TRANSIMS Training Course at TRACC

Transportation Research and Analysis Computing Center

Part 7

Convergence Control and Equilibration

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Unit 7

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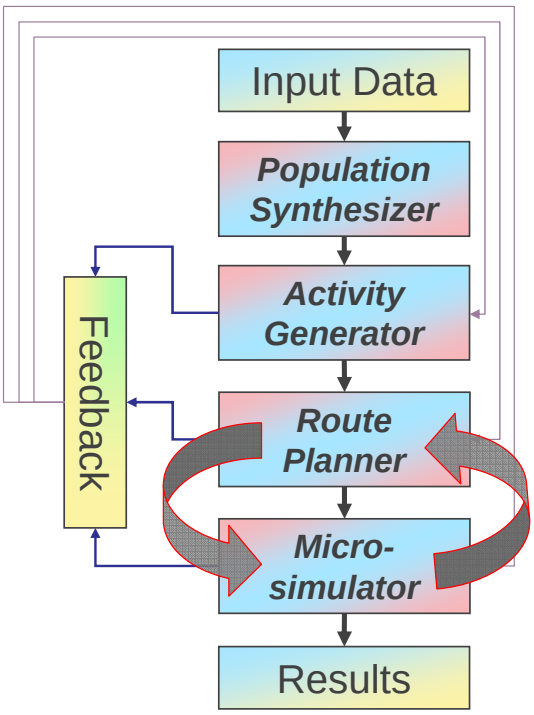
Contents

- Introduction
- Alexandria Model Example
- Feedback Process
  - Router Stabilization
  - Microsimulation Stabilization
  - Microsimulation User Equilibration
- Credits and Acknowledgement

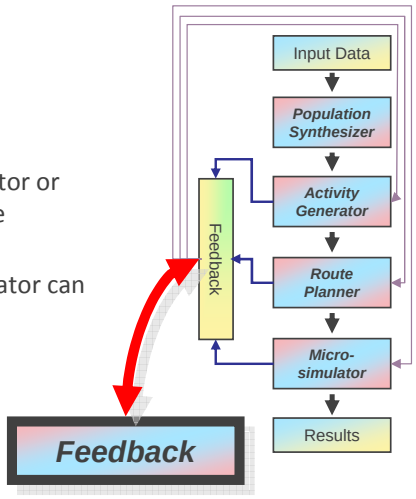
Introduction to Feedback

- Running the feedback procedure has two major goals
  - Eliminate the problems incurred due to routing and microsimulation
  - Achieve a routing and microsimulation result which represents, as realistically as possible, normal-day trips and congestion
- Important constraint
  - Travelers choose a mode of transportation according to travel surveys; they are not optimizing their travel by choosing modes
- Therefore, the TRANSIMS equilibration process typically iterates between router and microsimulator (details follow later)

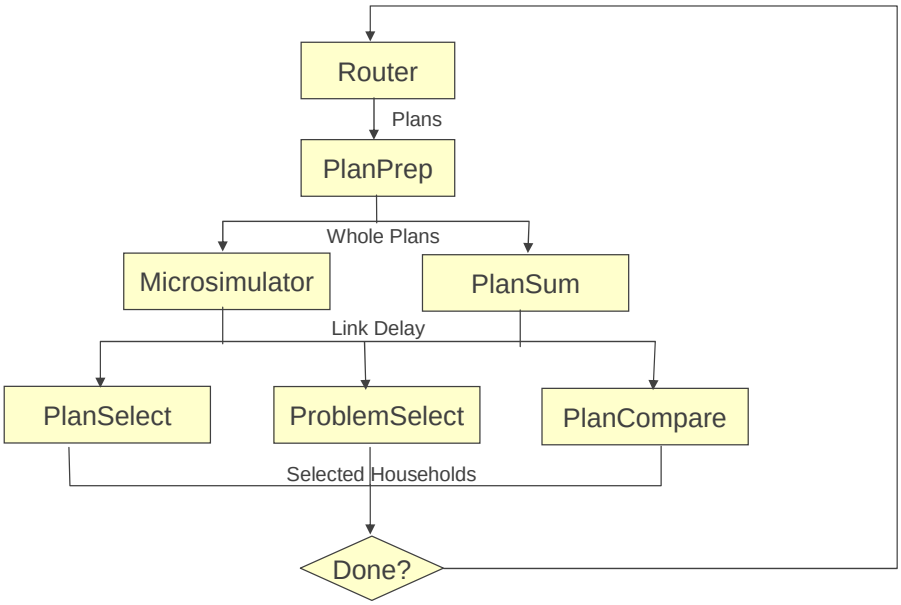


Problem-Based Feedback

- In the Router, some routes are not feasible
  - Significantly longer than dictated by the survey data
  - Not feasible based on the given transportation mode
  - These trips or activities are passed through microsimulator or PlanSum and then back through the router to determine appropriate alternatives
  - If available, re-assessing these trips in the activity generator can also be an effective feedback process
- In the Microsimulator, vehicles can stall because they are unable to change lanes or make turns
  - Passing the households that own the vehicle back to the router for new routing suggestions may solve the problem
  - Some plans cannot be followed because of time-dependent road closures and other triggers
- Several tools are available to select households for rerouting: PlanSelect, ProblemSelect, PlanCompare



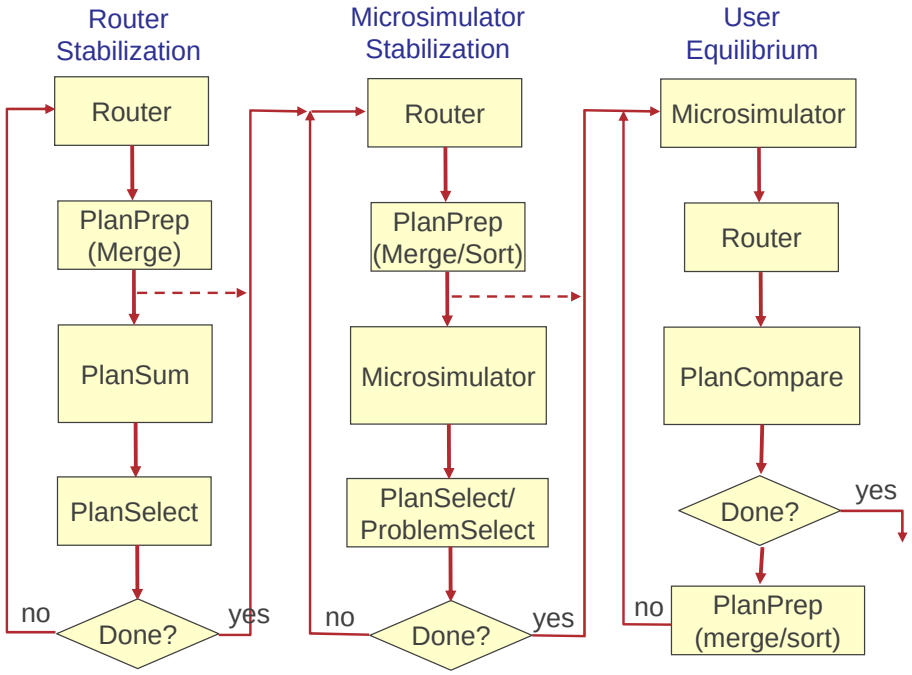
Program Flow



Feedback Procedures

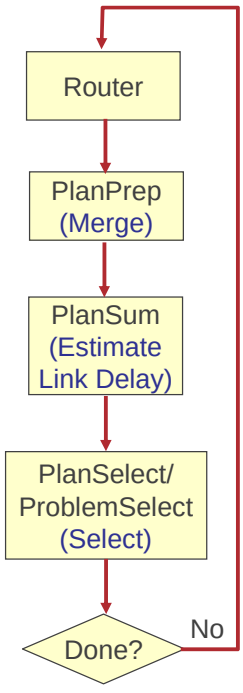
- Router Stabilization
  - Distribute traffic more logically prior to simulation
- Microsimulator Stabilization
  - Debug network and address simulation problems
- User Equilibrium
  - Equilibrate paths (Router) and travel times (Microsimulator)
- System Equilibrium
  - Stabilize link volumes and speed

Feedback Process Summary



Router Stabilization

- Objectives
  - Resolve Network Problems
  - Refine Travel Plans to logically distribute traffic prior to Microsimulation
- Feedback Process
  - Route (Router)
  - Merge (PlanPrep)
  - Estimate Link Delay (PlanSum)
  - Select (PlanSelect)



Trip Generation

- ConvertTrip
  - Convert Zone-to-Zone Traffic Table to Location-to-Location Trips

Zone-to-Zone Trip Table

ORG	DES	TRIPS
1	1	450
1	2	440
1	3	208
1	4	614
1	5	16
1	6	17
2	1	429
2	2	446
2	3	213
2	4	638
2	5	11
2	6	12
3	1	203
3	2	209
3	3	112

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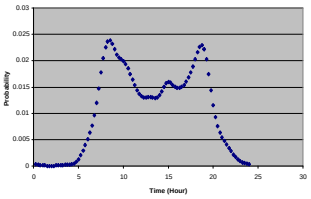
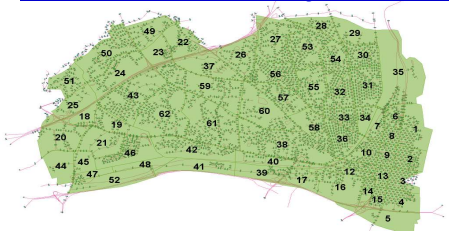
Diurnal Distribution



Traffic Zones & Activity Locations



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- **Trips**
- **Household**
- **Population**
- **Vehicle**

- Output:

Trip

HHOLD	PERSON	TRIP	PURPOSE	MODE	VEHICLE	START	ORIGIN	ARRIVE	DESTINATION	CONSTRAINT
1	1	1	1	1	1	30342	1877	31049	4159	1
2	1	1	1	2	2	29133	3178	29918	6947	1
3	1	1	1	2	3	26788	1890	27513	2956	1

Household

HHOLD	LOCATION	PERSONS	WORKERS	VEHICLES
1	1877	1	1	1
2	3178	1	1	1
3	1890	1	1	1

Population

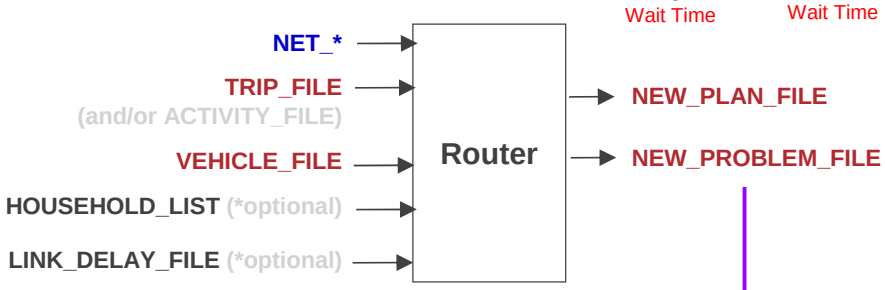
HHOLD	PERSON	AGE	GENDER	WORK	DRIVE
1	1	25	1	1	1
2	1	25	1	1	1
3	1	25	1	1	1
4	1	25	1	1	1

Vehicle

VEHICLE	HHOLD	LOCATION	TYPE	SUBTYPE
1	1	1877	1	0
2	2	3178	1	0
3	3	1890	1	0
4	4	4167	1	0

Router

- Router
  - Builds Time dependent Minimum Impedance Travel Paths (**Plans**) for Trips or Activities belonging to a specified list of Households
    - Impedance: Time, Cost, Penalty



HHOLD	PERSON	TRIP	MODE	PROBLEM	START	ORIGIN	ARRIVE	DESTINATION
489	1	1	2	1	25064	1894	26660	32
490	1	1	2	1	29876	4147	31446	32
668	1	1	2	1	33911	871	35893	3
672	1	1	2	1	38629	3709	40664	3
693	1	1	2	1	32564	3707	34589	3
1013	1	1	2	1	29235	3834	30669	32

Plan Select Utility in Router Feedback

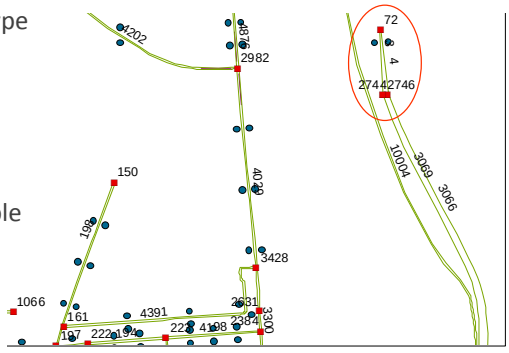
- Universal keys
  - *SELECTION_PERCENTAGE: What percent of eligible to select, use only this for random re-routing*
  - *MAXIMUM_PERCENT_SELECTED: Selection cannot be more that this percentage of total households*
- VC Ratio stabilization
  - *SELECT_VC_RATIO: Minimum V/C ratio eligible for selection*
- Node or Time selection
  - *SELECT_NODES_#: Plans must pass through this series of nodes at some point in the trip*
  - *SELECT_TIME_PERIODS: Plans must originate during listed periods*

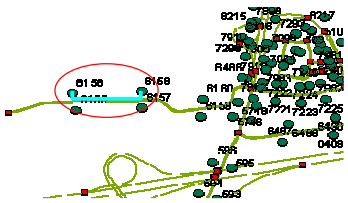
Plan Prep Utility

- Three Major functions
  - *Merging plan files: in cases of overlap, the household contained in the input plan file replaces the one in the merge plan file*
  - *Sorting plan files: most commonly sorted by time for use in microsimulation*
  - *Selection: if selecting households with Plan Select is not desirable, then Plan Prep may be used to select a percentage randomly from the plan file directly*

Resolving Network Errors

- Access Restriction Problem
  - Cause: The road is restricted to a certain vehicle type only
  - Resolution: Change the access type of the link
- Zero Node Problem
  - Cause: Origin and Destination in the same link
  - Resolution: Re-run convert-trips or change trip table manually
- Path-Building Problem
  - Cause: Cannot build path between origin and destination
  - Resolution: Skim network for selected trip and check for any major gaps in the road network or if either origin or destination are on one-way links
- Circuitry Problem
  - Cause: Path is overly circuitous
  - Resolution: Increase circuitry ratio





Router Stabilization (continued)

- Refine Travel Plans to logically distribute traffic prior to Microsimulation

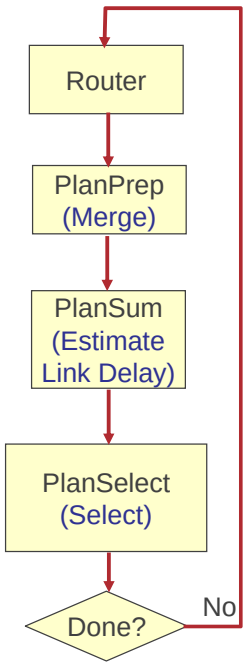
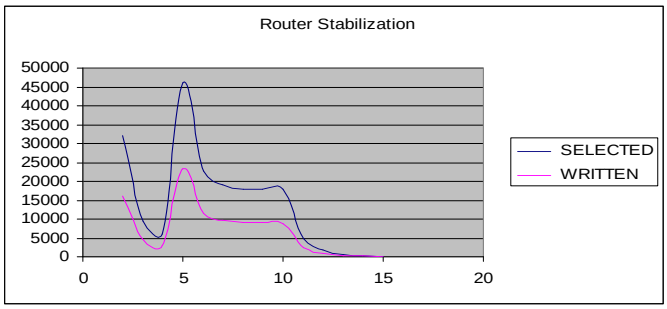


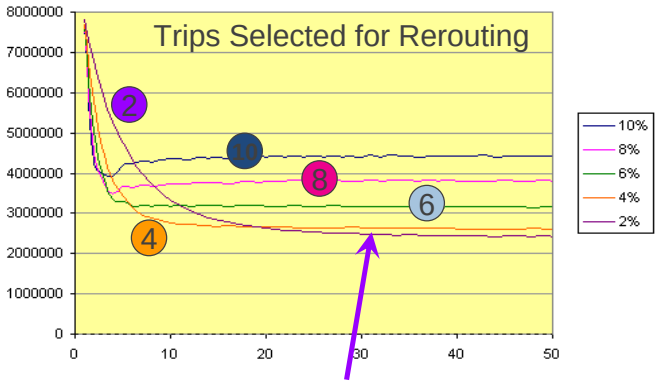
Table 1. Selection Criteria for Router Stabilization

Variables	Iterations		
	2-4	5-10	11-15
Select_VC_Ratios	2.0	1.5	-
Percent Time Difference	-	-	10
Minimum Time Difference	-	-	2
Maximum Time Difference			45
Selection_percentage	50	50	50
Maximum_percent_selected	10	10	10
Select_time_periods	all	all	all

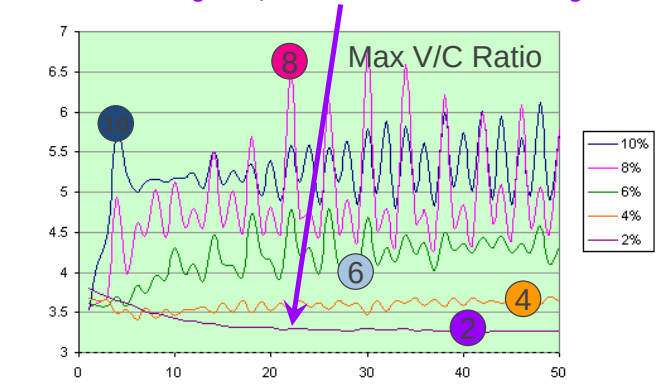


Router Feedback Oscillations

- The graphs on the right show 5 cases that ran through 50 iterations between Router and PlanSum (no microsimulation)
- PlanSelect has been instructed to select trips based volume/capacity ratios
  - Trips get selected if they go through a link at a time when the V/C ratio is greater than 1.3
  - Of 28 million trips, about 8 million get selected initially
  - Rerouting subsets of 2, 4, 6, 8, and 10 % in each iteration leads to the results shown on the right

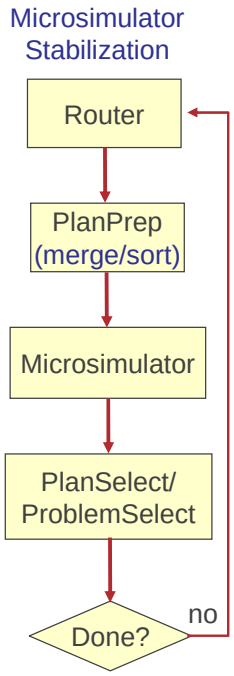


2%: Slow convergence, but achieves better convergence



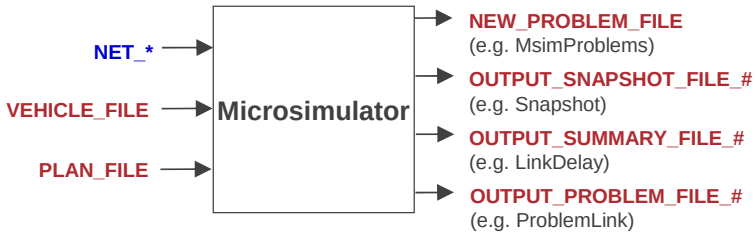
Microsimulator Stabilization

- Purpose
  - Debug further network problems
  - Address simulation problems
  - Equilibrate plan and simulation times
- Two principal kinds of microsimulator feedbacks
  - Targeted re-routes
    - Congested time periods
    - Geographic areas / OD patterns
    - Network coding changes / problems
  - Plan Time Stabilization
    - Re-route travelers whose trip duration in the Plan file is significantly different from the travel time calculated from the path



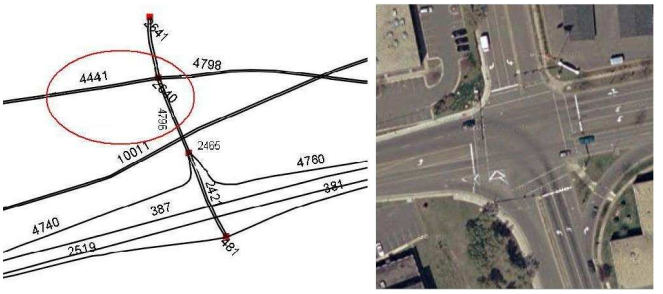
Microsimulator

- Microsimulator uses a cellular automata simulation process on a set of input plans to derive:
  - New_Problem_File: Problems with simulation
  - Output_Snapshot_File: File with step-by-step msim state
  - Output_Summary_File: Summarizes queues, delays, turn counts, etc…
  - Output_Problem_File: Summarizes additional problem info by link



Problem Select Utility

- ProblemSelect: Takes as input a microsimulator or router problem file. Utility allows selection of travelers by problem-type
- Some commonly used selection criteria include
  - PATH_BUILDING: Cannot route from origin to destination
  - LANE_CONNECTIVITY: Lane connectivity does not allow travel
  - LANE_MERGING: Difficulty merging onto desired lane
  - PARKING_ACCESS: Cannot access desired parking lot



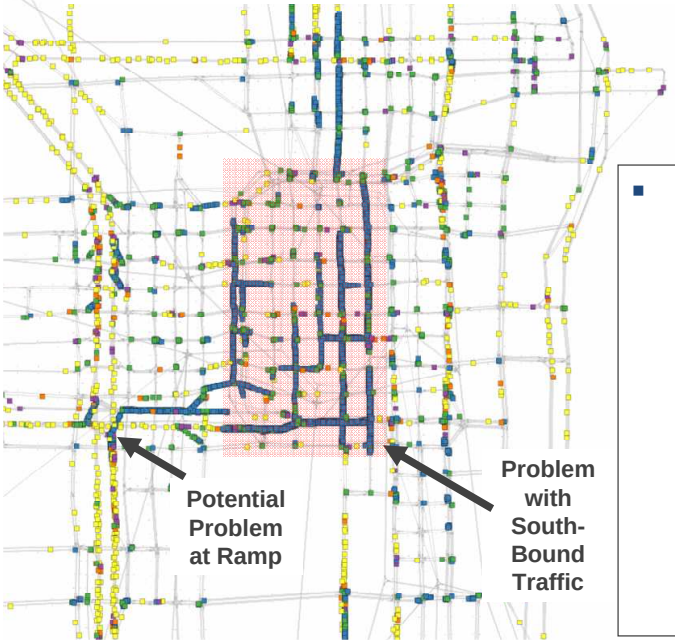
Network Connectivity Problem

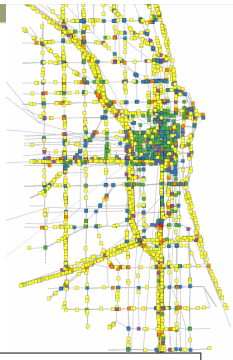
Parking Access Problems

Plan Select Utility in Microsimulator Feedback

- Targeted Feedback (PlanSelect)
  - Congested time periods
    - SELECT_TIME_PERIODS (e.g. 6:00..10:00)
  - Geographic areas / OD patterns
    - SELECT_COORDINATES (e.g., x1, y1, x2, y2)
    - SELECT_OD_COORDINATES
    - EXCLUDE_OD_COORDINATES
    - SELECT_SUBAREA_POLYGON (select all plans that cross polygon)
  - Network coding changes / problems
    - SELECT_PARKING_LOTS
    - SELECT_NODES
    - SELECT_LOCATIONS
- Plan Time stabilization
  - *PERCENT_TIME_DIFFERENCE (between plan time and msim result)*
  - *MINIMUM_TIME_DIFFERENCE*
  - *MAXIMUM_TIME_DIFFERENCE*

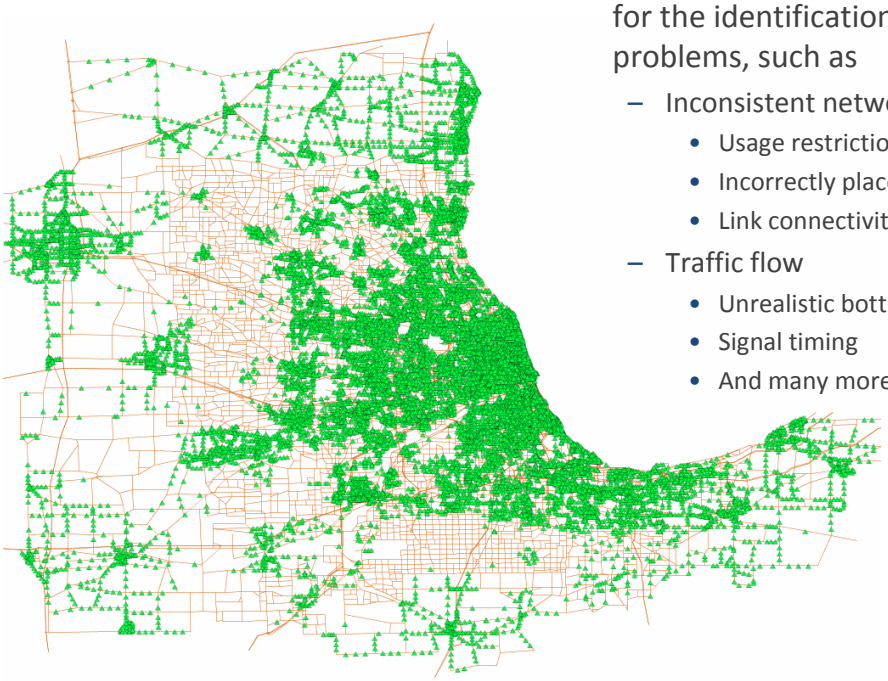
Network Cleaning





- Several tools exist to identify problems visually and numerically
  - LinkSum, PlanSum, ArcDiff, ArcPlan, ArcProblem, ArcSnapshot, and more
  - ArcSnapshot output is shown on the right, vehicles are color-coded by speed
  - Video sequences can help identifying problems at intersection, especially with traffic signals

Network Cleaning



- Plotting of problems from both the router and the microsimulator allows for the identification of many problems, such as
  - Inconsistent network coding
    - Usage restrictions
    - Incorrectly placed signals
    - Link connectivity
  - Traffic flow
    - Unrealistic bottlenecks
    - Signal timing
    - And many more …

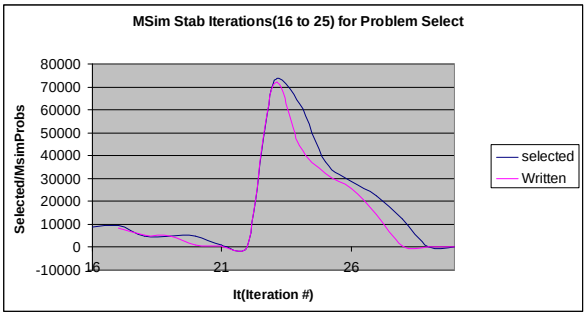
Microsimulator Stabilization Example

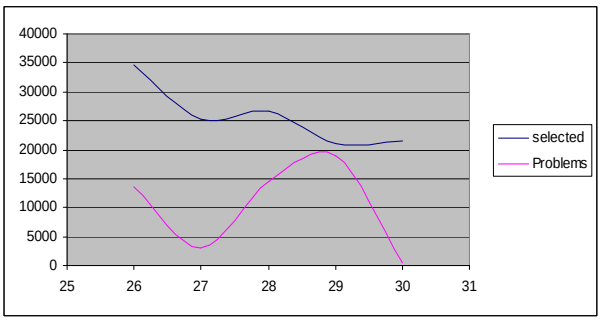
IT	ProblemSelectType	Selected = written	Msim Run time	Msim Total Probs
16	WAIT_TIME	8796	6:10AM	9958
17	WAIT_TIME	9732	6:10AM	8468
18	WAIT_TIME, ARRIVAL_TIME, DEPARTURE_TIME	4809	6:10AM	5128
19	WAIT_TIME, ARRIVAL_TIME, DEPARTURE_TIME	4915	6:10AM	4915
20	WAIT_TIME, ARRIVAL_TIME	4704	6:10AM	996
21	WAIT_TIME, ARRIVAL_TIME	827	6:10AM	530
22	WAIT_TIME, ARRIVAL_TIME	370	6:10AM	462
23	WAIT_TIME, ARRIVAL_TIME	71669	6:10AM	70836
24	All	62653	Whole Day	44287
25	ARRIVAL_TIME	37404	Whole Day	32237
26	ARRIVAL_TIME	28920	Whole Day	25744
27	ARRIVAL_TIME	22537	Whole Day	14391
28	ARRIVAL_TIME	12499	Whole Day	595
29	ARRIVAL_TIME	287	Whole Day	362
30	WAIT_TIME, VEHICLE_SPACING	287	Whole Day	362

Microsimulator Stabilization Example (cont'd)

PlanSelect Iterations - all done for the whole day

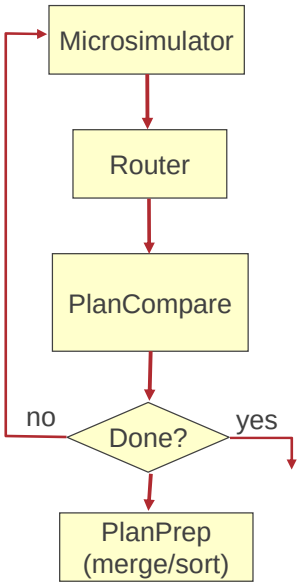
IT	VCRATIO	SELPCT	MAXPCT	TOTAL	SELECTED	WRITTEN	TOTAL_PROBS
31	1	50	10	294362	34645	17424	13609
32	1	50	10	294362	25238	12655	3049
33	1	50	10	294362	26713	13405	14534
34	1	50	10	294362	21086	10598	18872
35	1	50	10	294362	21487	10804	354





User Equilibration

- User Equilibrium:
  - A condition where no traveler can reduce their trip travel time by changing paths
- TRANSIMS approximation procedure
  - Use Microsimulator Link Delay to re-route all travelers and compare the trip duration to the trip duration stored in the simulated Plan file
  - Replace significantly different plans and resimulate
  - User Equilibrium =<2.0% travelers selected



PlanCompare Utility

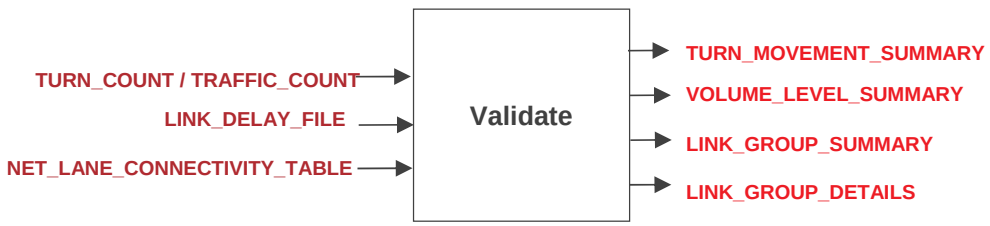
- Takes as input two plan files and generates a comparison file and household list based on the following parameters
  - Universal selection keys
    - SELECTION_PERCENTAGE
    - MAXIMUM_PERCENT_SELECTED;
  - Related to differences in travel time
    - PERCENT_TIME_DIFFERENCE
    - MINIMUM_TIME_DIFFERENCE
    - MAXIMUM_TIME_DIFFERENCE
  - Related to differences in path taken
    - PERCENT_PATH_DIFFERENCE
    - MINIMUM_PATH_DIFFERENCE
    - MAXIMUM_PATH_DIFFERENCE
  - Related to neighborhood of comparison
    - SUMMARY_TIME_PERIODS
    - SUMMARY_TIME_INCREMENT

Validation

- During or after feedback it may be necessary to ensure that the results are realistic. The following tools are available for this purpose:
  - Numerical
    - Validate
    - LinkSum
  - Visual
    - ArcPlan
    - ArcSnapshot

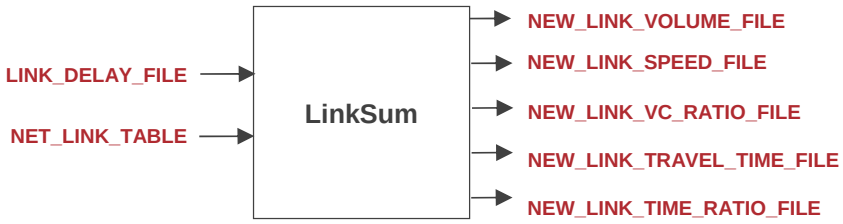
Validate

- Validate: Performs two primary types of analysis
  - Turn_Movement: Compare observed turn counts to simulated counts
    - Input Turn Count file contains:
      - Type of turn at a given intersection (left, right thru)
      - Volume of turns
      - A time range over which the turns occur
  - Traffic_Count: Compare observed link volumes to simulated volumes
    - Input Traffic_Count file contains:
      - Link, Anode, Bnode
      - Volume of traffic from A to B and B to A



Link Sum Utility

- LinkSum
  - Takes as input the microsimulator link delay file and outputs various summaries and analyses including:
    - *TOP_100_LINK_VOLUMES*
    - *TOP_100_LANE_VOLUMES*
    - *TOP_100_PERIOD_VOLUMES*
    - *TOP_100_SPEED_REDUCTIONS*
    - *TOP_100_TRAVEL_TIME_RATIOS*
    - *TOP_100_VOLUME_CAPACITY_RATIOS*
    - *TOP_100_TRAVEL_TIME_CHANGES*
    - *TOP_100_VOLUME_CHANGES*



Credits and Acknowledgements

- Parts of this training materials were based on AECOM training (Traffic Assignment, June 28, 2007)
- GIS visualization materials were mostly developed at Argonne based on the TRANSIMS tools developed by AECOM for USDOT
- Chicago road and transit network data used in some of the examples was provided by the Chicago Metropolitan Agency for Planning
- USDOT provided the funding for the development of these training materials
- USDOT provided the funding for the TRACC computing center and the resources necessary to perform these training session