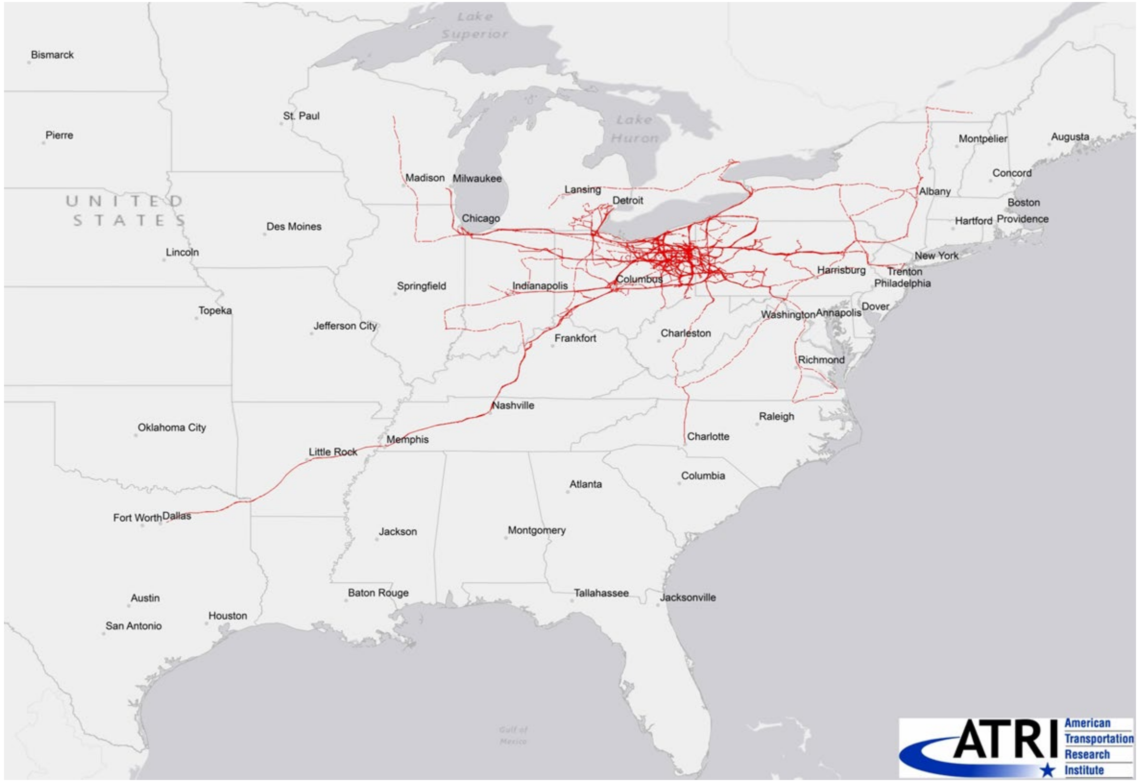
ALABAMA TRANSPORTATION PLANNERS ASSOCIATION

REAL EXAMPLE: US 30 STUDY IN OHIO

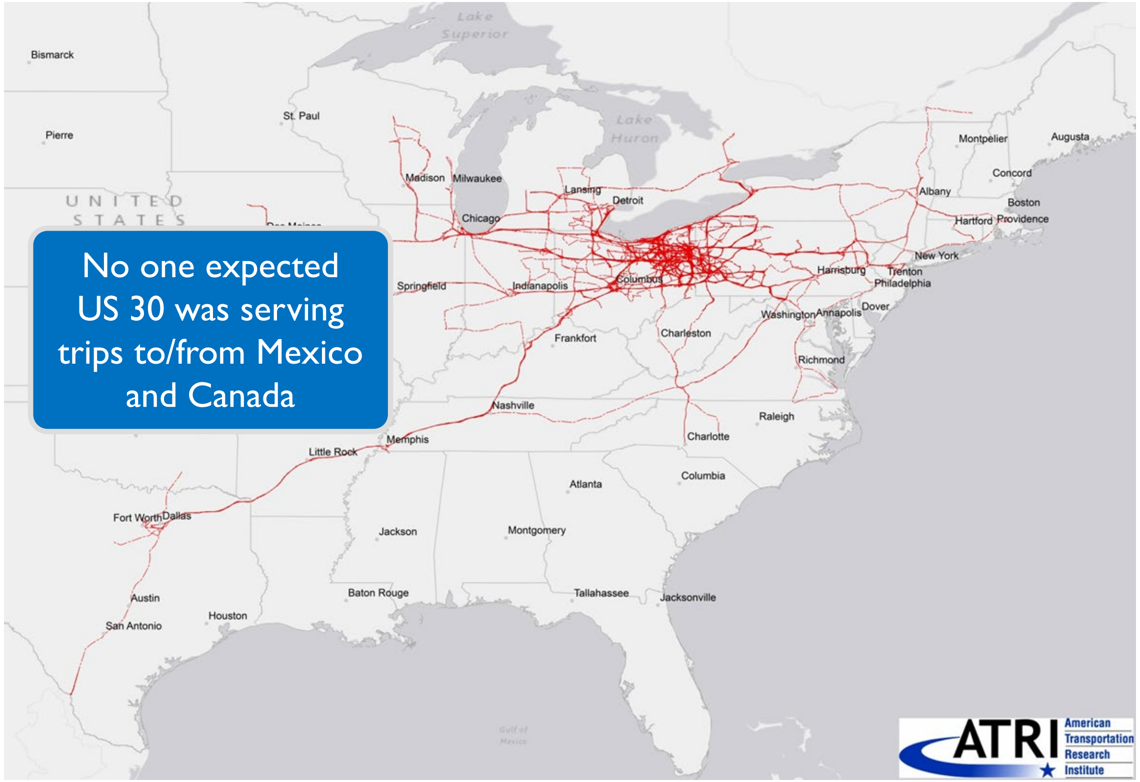
TRUCKS USING US 30 – 1 DAY



TRUCKS USING US 30 – AFTER 2 DAYS



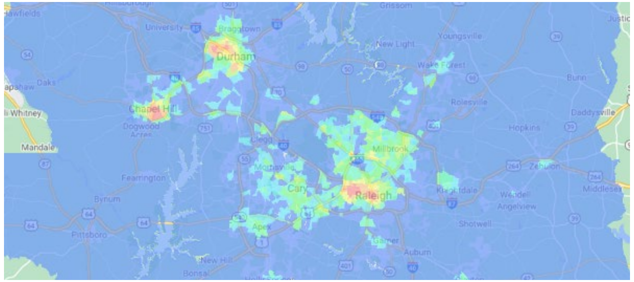
TRUCKS USING US 30 – AFTER 5 DAYS

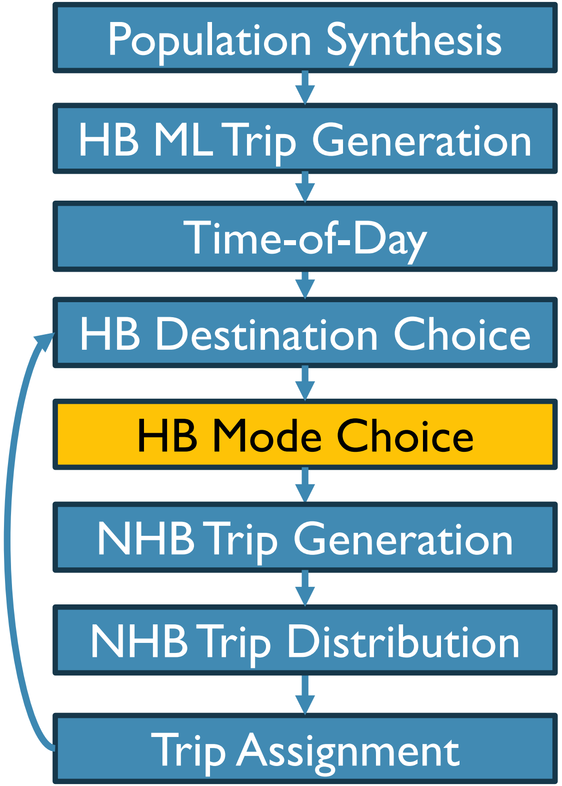


No one expected US 30 was serving trips to/from Mexico and Canada

MODE CHOICE IMPROVEMENTS

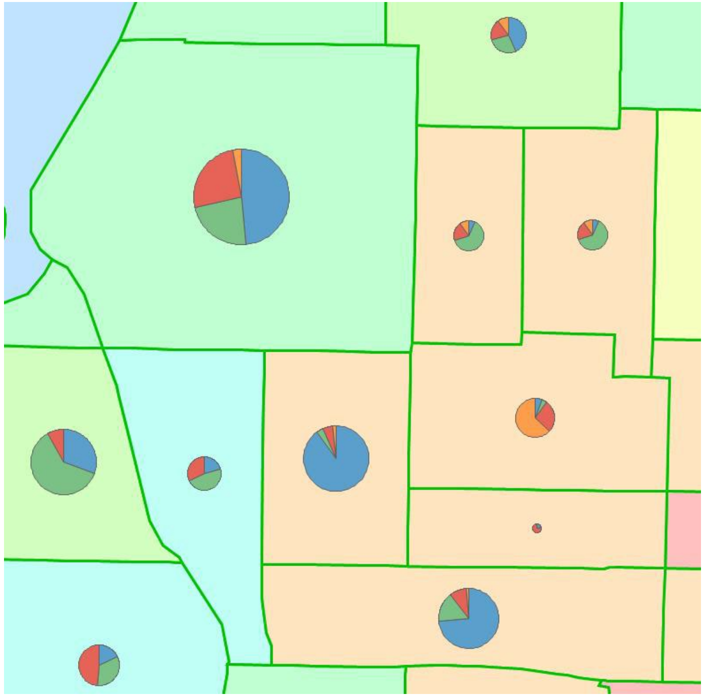
- Model form still nested logit
- Addition of modes for walk/bike and Uber/Lyft
- Model sensitivity to neighborhood walkability
- Use of all-streets networks, more TAZs





SIMPLE MODE CHOICE

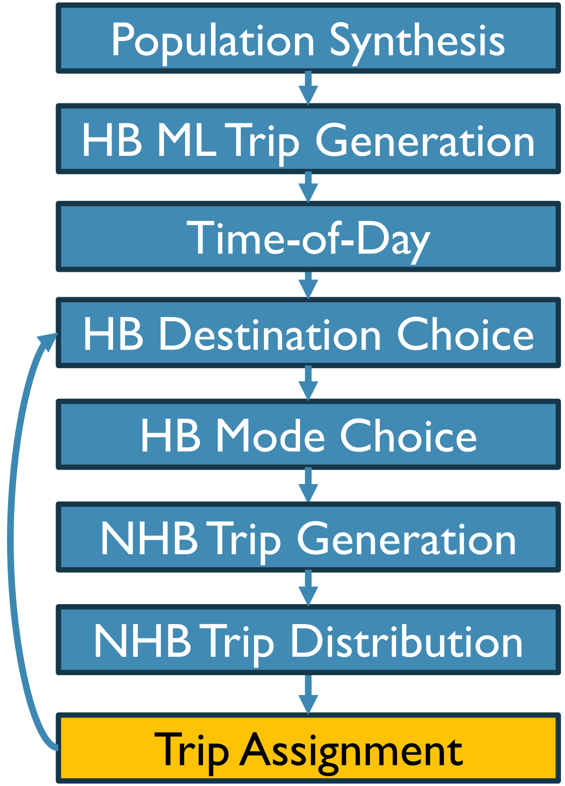
- Simplified, pre-distribution mode choice, especially for smaller MPOs where there is no need for route level transit forecasts
- Produces
  - Transit system ridership
  - Walk/bike trips by residence TAZ



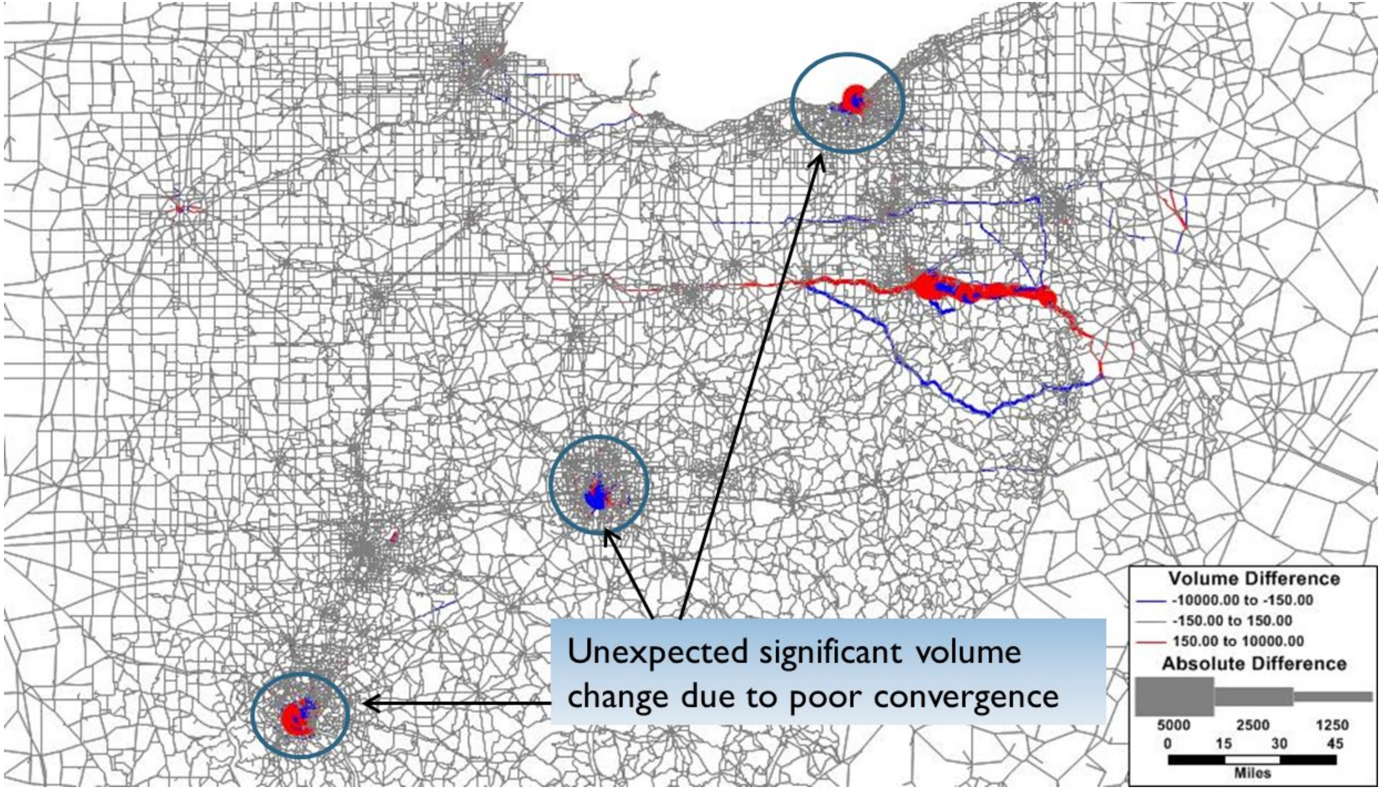
ASSIGNMENT IMPROVEMENTS

- Greater awareness of the need for assignment convergence

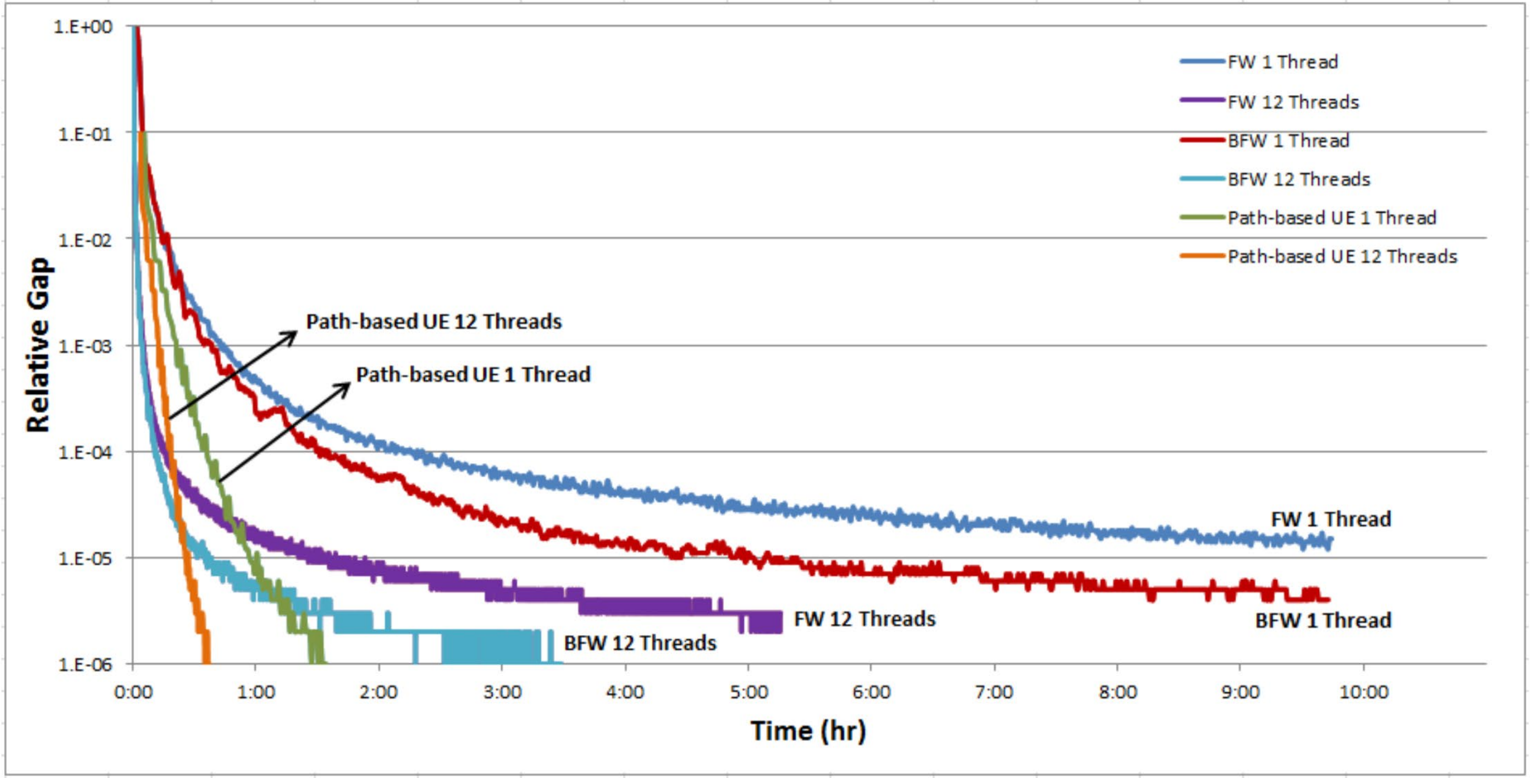
- Faster converging assignment algorithms
  - Bi-/Tri-Conjugate Frank-Wolfe
  - Path-based Assignment



POOR CONVERGENCE PROBLEMS



FAST CONVERGING UE ALGORITHMS



DYNAMIC TRAFFIC ASSIGNMENT (DTA)

- As a post-process not a replacement for static UE
- Evaluate operational improvements

SUMMARY

- Some MPOs are moving to ABMs but most are not
- Some are continuing to use tradition 3 or 4-step models
- Many are migrating towards "hybrid" models
  - Linking NHB and HB trips
  - Improvements to all the modeling steps
- Many are using big data to improve their models
- Some are adding DTA models

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