Chapter 1

TRANSIMS OVERVIEW

CONTENTS

TRANSIMS OVERVIEW

1.1 Introduction

The Transportation Analysis and Simulation System, or TRANSIMS, is an integrated system of travel forecasting models designed to give transportation planners accurate and complete information on traffic impacts, congestion, and pollution. It was developed by Los Alamos National Laboratory to address new transportation and air quality forecasting procedures required by the Clean Air Act, the Intermodal Surface Transportation Efficiency Act, and other regulations.

1.2 Background

The urban travel demand models developed in the mid 1950s provided accurate and precise answers to the planning and policy issues being addressed at that time, which mainly revolved around expansion of the highway system to meet the rapidly growing travel demand. However, urban transportation planning and analysis has undergone changes over the years, while the structure of the travel demand models has remained largely unchanged except for the introduction of disaggregate choice models beginning in the mid-1970s. Legislative and analytical requirements that exceed the capabilities of these models and methodologies have driven new technical approaches such as TRANSIMS.

TRANSIMS is part of the Travel Model Improvement Program (TMIP) sponsored by the U.S. Department of Transportation, the Environmental Protection Agency (EPA), and the Department of Energy. TMIP is a multi-year, multi-agency program designed to improve both analytical tools and the integration of these tools into the transportation planning process. TMIP was created in order to increase the ability of existing travel forecasting procedures to respond to emerging policy and technology issues. Moreover, it also redesigns the travel forecasting process to reflect changes in behavior, responds to greater information needs placed on the forecasting process, and takes advantage of changes in data collection technology. In addition, TMIP integrates forecasting techniques into the decision making process, providing better understanding of effects of transportation decisions. TMIP has focused on both short-term and long-term improvements to models and planning procedures. The short-term improvements concentrate on changes to the existing four-step modeling process. TRANSIMS is a long-term effort to redesign the modeling process from the ground up.

The goal of TRANSIMS is to develop technologies that can be used by transportation planners in any urban environment. TRANSIMS will offer transportation planning agencies increased policy sensitivity, more detailed vehicle-emission estimates, and improved analysis and visualization capabilities. The philosophy underlying TRANSIMS is that to study the transportation system's performance effectively, one needs to simulate travel in a study area with a rather fine temporal and spatial resolution. Other research and development efforts have also come to the conclusion that the next generation of urban travel models should be based on simulation and they should employ the activity-based approach to travel demand modeling.

To run a microsimulation, individuals and their activity-travel pattern are required. To generate synthetic households and people in these households, TRANSIMS uses census data and land use data. TRANSIMS tracks individuals, households, and vehicles, not zonal aggregation of households and employment as do existing models. TRANSIMS also attempts to synthesize complete activity-travel pattern for synthetic populations in order to create a virtual study region with a complete representation of the real world. TRANSIMS builds a model of households and activity demand.

TRANSIMS not only synthesizes the individual and their activities, but also creates the transportation network and the trip route satisfying single activity carried by an individual. The model also forecasts how changes in transportation policy or infrastructure might affect those activities and trips. TRANSIMS tries to capture every important interaction between travel subsystems, such as an individual's activity plans and congestion on the transportation system. For instance, when a trip takes too long, people find other routes, change from car to bus or vice versa, leave at different times, or decide not to do a given activity at a given location.

The modules developed for TRANSIMS contain many significant advances beyond four-step models. For example, TRANSIMS simulation observes the movement of individuals and vehicles second by second throughout the entire day rather than total travel for various periods. This movement represents realistic traffic dynamics produced from interactions of individual vehicles. The regional microsimulation uses vehicle interactions to produce operating speeds, intersection operations, and vehicle operating conditions for each vehicle in the system instead of deterministic equations. The TRANSIMS microsimulation permits very detailed analysis of traffic operations on the transportation network. This capability could be used to evaluate improvements such as traffic signal plans and ramp metering.

To identify traffic congestion and emission concentration, every vehicle in the study area should be monitored. Existing emissions models use average speed estimates from the current models. The resulting emissions estimates are insensitive to traffic conditions and lack precision. In contrast, the TRANSIMS emissions module demonstrates how vehicle pollutant emissions and fuel consumption can be estimated based on the operation of individual vehicles as they interact in roadway traffic.

Underlying the development of the TRANSIMS modules has been an effort to tightly couple the functions and data flow among the four modules in the existing four-step modeling process. While it is currently possible to add a microsimulation or an air quality emissions calculation into current forecasting models, such capabilities require considerable post processing. Also, feedback and the careful scrutiny of policy or infrastructure actions are currently difficult to achieve using ad hoc approaches. By integrating all these capabilities in one model, TRANSIMS overcomes many of the limitations that transportation professionals currently experience.

1.3 TRANSIMS Framework

TRANSIMS consists of a series of modules that produce synthetic households, activities for individuals within these households, the choice of routes for movements among these activities, and the microsimulation of these movements to create traffic dynamics on the network, and consequently produced emissions estimation as shown in Figure-1.1. The TRANSIMS framework allows each module to be executed in any desired order by a set of scripts specified by the user in the Feedback Controller. TRANSIMS starts with creating the identity of individual synthetic travelers and maintaining them throughout the entire simulation. All synthetic travelers are generated by the Population Synthesizer module using census data, land use data, and network data.

After the Population Synthesizer module estimates the number of synthetic households, the demographic characteristics of each individual of these households, and the locations of these households on the network, the Activity Generator creates an activity list for each synthetic traveler. Activities include work, shopping, school, etc. These activity estimations are based on the activity survey demographic characteristics of individuals, and from the survey data. In addition, activity times and activity locations are determined for each individual.

The Route Planner module then computes combined route and mode trip plans to accomplish the desired activities of each individual, such as work, shopping, etc. The Traffic Microsimulation module uses the intermodal paths developed in the Route Planner module to perform a regional microsimulation of vehicle interactions. The microsimulation continuously computes the operating status, including locations, speeds, and acceleration or deceleration of all vehicles throughout the simulation period. The output can provide a detailed, second by second history of every traveler in the system over a 24-hour period. Every motor vehicle in the study area is monitored in this manner to identify traffic congestion and emission concentrations, which is done by the Emissions Estimator module. The Emissions Estimator module provides the data for the air quality analysis. Using the vehicle information generated in the microsimulation module, the emissions module forecasts the nature, amount, and location of motor vehicle emissions. .

Finally, the Feedback Controller module manages the feedback of information among the Activity Generator, the Route Planner, and the Traffic Microsimulator modules of TRANSIMS as shown in

Figure-1.1. This feedback controller module uses decision rules to determine things like what percentage of the regional trips should be fed back between modules, which trips should be fed back, how far back the trips should go for replanning, and when to stop iterating to reach stability in the results. As in the traditional assignment methodologies, the Route Planner may place more vehicles on links than the capacity of the link allows, this may cause congestion to spill back onto other links. Results of the microsimulation in these cases can be fed back to reroute selected travelers to stabilize this situation.

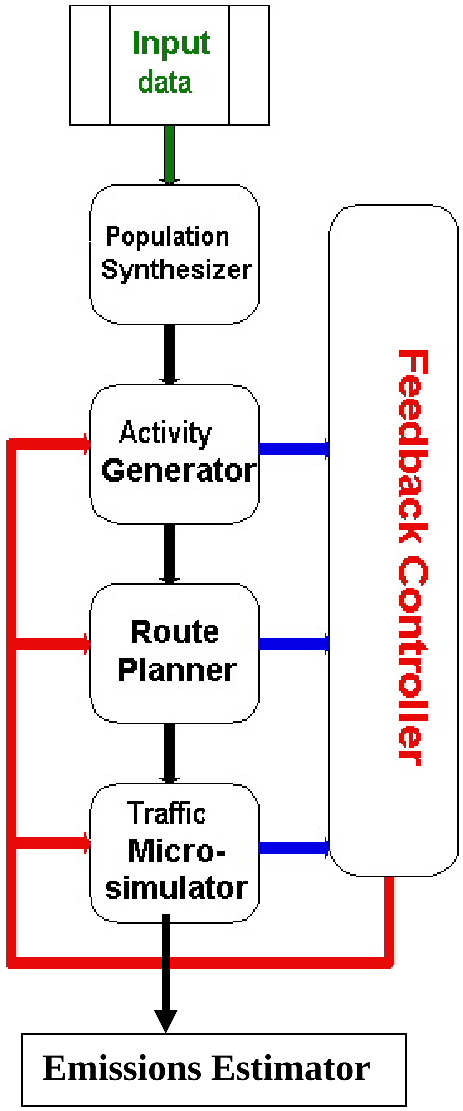

Figure-1.1: TRANSIMS framework

1.4 TRANSIMS Input

In order the make the travelers in the synthetic households imitate the travel and driving behavior of real people, TRANSIMS obtains information regarding the real population from census data to create the identity of individual synthetic travelers in the simulation. There are two types of census data that TRANSIMS uses, one is the US Census Bureau Public Use

Microdata Samples (PUMS), the other is the Standard Tape File 3A (STF-3A). PUMS data consists of a 5% representative sample of complete census records (Long Form) from those households contained in a collection of census tracts or other small geographic census areas. STF-3A data (Short Form) contains one-dimensional demographic summaries data for small geographic areas such as census tract or census block groups.

Other input data are the TRANSIMS networks. TRANSIMS networks contain detailed information about the number of lanes, presence of turn pockets and merge lanes, lane-use restrictions, high-occupancy-vehicle lanes, turn prohibitions, and speed limits on each link of the network. TRANSIMS also requires data on the location and type of signalized intersections in order to produce realistic traffic flows.

Further input data are land-use data, traveler activity surveys, itinerant travelers, and zone-to-zone specific information. All the input files are described in the next chapter. A summary of the network tables is shown in Table-1.1. The next section briefly describes the main functions of each module in TRANSIMS.

Table-1.1: Network Data Files

Network Table
Node
Link
Speed
Pocket Lane
Lane Use
Parking
Barrier
Transit Stop
Lane Connectivity
Turn Prohibition
Unsignalized Node
Signalized Node
Phasing Plan
Timing Plan
Detector
Signal Coordinator
Activity Location
Process Link
Study Area Link

1.5. Module Description

1.5.1 Population Synthesizer Module

The Population Synthesizer module in TRANSIMS uses Census data to build synthetic households for the study area, and also uses land use data to locate the households relative to the transportation network. The output of the Population Synthesizer module is synthetic households with a set of information associated with each household, and each individual living in that household. It also provides the household location in the TRANSIMS network including how many vehicles belong to each household. The data input and output for the Population Synthesizer can be summarized as shown in Figure-1.2.

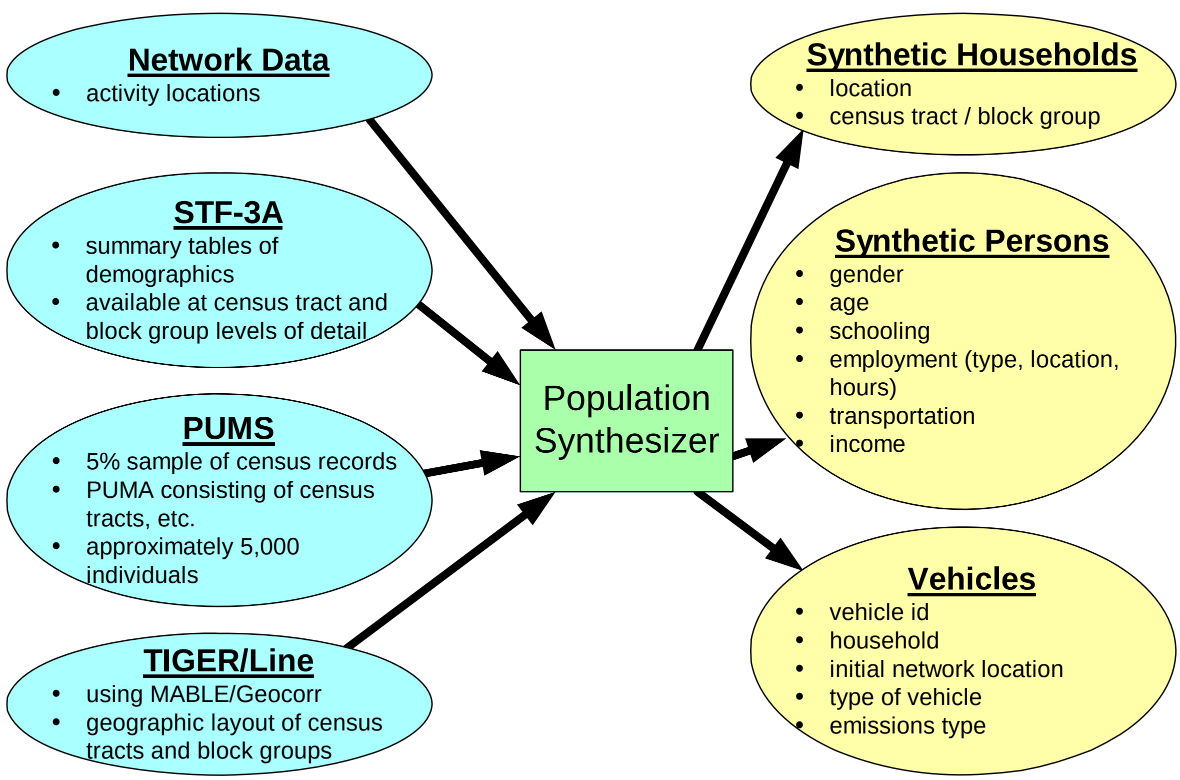

Figure-1.2: Input/Output flow for Population Synthesizer data

Synthetic households are usually generated for a block group within a census tract, and each synthetic household is classified as family, non-family, or individuals living in group quarters such as dormitories. Each individual has an associated set of demographics which may consist of age, income, status, etc. These demographics are matched closely to the demographics of the real household. An example of the demographics of a real household obtained from census data is shown in Figure-1.3.

			
Age	26	26	7
Income	$25k	$18k	$0
Status	Worker	Worker	Student
Automobile			

Figure-1.3: Demographics example of a real household

Using the census data from STF-3A and PUMS, the population synthesizer can estimate a proportion of real households for each block group in each demographic category. Synthetic households are formed for each block group according to these proportions. TRANSIMS not only creates synthetic households but also matches the demographics between synthetic households and real households. This includes household structure, individuals' incomes and ages, employment status, and student status as shown in Figure-1.4.

After the synthetic households are created, they are distributed spatially to approximate regional population distribution. The Population Synthesizer places these households to activity locations on the walk link of the TRANSIMS network according to land use characteristics associated with the activity locations on that link, as shown in figure-1.5.

Demographics of a real household

No. in Household: 3	
Person 1	
Sex:	Male
Age:	26
Income:	$25 k
Status:	Worker
Person 2	
Sex:	Female
Age:	26
Income:	$18 k
Status:	Worker
Person 3	
Sex:	Male
Age:	7
Income:	$0 k
Status:	Student

Generated demographics of synthetic households

No. in Household: 3	
Person 1	
Sex:	Male
Age:	32
Income:	$34 k
Status:	Worker
Person 2	
Sex:	Female
Age:	24
Income:	$16 k
Status:	Worker
Person 3	
Sex:	Male
Age:	5
Income:	$0 k
Status:	Student

No. in Household: 3	
Person 1	
Sex:	Male
Age:	28
Income:	$30 k
Status:	Worker
Person 2	
Sex:	Female
Age:	26
Income:	$24 k
Status:	Worker
Person 3	
Sex:	Male
Age:	4
Income:	$0 k
Status:	Student

Figure-1.4: The Population Synthesizer matches the demographics of real household to synthetic households

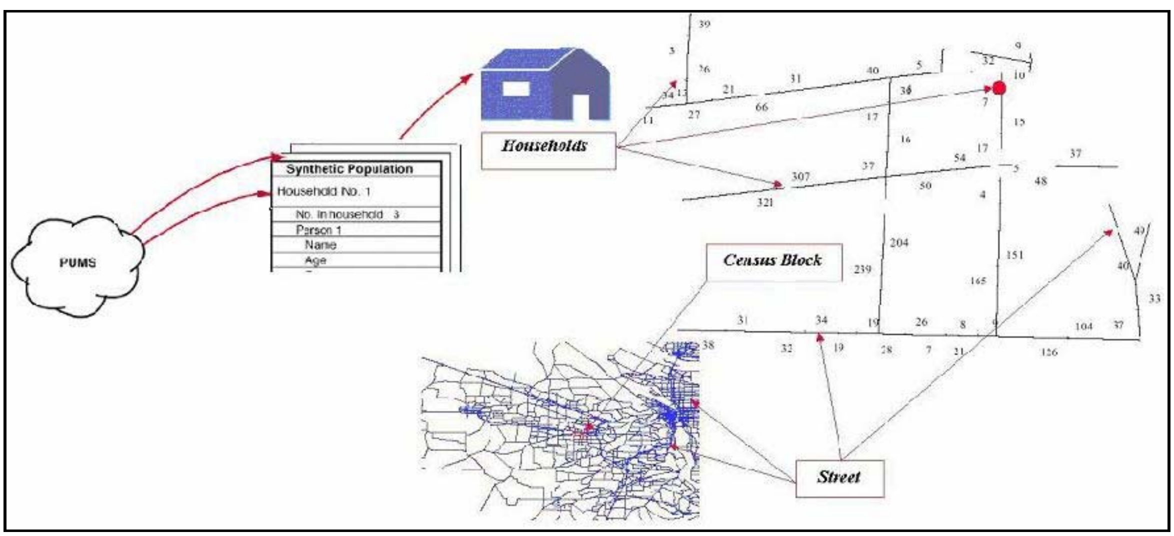

Figure-1.5: The Population Synthesizer creating synthetic households and placing them on the network

Then, vehicle ownership is generated for each synthetic household as given by the PUMS data.
Figure-1.5 summarizes the functions of the Population Synthesizer module. It uses the census data from PUMS and STF-3A to generate synthetic household and the vehicles corresponding to each household, and then locates these synthetic households on the TRANSIMS network using the land use and network data. All the outputs obtained from the Population Synthesizer are used as inputs for the Activity Generator module.

1.5.2 Activity Generator Module

TRANSIMS generates a list of activities for each individual in a synthetic household by using the Activity Generator module. These activities are based on demographic surveys and activity surveys which are collected from the real households in the study area. The demographic survey contains information about characteristics of each individual household in the survey sample of real households, which is used to match the demographic characteristics of the synthetic households obtained from the census PUMS data. The activity survey obtained from the sample of real households includes travel and event-participation information for each individual household member over a period of one or more days. The household activity survey, the synthetic households obtained from the Population Synthesizer module, and the network data constitute the input list to the Activity Generator as shown in figure1.6.

The assignment of activities from survey households to synthetic households is done based on household demographic characteristics. The demographics of synthetic households must match the demographics of the survey households. A classification and regression tree algorithm (CART) is used to group the survey households having similar activity time patterns according to these demographic characteristics. Figure-1.7 shows the grouping of the activity survey households in Portland according to selected demographic characteristics.

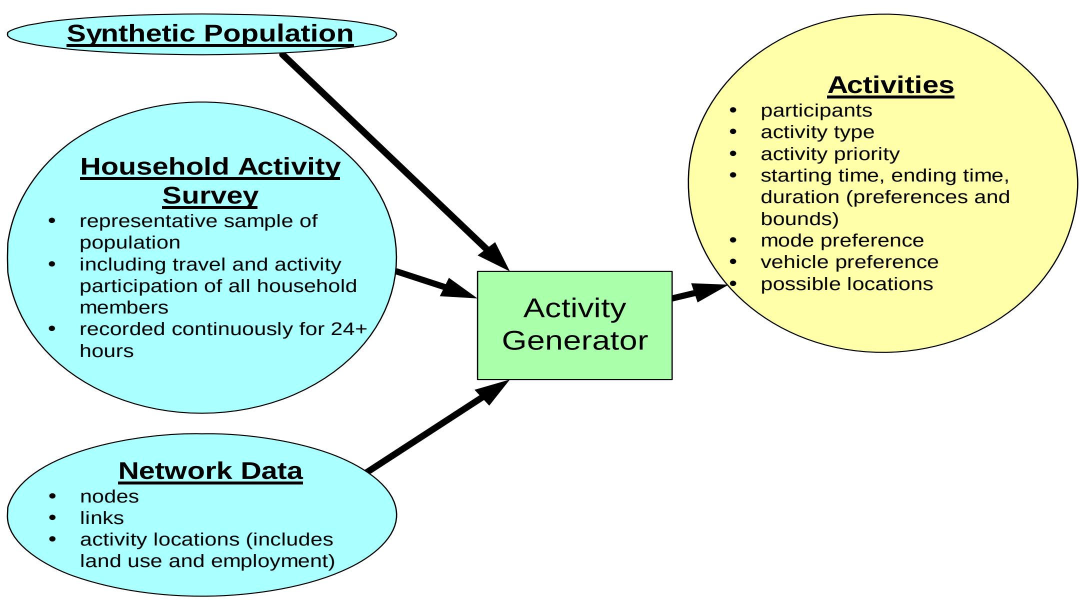

Figure-1.6: Input/Output data flow for Activity Generator

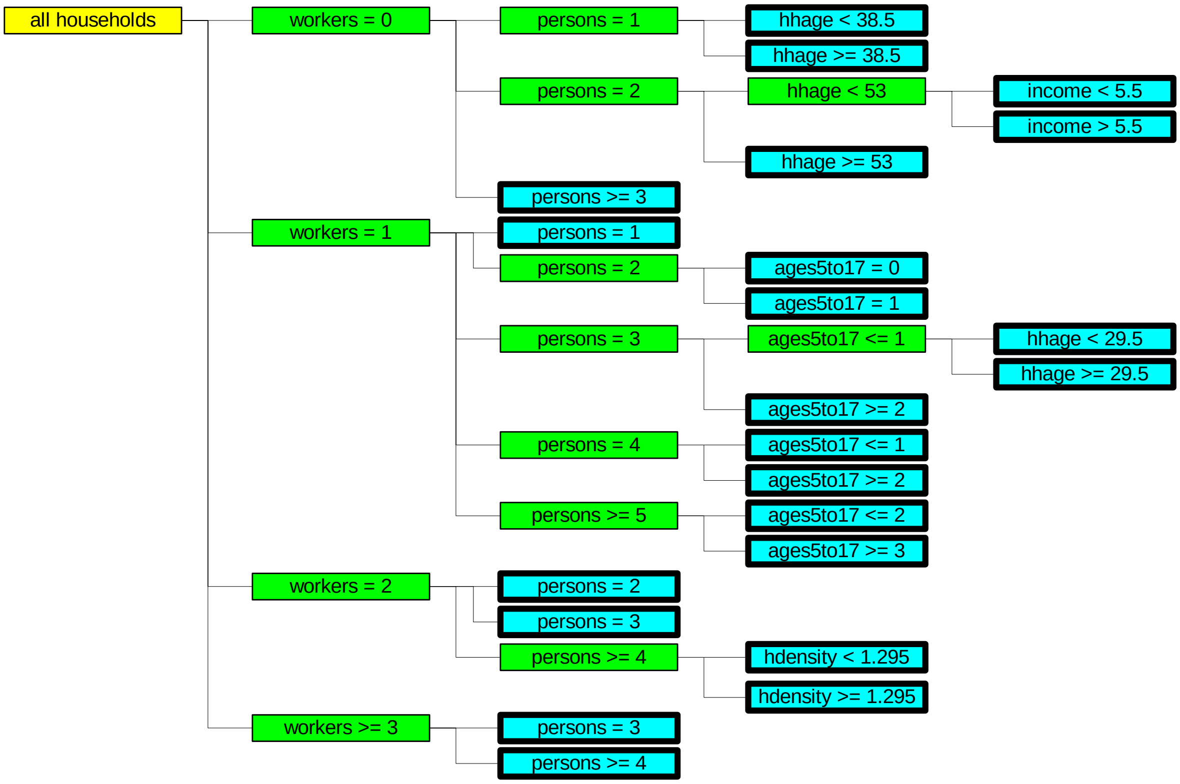

Figure-1.7: Portland CART tree using Household Demographics

The end nodes in this tree represent survey households that have similar activity patterns based on the classified demographic characteristics. The matching is done by selecting a survey household in the end node and giving its 24-hour activities to a synthetic household that has the same demographic path to that end node.

The activity matching is done for each individual member of the synthetic household based on age, gender, and relation. Each activity in the list of activities assigned to each individual has as associated activity type (i.e. work, shopping, school, etc), duration, mode preference, beginning time, and ending time. Figure-1.8 shows an example of the activity list for an individual synthetic household. This household consists of 3 people. The first member, person ID 55728, drives from home to work and then drives back home. The second member, person ID 55729, and the third member, person ID 55730, walk from home to visit and then walk back home. Then, all the members in this household drive to other, shop, and back home, 55728, the first member, drives the car. Any two activities in TRANSIMS, separated by time and location, have travel required between them. Therefore, a travel mode between activities is also assigned, for example, car, bus, walk, etc. However, the Route Planner searches for the best of all possible modes to execute the travel between two activities. To locate the non-home activities, TRANSIMS uses a model that considers the zonal attractiveness value, the travel times between activities, and the intensity of activities within the zone.

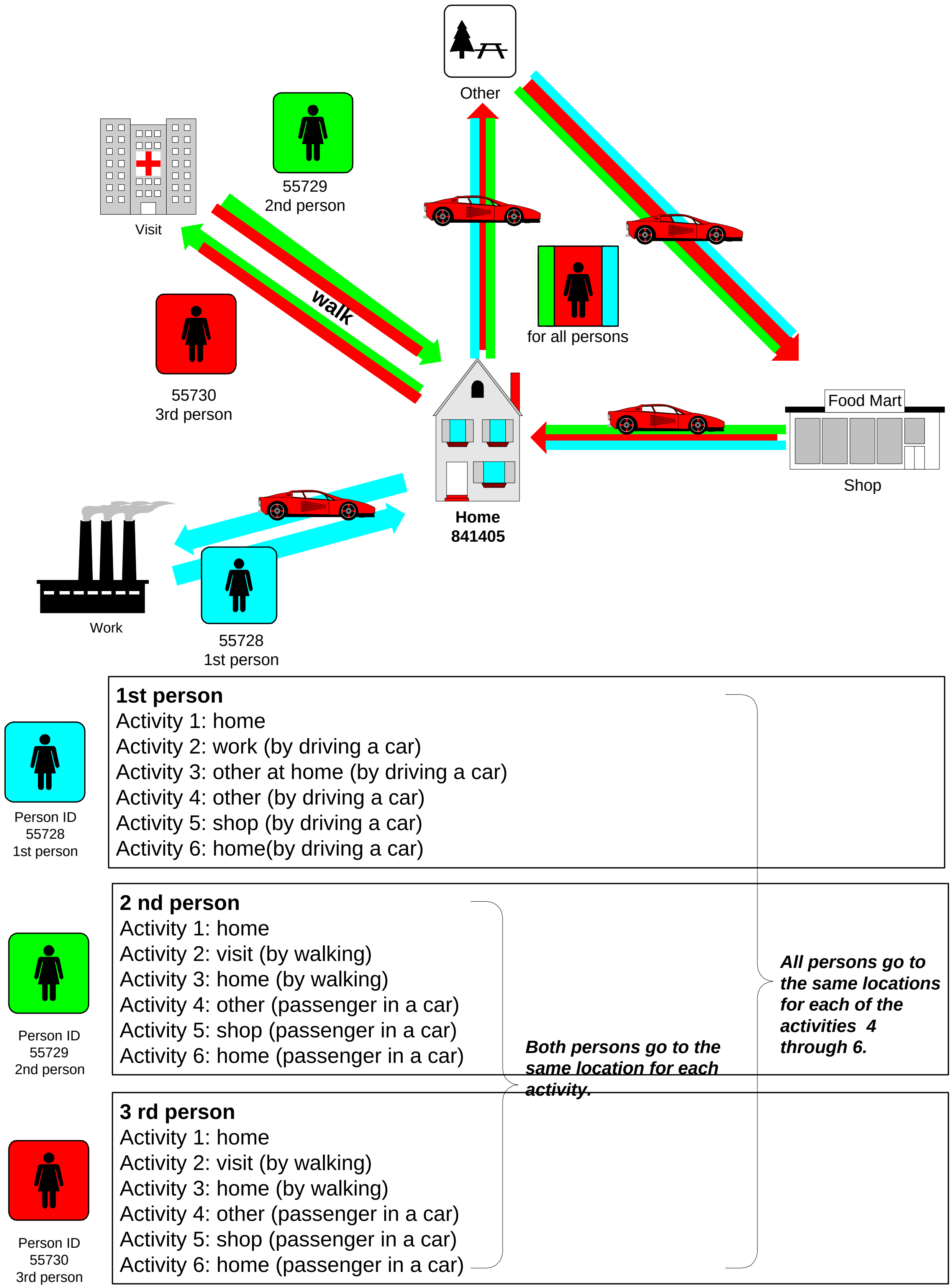

Figure-1.8: Example of activity list of a synthetic household in TRANSIMS

1.5.3. Route Planner Module

The Route Planner module in TRANSIMS produces route plans for every individual according to the activity list generated by the Activity Generator. Moreover, the Route Planner selects the shortest-time path in the network for each individual trip. In addition to the activity list from the Activity Generator, the inputs to the Route Planner module include TRANSIMS network (Transit data and Network data), the vehicle file, and the link travel times as feedback from the microsimulator as shown in Figure-1.9.

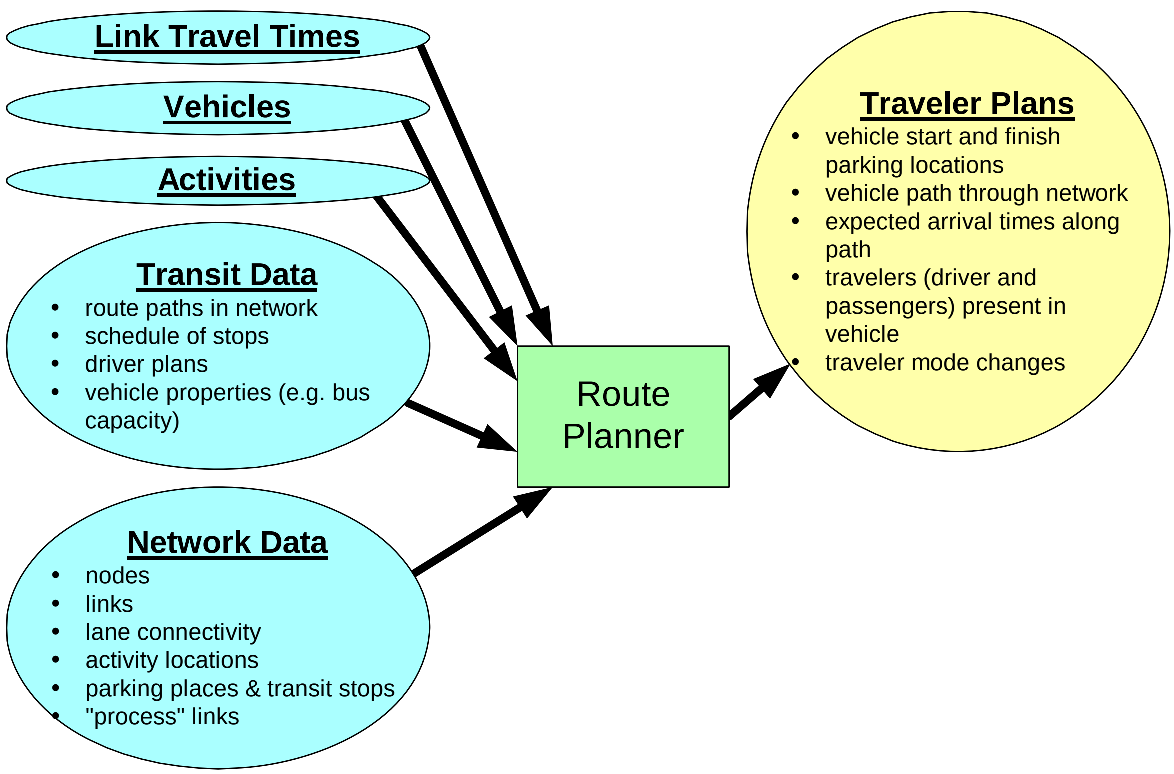

Figure-1.9: Input/Output flow data of Route Planner module

TRANSIMS assumes that people in the real world choose their paths by selecting the shortest time path, under an upper time limit constraint obtained from the activity survey data. Therefore, TRANSIMS creates a unique algorithm called a label-constrained, time-dependent shortest path which is a modification of Dijkstra's algorithm in order to select routes for each trip plan of an individual member of a synthetic household. For example, a trip plan may consist of a trip from home to work, from work to shopping, and then from shopping to home. Each trip plan is a set of trips that represent each individual's movement between his/her desired activities through the network. Each trip may consist of several legs that are composed of nodes and links which are traversed with a single travel mode. Each leg starts and ends at an activity location, parking location, or transit stop.

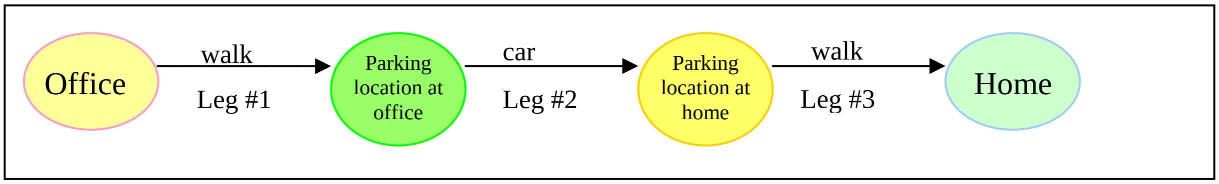

Figure-1.10: A trip from office to home consist of several legs

Figure-1.10 shows an example of a single trip from office to home. It contains a walking leg from the actual office location to the parking lot, a car leg to parking at home, and a walking leg from the parking place to the house. It can be represented as mode string of walk-car-walk or as "w-c-w". The first leg uses the walk mode from the office building to the parking lot at office. The second leg uses the car mode from the parking lot located at office to the parking lot located at home. The third leg uses the walk mode from the parking lot to home.

In order to find the route for each traveler, the Route Planner transforms the TRANSIMS network to an Internal Planner network for routing purpose. The TRANSIMS network provides information about streets, intersections, signals, parking, activity locations, and transit modes within a road transportation network. Route Planner uses this information to construct the Internal Planner Network which consists of nodes, link, travel time on each link, and the possible travel mode on each link. The Route Planner views the network as a set of layers, each of which belong to a mode, as is shown in Figure-1.11.

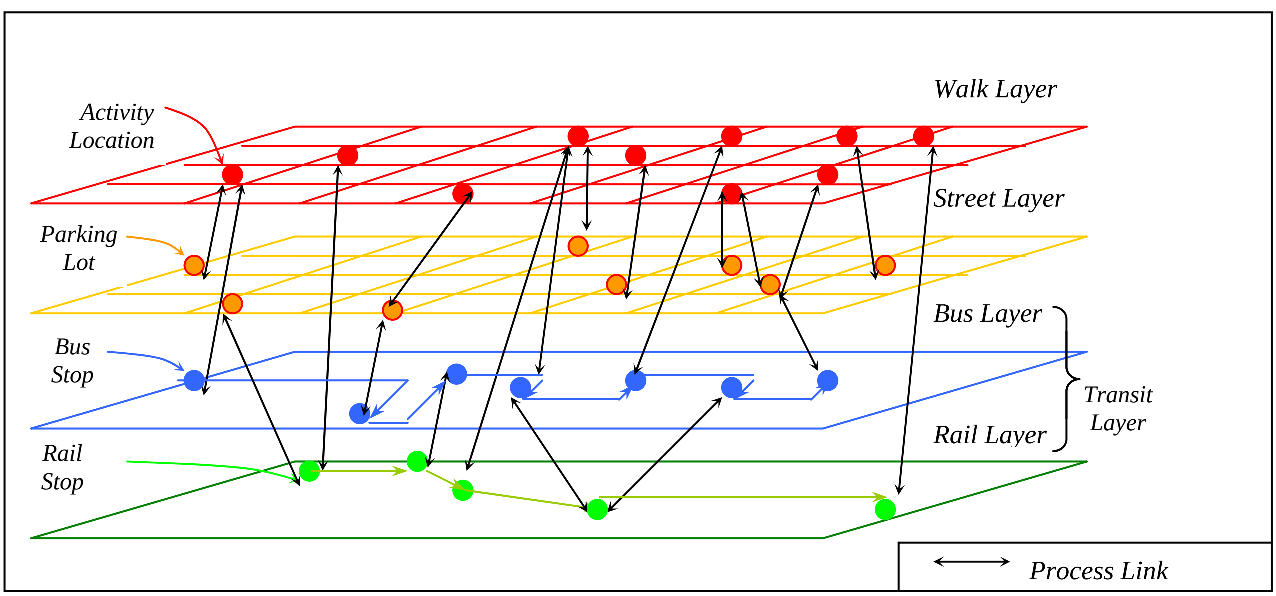

Figure-1.11: Internal Planner Network

To illustrate this transformation between the TRANSIMS network and the Internal Planner Network, an example is displayed in Figure-1.12 and Figure-1.13. This example depicts the TRANSIMS network representation of two streets with a bus stop, and an activity location on each street. The transit layers can be split into many different transportation layers such as bus route 1 layer, bus route 2 layer, rail 1, etc. Figure-1.12 shows a bi-directional street link in the TRANSIMS network between street nodes 1 and 2 and nodes 3 and 4. Figure-1.13 shows the constructed Internal Network for this example.

There are two bus routes connecting the bus stops. Note that each bus stop in Figure-1.12 splits into three nodes in Figure-1.13. For example, a bus stop *BS*1 in Figure-1.12 splits into a node for the bus shelter for passengers (*S*1), a node for the bus-stop place for the bus route 1 ($BS1_{R1}$), and a node for the bus-parking place for the bus route 2 ($BS1_{R2}$).

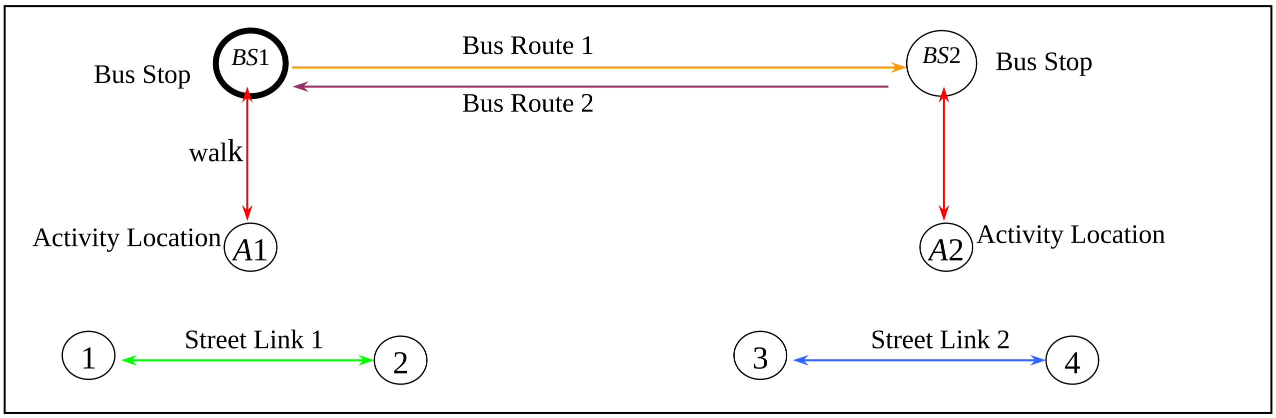

Figure-1.12: TRANSIMS network representation of two streets with a bus stop and an activity location on each street. There are two bus routes connecting the bus stops

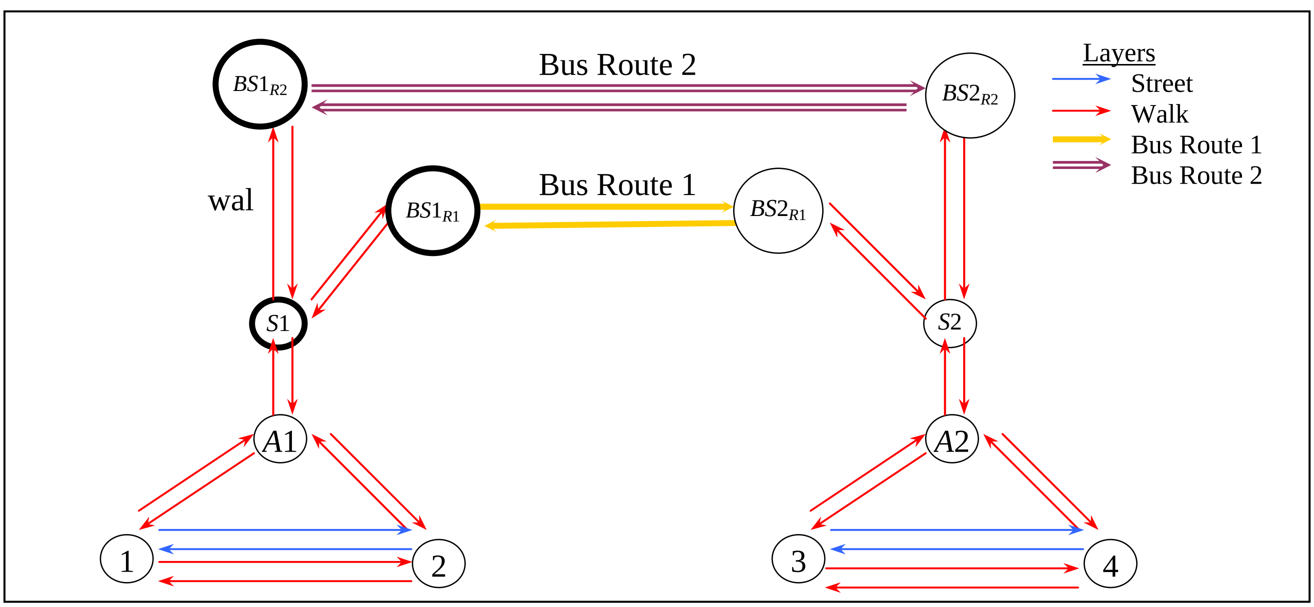

Figure-1.13: The Internal Network representation corresponding to Figure-1.12

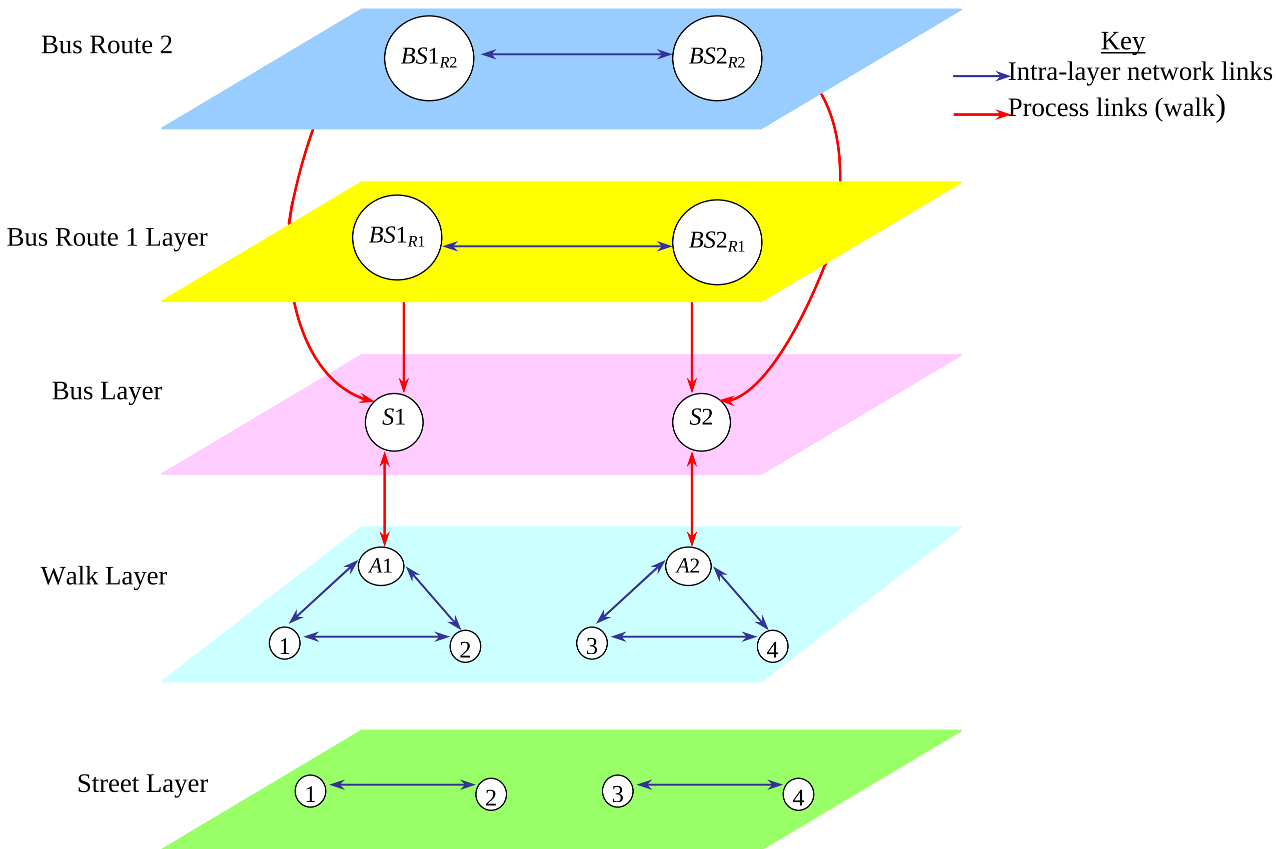

Figure-1.14: Layers of the Internal Network corresponding to Figure-1.13

Figure-1.14 illustrates the layers of the Internal Network corresponding to Figure-1.13. There are five different layers in this Internal Network. All activity locations are always placed on the walk layer, while the intersection nodes and parking location are placed on the street layer. The bus layers contain the bus stations, and the two bus route layers. Conceptually, nodes 1, 2, 3, and 4 appear in two different layers, the walk layer and the street layer even though these appearances correspond to the same nodes in the TRANSIMS network. Generally, each activity location is attached to a corresponding parking location and/or transit stop. Each parking or transit stop must be explicitly connected to appropriate activity locations in the walk-network using process links.

We can explain how the Route Planner uses information about a trip in Figure-1.10 to build the network in the following way. The first leg of the trip is the walking leg in which the Route Planner searches for possible paths within the walking layer of the network to obtain a walking route from the walking location to the parking location of the individual's vehicle.

When such a path is found, a series of least-cost driving links in the street layer are found to obtain a route to a parking location near his house. A walk route is then developed to move the traveler from the parking lot to his home.

Trips that cannot meet each individual's goal are fed back to the activity list to choose a new activity time or location or mode for travel to the activity. When all trip plans are done, TRANSIMS passes this information to the Traffic Microsimulator in order to execute these plans.

Figure-1.15 shows the shortest route obtained from the Route Planner. This figure has been obtained from the Output Visualizer module.

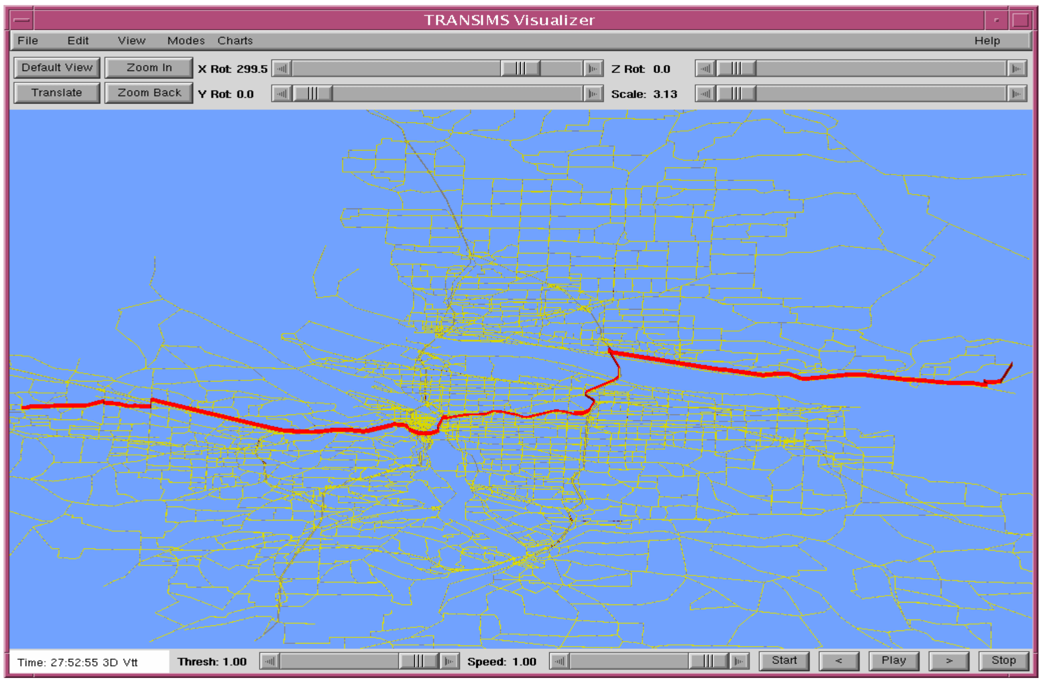

Figure-1.15: A Single route viewed with the Output Visualizer

1.5.4 Traffic Microsimulator Module

The Traffic Microsimulator module in TRANSIMS executes travel plans and computes the overall intra- and inter-modal transportation system dynamics. The Traffic Microsimulator is updated every second to ensure that dynamic vehicle behaviors are captured with enough fidelity to generate realistic overall traffic behavior. Interactions of travelers produce emergent traffic behaviors such as traffic congestion which consequently are used to compute vehicle emissions. The input and output data flow of the microsimulation is shown in Figure-1.16. The input of the Traffic Microsimulator module consists of the TRANSIMS network, vehicle file, and traveler plans obtained from the Route Planner.

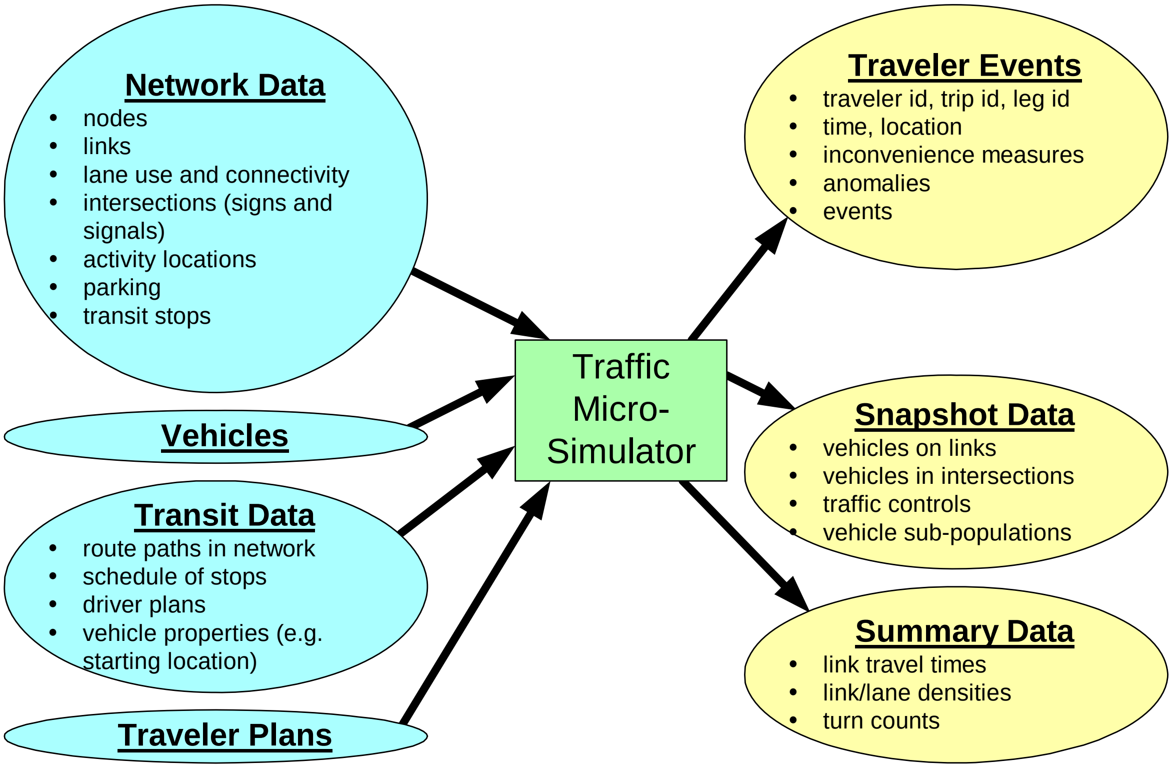

Figure-1.16: Input/Output flow data of Traffic Microsimulator module

Each individual moves from one activity to another according to the plan obtained from the Route Planner, using combinations of modes such as walking, driving, or riding in a vehicle. All vehicle movements are simulated in detail to include driving on roads, stopping for signals, accelerating, decelerating, changing lanes, stopping to pick up passengers, etc.

Vehicles follow a set of rules that guarantee that no vehicle collisions will occur. This movement is accomplished by using a cellular automata principle. Each section of roadway is divided into cells as shown in

Figure-1.17. Each cell either contains a vehicle or is empty. Simulation is carried out in discrete timesteps. For each second, the vehicle decides whether to accelerate, brake, or change lanes in response to the nearby vehicles in the grid. The simulation guarantees that each vehicle makes decisions based on the state of every other vehicle in its surroundings at the same time.

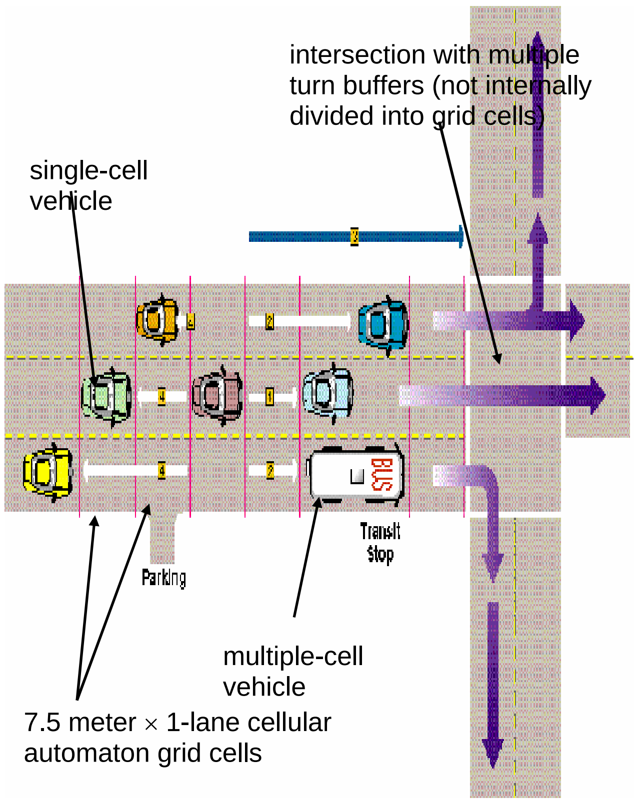

Figure-1.17: Cellular Automaton Microsimulation

There are three major types of output from the Traffic Microsimulator.

Figure-1.18 shows traveler events output data which report almost everything that happens to a traveler.

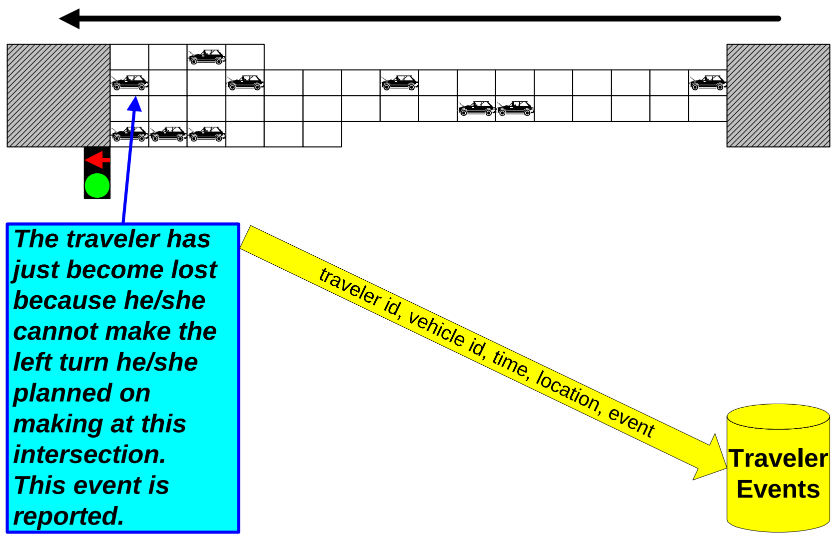

Figure-1.18: Traveler events output

Figure-1.19 shows summary data which consist of spatial and temporal data. Spatial summaries include data aggregated over user-defined sections of roadway along the street networks, for example, densities and total flow in a 150-meter section. Temporal summaries include data about travel times along streets at various times of day.

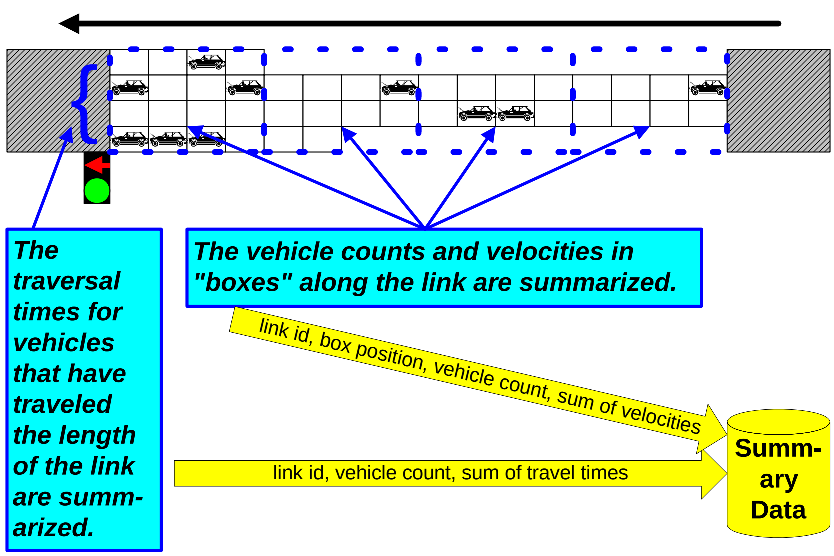

Figure-1.19: Summary data output

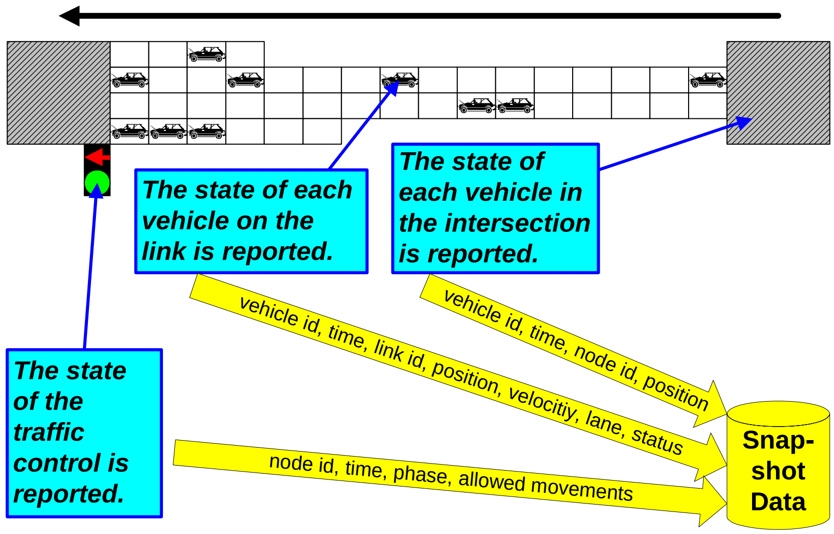

Figure-1.20: Snapshot data output

Traffic animation can be produced from the snapshot files, which contain time, position, and velocity information for each vehicle in the simulation as shown in

Figure-1.20. The Traffic Microsimulator snapshot data may be displayed dynamically. The individual vehicles are shown as they move on the transportation network. Figure-1.21 is a picture of a single timestep obtained from the Output Visualizer.

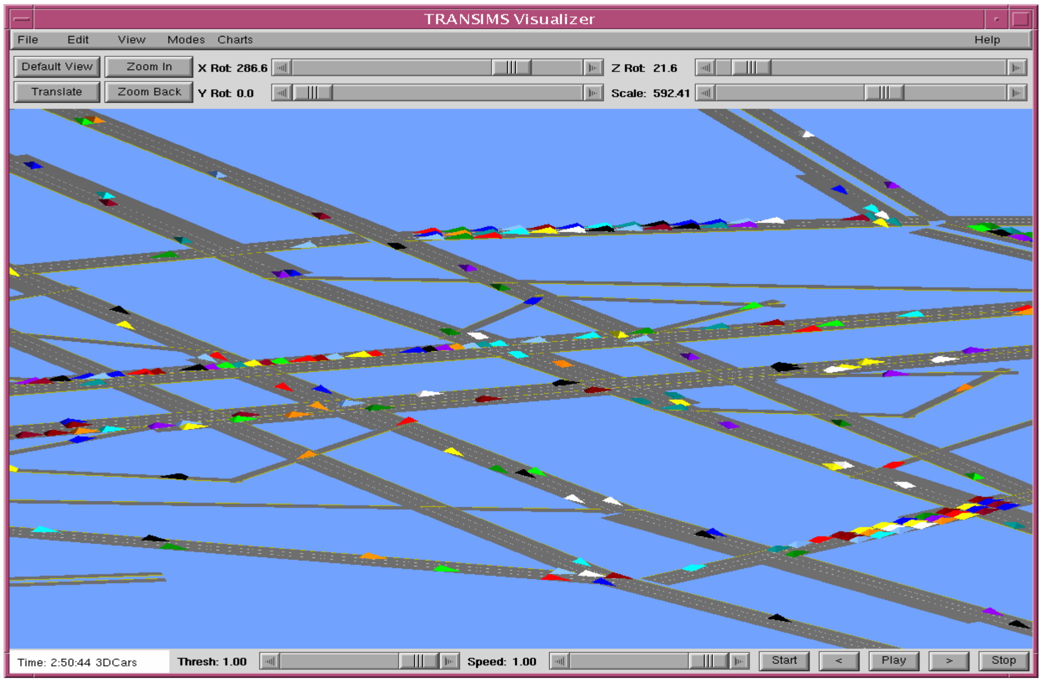

Figure-1.21: The Output Visualizer shows the dynamic second-to-second movement of vehicles on the roadway network

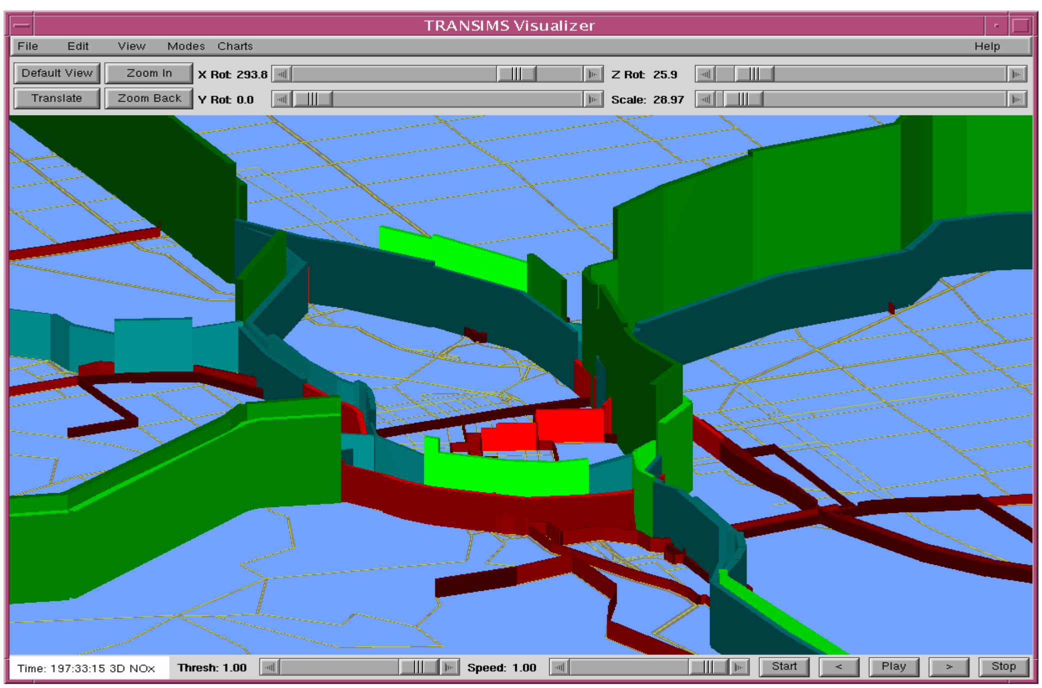

Figure-1.22: Multiple routes are overlaid in time to show predicted congestion points

Planned routes are overlaid in time and displayed in Figure-1.22. These show potential congestion points on the roadway network. Figure-1.23 shows the traffic density over a short time period where red indicates areas where the traffic is heaviest. All Traffic Microsimulation output forms a basis for environmental calculations, such as emissions, and for iteration decision-making.

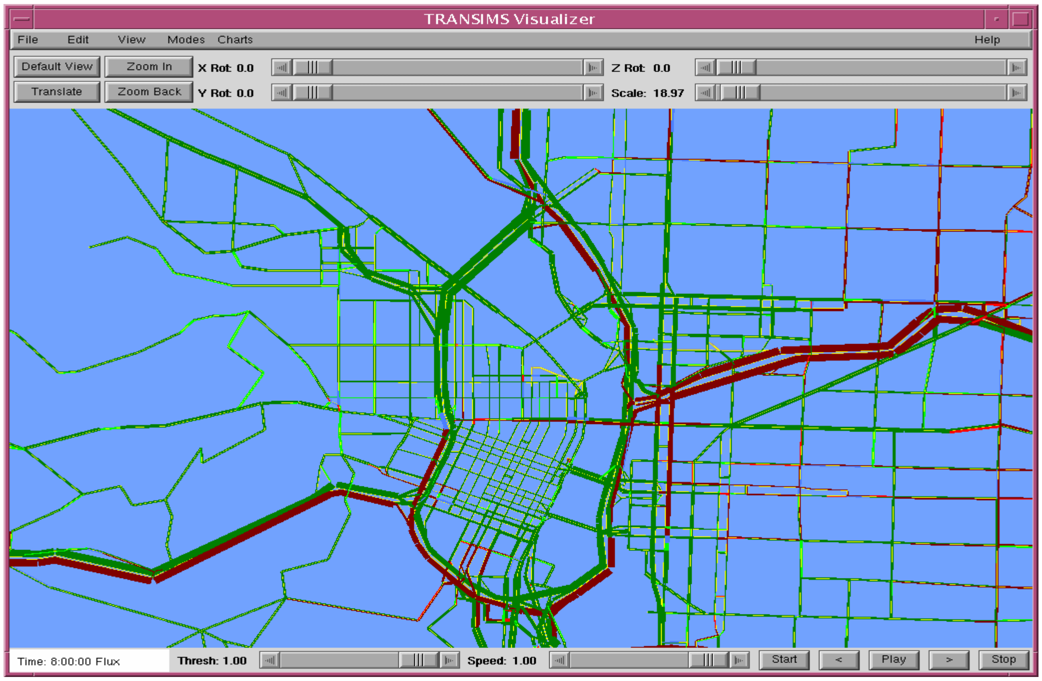

Figure-1.23: Traffic density from the Traffic Microsimulator over a shot time period

1.5.5 Emissions Estimator Module

The Emissions Estimator is used to translate traffic dynamics from microsimulator into consequent air quality, energy consumption, and pollutant emissions. It uses results from the Traffic Microsimulator to predict tailpipe for light and heavy-duty vehicles and evaporative emissions for light duty vehicles. These emissions are aggregated to inform overall regional air quality estimates produced by regulatory emissions models.

The Emissions Estimator demonstrates a power-based emissions model linked with the results of a traffic microsimulator. It does not replace the EPA models and it is not sensitive to technology or policy changes. While the Emissions Estimator's results may provide useful insight into the relative impacts of changes in a regional transport system, application of these results in a regulatory setting will require careful interpretation.

The Emissions Estimator requires information from the vehicle file, the Traffic Microsimulator output, TRANSIMS network, and external data sets as shown in Figure-1.24. The Emissions Estimator output can be used to compute pollution emissions, atmospheric conditions, local transport and dispersion, and chemical reactions. The output data are aggregated on 30-meter segments for each one-hour period. Fuel consumption and CO_2 emissions are also estimated.

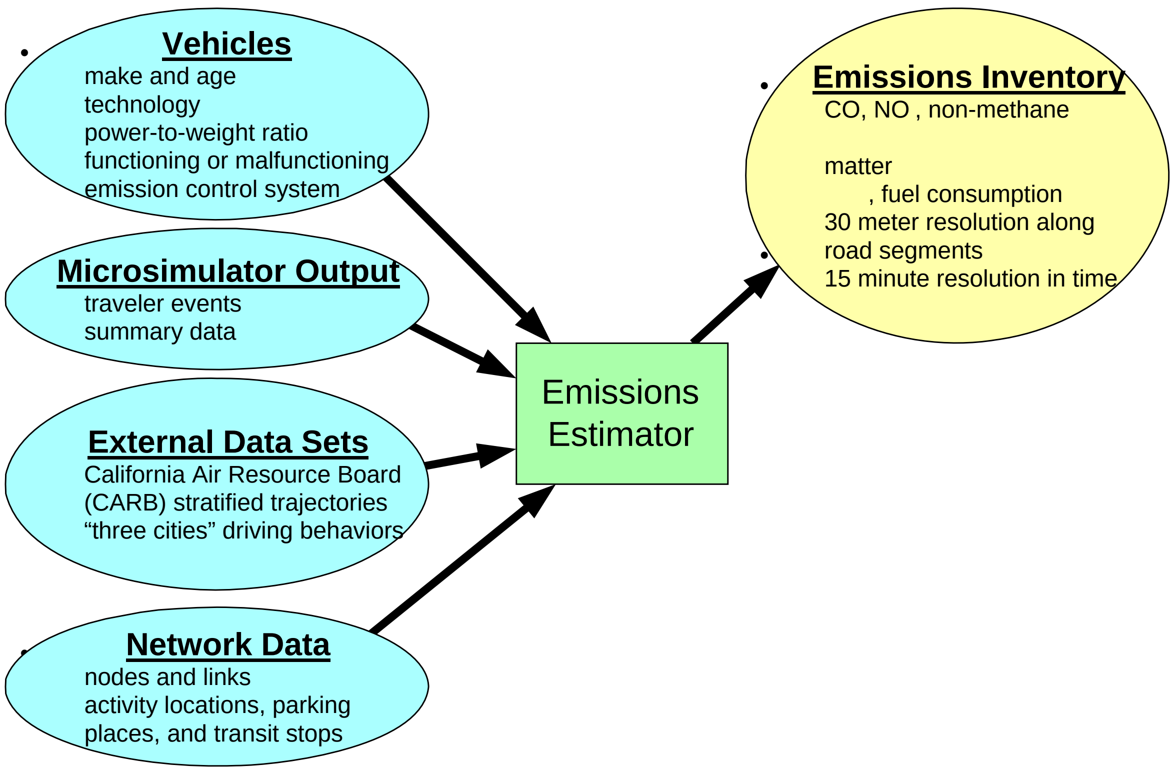

Figure-1.24: Input/Output flow data of Emissions Estimator

The Emissions Estimator is designed to produce fleet average emissions rather than emissions from individual vehicles. It uses continuous approximations for densities, and thus requires that many vehicles be considered over at least a one-hour period in order for appropriate statistics to be developed.

The Emissions Estimator requires information on fleet composition, vehicle loads, and traffic patterns. The Population Synthesizer provides vehicle fleet characteristics, including the fraction of the fleet that is malfunctioning. The Traffic Microsimulator produces the traffic patterns. The TRANSIMS Emissions Estimator module is divided into three submodules which are Tailpipe Emissions from light-duty vehicles (LDVs) and heavy-duty vehicles (HDVs), and Evaporative Emissions.

LDV Tailpipe Emissions submodule treats tailpipe emissions from cars, small trucks, and sport-utility vehicles. LDV fleet composition is given in the vehicle file from the Population Synthesizer. Twenty-three categories of vehicles in this file reflect such characteristics as engine-to-weight ratio and catalyst type. The LDV Tailpipe submodule treats emissions from malfunctioning vehicles, off-cycle driving, normal driving, and vehicles with cold engines and/or cold catalyst. Fleet status is developed from the pattern of usage of the vehicles traversing a given link. Fuel consumption is a function of the temperature of the engine and its catalytic converter. The Traffic Microsimulator records when and where the vehicles have been operating on an individual vehicle basis. Consequently, the fraction of the fleet in various phases of cold engine/cold catalyst operation can be estimated from the vehicle origins and links traveled. Predictive models of tailpipe emission can be developed by using good estimates of vehicles' continuous power output and the type of vehicle. The continuous power is proportional to the product of its velocity and acceleration which can be obtained from TRANSIMS microsimulator.

The HDV Tailpipe submodule treats tailpipe emissions from trucks and buses. Truck emissions are not sensitive to as many power levels as LDVs emissions since they are sensitive to the load carried by the vehicle. However, truck emissions are sensitive to power demands associated with accelerations, climbing grades, and hauling heavy loads. The traffic Microsimulator counts each type of vehicle in each speed bin for each 30-meter segment of each link over 15-minutes average period of the simulation. The HDV tailpipe submodule estimates emissions for the HDVs with specified loads, speeds, grades, and acceleration categories.

The TRANSIMS Evaporative Emissions module deals with emissions that are caused by the evaporation of the fuel in vehicles. This module considers both normally operating vehicles and vehicles with significant leaks in the fuel system. The Evaporative Emissions module takes vehicle activity information and activity-specific emissions models from EPA to determine non-operating evaporative emissions value. An age distribution of the vehicles in simulation is also used. The information from the Traffic Microsimulator is used to determine the location of vehicles and also whether it is presently operating or has operated in the previous hour.

1.5.6 Feedback Controller Module

Feedback Controller module is a primary mechanism used to achieve internal consistency among modules. For example, it is used to achieve a reasonable agreement among the travel demands expressed in the activities lists, the travel plans to meet these demands, and the execution of the plans in the Traffic Microsimulator. The Feedback Controller selectively feeds back information from one module to another by using the Collator, Stratifier, and Selector tools. This information is used to modify a designated subset of activities and plans of the synthetic households to achieve realistic overall traffic results.

The goal of the feedback process is to nudge the solution towards Nash Equilibrium. However, the exact solution for Nash equilibrium is infeasible under a microsimulator environment. Therefore, stopping criteria is used when the target has been reached within acceptable tolerance as shown in Figure-1.25.

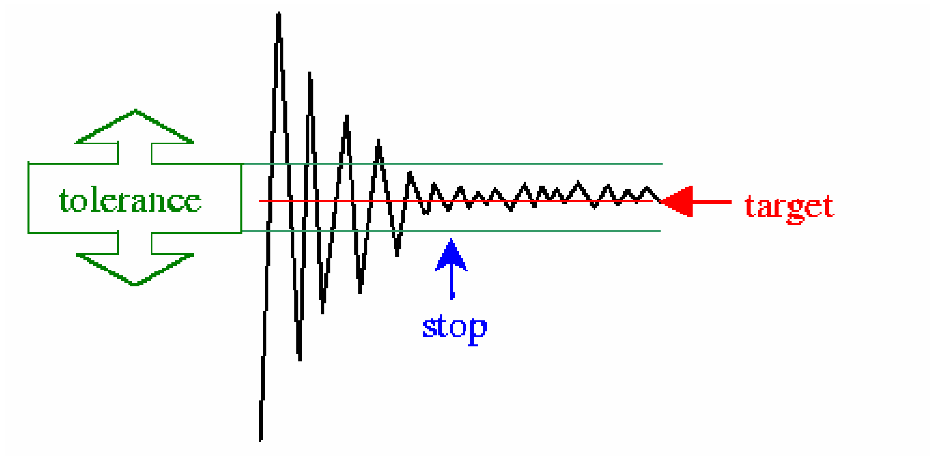

Figure-1.25: Stopping Criteria

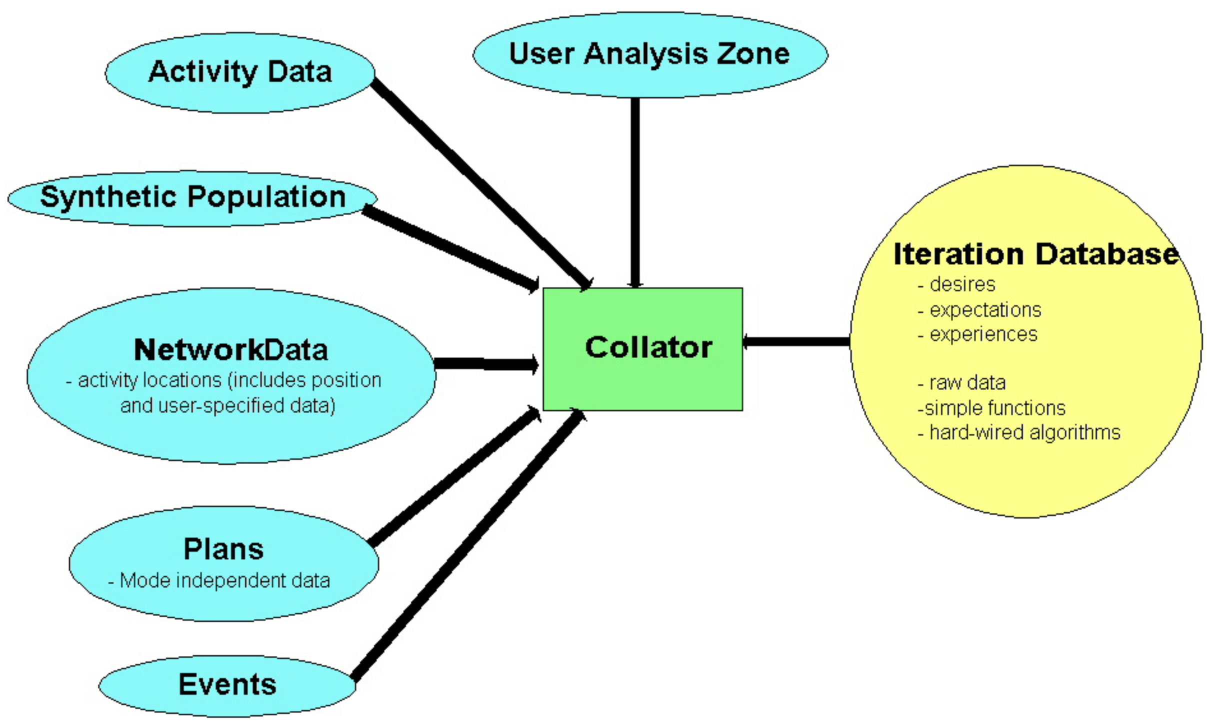

Figure-1.26: Input/output of the Collator in the Feedback Controller

Figure-1.26 shows the input and output data flow for the Collator tool. Output of the Collator can be either raw or derived data. Raw data can be from Population files (person or household demographics), Activity files (type, priority, desired times, participants, mode), Plan files (expected travel times, modes), Event files (actual travel times and distances, number of stops, time stopped, anomalies), and Network data (activity location properties). For output as derived data, it can count the number of legs in a trip, count number of legs using a particular mode in a trip, sum the distance, time, or just the time spent working or waiting, or create a string of characters describing the mode used for each leg (e.g. “wcwtw”). After forming the iteration database, the Stratifier in the Feedback Controller module plays a significant role in categorizing the database.

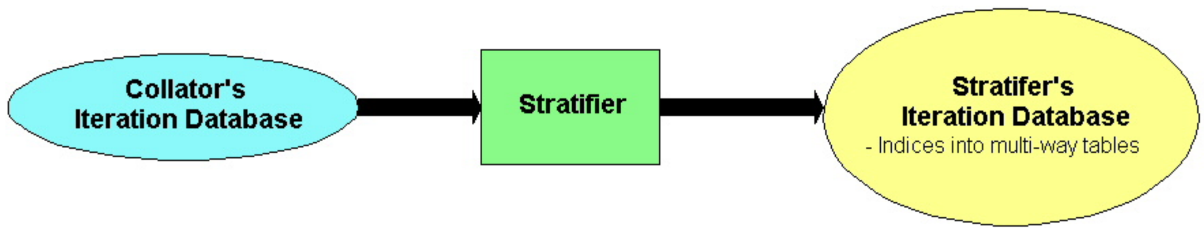

Figure-1.27: The data flow in the Stratifier

The Stratifier discretizes univariate data from the output of the Collator’s iteration database, and then builds multi-way tables where each cell corresponds to a set of bins. Figure-1.27 shows the data flow for the Stratifier tool in the Feedback Controller module.

The Selector in the Feedback Controller uses the Collator’s iteration database and the Stratifier’s database as inputs of the Selector as shown in Figure-1.28. The Selector uses this information in completing the decision-making process for all of the travelers. It decides whether to regenerate the activities, replan the routes, or resimulate the travelers plans by running TRANSIMS to recalculate the updated activity set, the plan set, or the microsimulation output files, respectively.

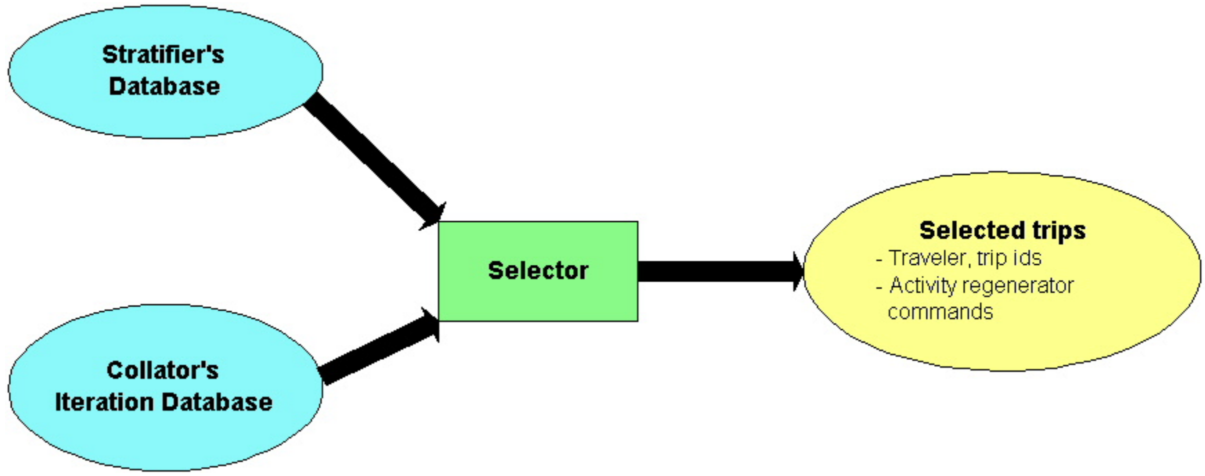

Figure-1.28: The data flow of the Selector

The flexibility of the TRANSIMS framework allows for variations on the selection process described above by using tools of the Feedback Controller module. For example, some tools of the Feedback Controller may run again after the Activity Generator or Route Planner completes its execution in order for the Feedback Controller to decide which of the activities or plans just generated will be accepted for travelers. One can also design selectors that will feed travelers to the Activity Generator or Route Planner one-by-one so that the Feedback Controller, Activity Generator, Route Planner, and Traffic Microsimulator all execute simultaneously with their coordination controlled by the Feedback Controller. This may increase the computational efficiency of a study and allow for new experimental designs with finely controlled iteration.

Several selector implementation scripts have been written that have been used in the demonstration studies of TRANSIMS. For example, Figure-1.29 shows a typical iteration scheme that is setup by the Selector script.

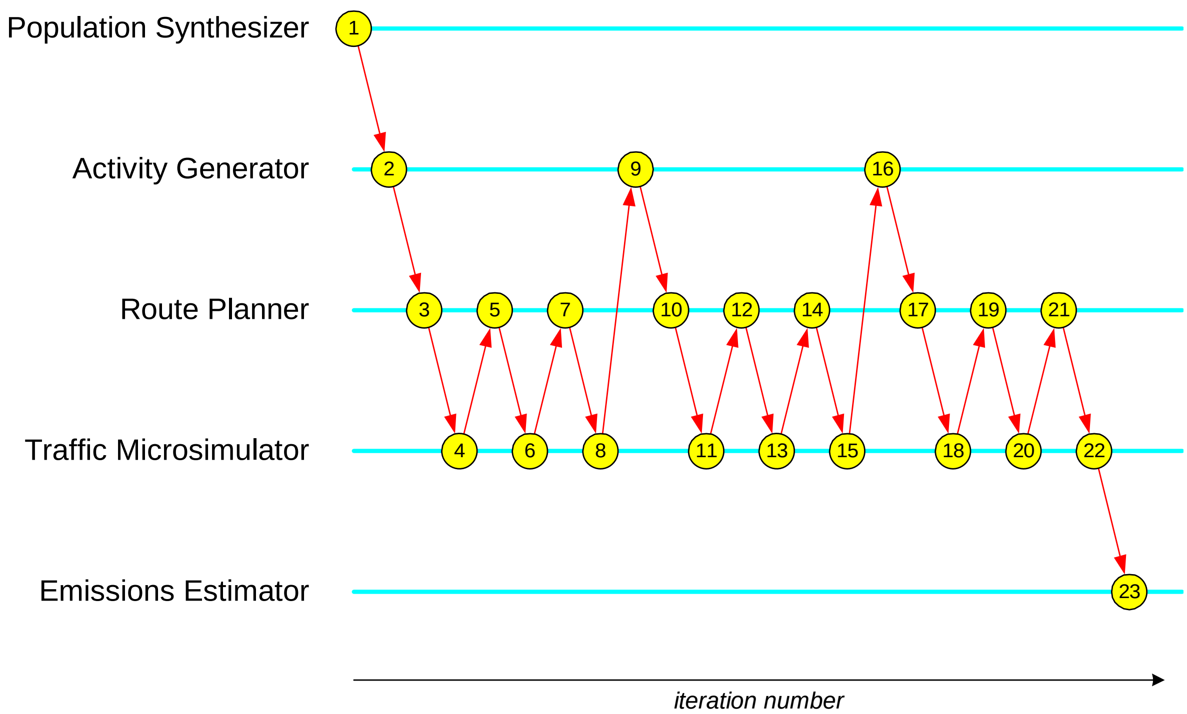

Figure-1.29: a typical iteration scheme set up by Feedback Controller scripts

In this scheme, the Activities Generator, the Route Planner, and Traffic Microsimulator are treated until traffic behavior on the network stabilizes. TRANSIMS requests the Population Synthesizer, Activity Generator, Route planner and Traffic Microsimulator to be run in iterations 1, 2, 3, and 4. For iterations 9, and 16, TRANSIMS reads the iteration database, identifies households containing travelers who are more than 15 minutes late for their work activity, and then requests the Activity Generator to be run for those households. TRANSIMS reads the iteration database, identifies travelers who are more than 5% late for any activity, and then requests the Route Planner to be run for those travelers for iterations 5, 7, 10, 12, 14, 17, 19, and 21. The Traffic Microsimulator is run for iterations 6, 8, 11, 13, 15, 18, 20, and 22. TRANSIMS stops at iteration 23 after the Emissions Estimator is run.

The Feedback Controller controls when modules are run and how the data are routed between modules as an iterative process. A typical TRANSIMS study involves repeated iteration between modules. There is no single, standard selector component because different study designs involve different iteration schemes. A variety of selectors have uses in different studies or other contexts.

Not only is the Feedback Controller used to control the iteration process, but also it allows the overall computational system to abstractly reflect learned behavior within the synthetic households. In TRANSIMS this synthetic traveler emulates the ability of humans to learn from day-to-day experiences in order to avoid congestion.

For the conclusion, the Feedback Controller is mainly used to calibrate component models, to drive the system towards a Nash equilibrium, to forecast the response to changes subject to constraints, and to examine the demographics of affected travelers.

1.5.7 Output Visualizer Module

One of the most important analysis techniques is graphical visualization of the results of a study. TRANSIMS allows an analyst to view and animate data generated by other TRANSIMS modules, and provides a unified and flexible means for exploring the voluminous output data potentially available by using Output Visualizer. The data flow for the Output Visualizer is shown as in Figure-1.30.

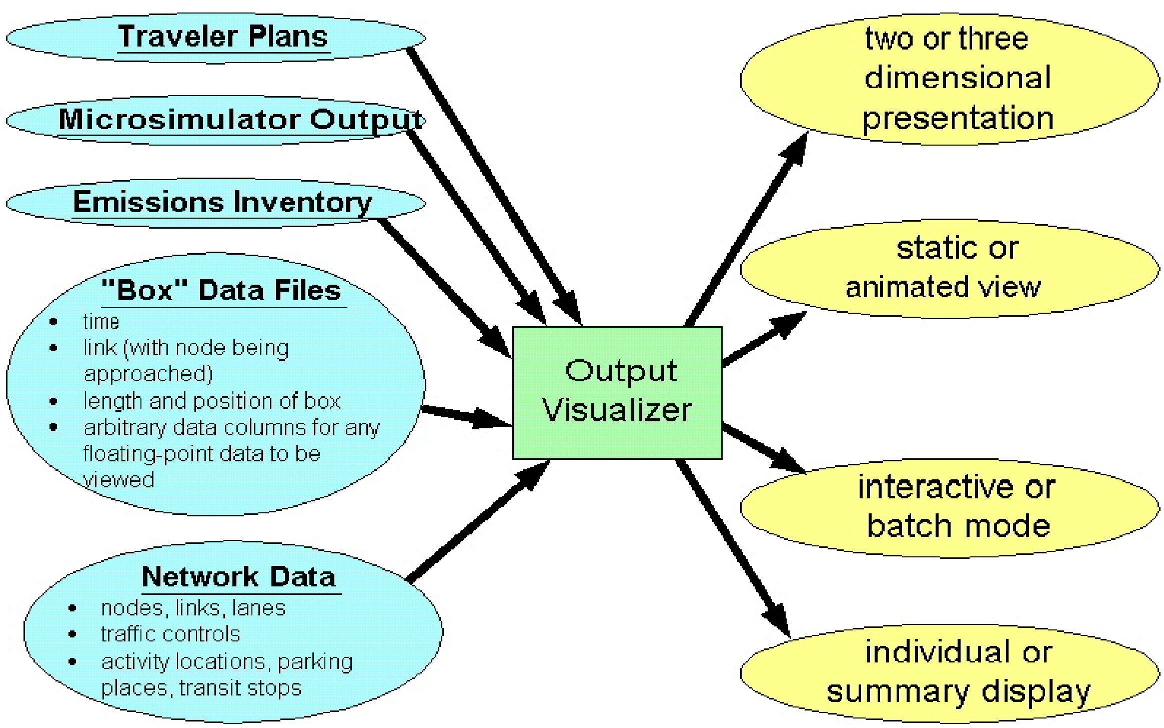

Figure-1.30: The data flow of the Output Visualizer module

All displays are both temporally and spatially dynamic. The spatial areas may be located and the display zoomed to give better viewing. Moreover, all displays may be stepped through time to assess the changing characteristics of the roadway network. Examples of the Output Visualizer are shown in Figure-1.15, Figure-1.21, Figure-1.22, and Figure-1.23 which are in the Route Planner and the Traffic Microsimulator modules.

The TRANSIMS framework can be summarized as follows: TRANSIMS is a flexible software system for transportation planning studies or experiments. The TRANSIMS framework supports the future growth of TRANSIMS technology. The TRANSIMS framework provides tools for manipulating the information and controlling iterations between modules. TRANSIMS does not provide cookbook recipes, each city has unique aspects. There are many approaches to doing each forecast, it depends on what we need to study or to get from experiments. The data flow in the TRANSIMS framework can be summarized as in Figure-1.31.

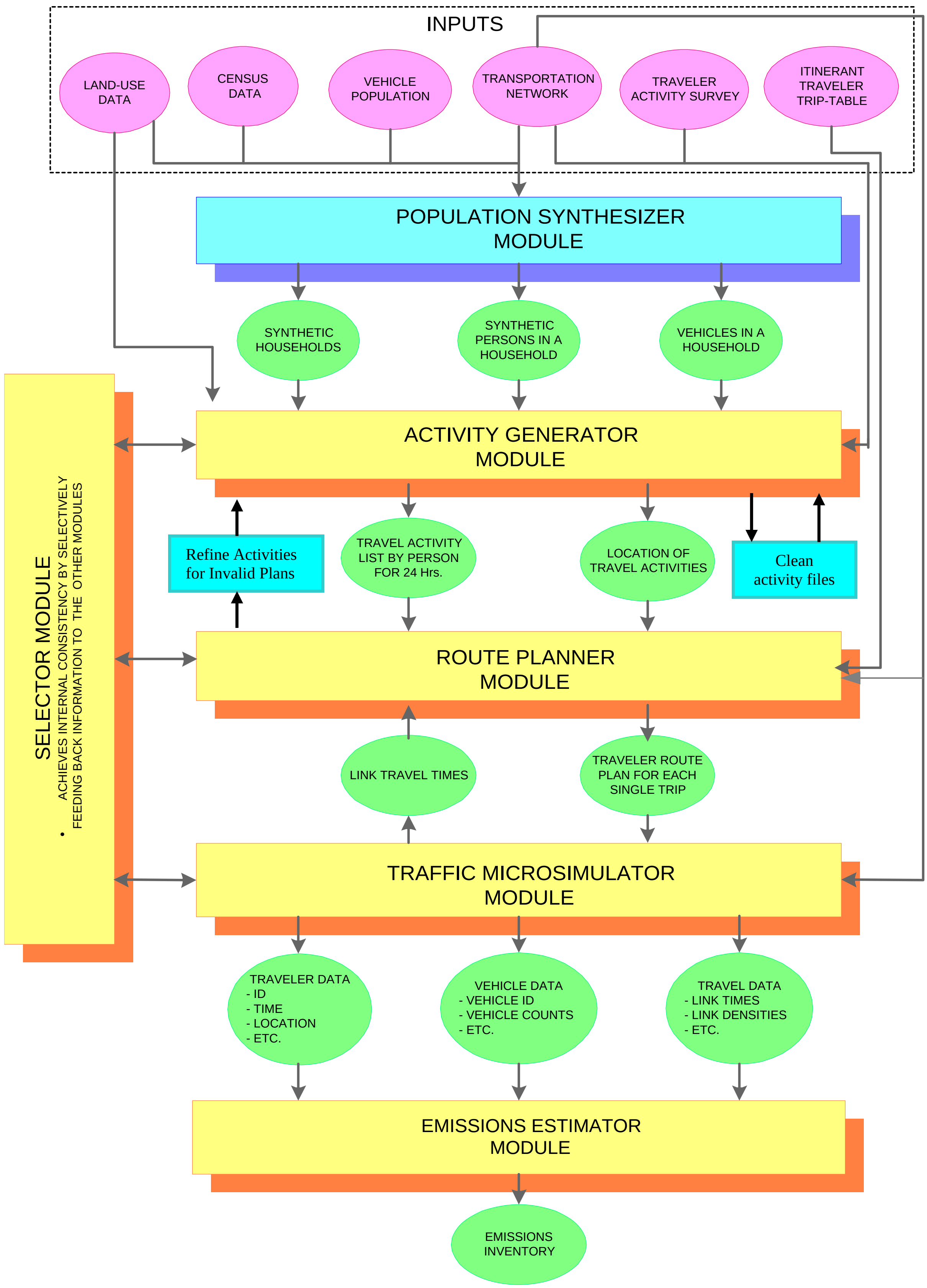

Figure-1.31: The data flow in TRANSIMS framework