Transportation Survey

Introduction

The first stage in the formulation of a transportation plan is to collect data on all factors that are likely to influence travel pattern. The work involves a number of surveys so as to have an inventory of existing travel pattern, an inventory of existing transportation facilities and an inventory of existing land use and economic activities. It also helps in the building up of a local authority database used for policy & priority determination or in allocating costs & income on a jointly operated venture.

Definition of the Study Area

Transportation planning can be at the national level, regional level or at the urban level. For planning at the urban level, the study area should embrace the whole conurbation containing the existing and potential continuously built-up areas of the city. The imaginary line representing the boundary of the study area is termed as the 'external cordon'. The area inside the external cordon line determines the travel pattern to a large extent and as such is surveyed in great detail. The selection of the external cordon line for an urban transportation study should be done carefully due to the following factors.

- ❖ The external cordon lines should circumscribe all areas which are already built-up and those areas which are considered likely to be developed during the period of study.
- ❖ The external cordon line should be compatible with previous studies and the area of studies planned for the future.
- ❖ The external cordon line should be continuous and uniform in its course so that movement crosses it once. The line should intersect roads where it is safe and convenient to carry out traffic surveys.

The definition of the study area consists of several steps:

- The delineation of the study area
- The subdivision of the study area into zones
- The definition of zone centroids.

Zoning

The defined study area is sub-divided into smaller areas called zones. The purpose of such a sub-division is to facilitate the spatial quantification of land use and economic factors which influence travel pattern. The data collected on individual household basis cannot be conveniently considered and analyzed unless they are aggregated into small zones. Sub-division into zones further helps in geographically associating the origins and destinations of travel. In large study projects, it is more convenient to divide the study area into sectors, which are sub-divided into smaller zones. A convenient system of coding of the zones will be useful for the study. One such system is to divide the study area into 9 sectors. Each sector is sub-divided into 10 zones. A sub-zone bearing a number 481 belongs to sector 4 and to zone 8 in that sector and is sub-zone 1 in that zone

Zones are modelled as if all their attributes and properties were concentrated in a single point called the zone centroid. The centroids are connected to the nearest road junction or rail station by centroid connectors. Both centroid and centroid connectors are notional and it is assumed that all people have same travel cost from the centroid to the nearest transport facility which is the average for a zone. The intersection from outside world is normally represented through external zones. The external zones are defined by the catchment area of the major transport links feeding to the study area. Although the list is not complete, few guidelines are given below for selecting zones. 1. Zones should match other administrative divisions, particularly census zones. 2. Zones should have homogeneous characteristics, especially in land use, population etc. 3. Zone boundaries should match cordon and screen lines, but should not match major roads. 4. Zones should be as smaller in size as possible so that the error in aggregation caused by the assumption that all activities are concentrated at the zone centroids is minimum. 5. The zones should have a homogenous land use. 6. Natural or physical barriers such as canals, rives etc. can form convenient zone boundaries.

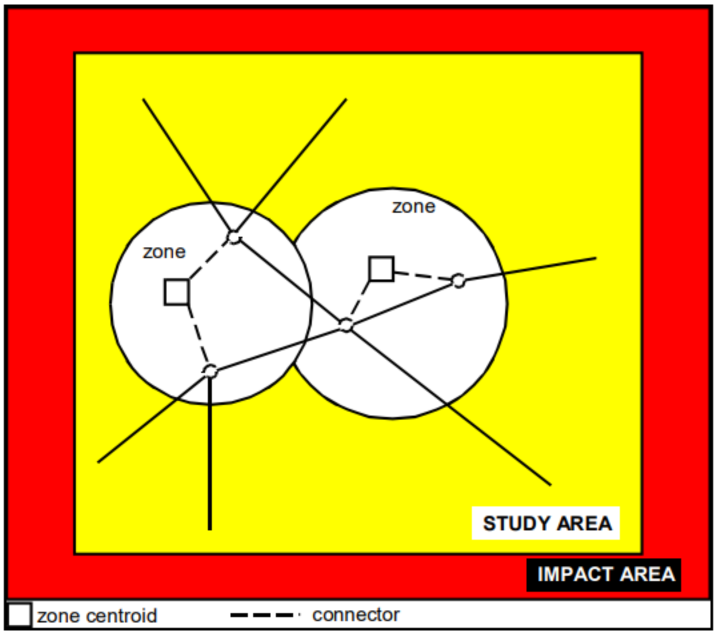

Figure 1. Geographical representation of study area.

With respect to the delineation of the traffic zones there are a number of existing administrative spatial systems that can be used to define zones. This means that a traffic zone most favorably consists of one or more units of such an existing spatial system. Such systems are:

- municipalities
- census districts
- postal districts
- election districts
- etc.

The characteristics of these spatial systems, consisting of data about the geographical definition of the subareas and about their demographic or socio-economic content are available from various official institutions (Ministry of Transport, Chamber of Commerce, etc.). Adopting such data reduces the costs of data collection and system design. In making municipal transportation plans zone sizes of about 1000 to 2000 inhabitants are advised. For cities of the size of Delft this means about 50 traffic zones. For regional studies a maximum of 500 zones is applied.

Zonal form

On the one hand, ideally zones should follow available delineations given by official spatial systems in order to save costs and to increase comparability. On the other hand, traffic zones should have a compact convex form in order to minimize errors in trip distances.

Zonal centroids

A traffic zone is represented by a single point of the zone, called centroid. It is the geographical representation of the zone. It is assumed that all trips start and end in that point. The centroid is part of the modeled transport network. It is a fictitious network node that connects the zone to the surrounding networks. It is linked to the network by so-called connectors which fictitious links are representing the underlying local network not included in the network model. The location of the centroid is chosen such that it is indeed the center of gravity of the zone, which means that its location minimizes the distance and time errors in geographically representing the individual trip addresses (see Figure 2). Interzonal characteristics such as distance or travel times between zones are based on the distances or travel times between the centroids of the zones.

Zonal hierarchy

In most applications a single zoning system is used for all analysis steps. However, different modeling steps may require different zonal systems. Especially the modal choice analysis may benefit from a more detailed spatial description of trips than the other steps. To this end, many studies apply a hierarchy of zones. In applications most National Transportation Model, trip characteristics needed for modal and destination choice analysis are established with a 1200 zone system whereas trip production and traffic assignment work with a condensed 350 zone system.

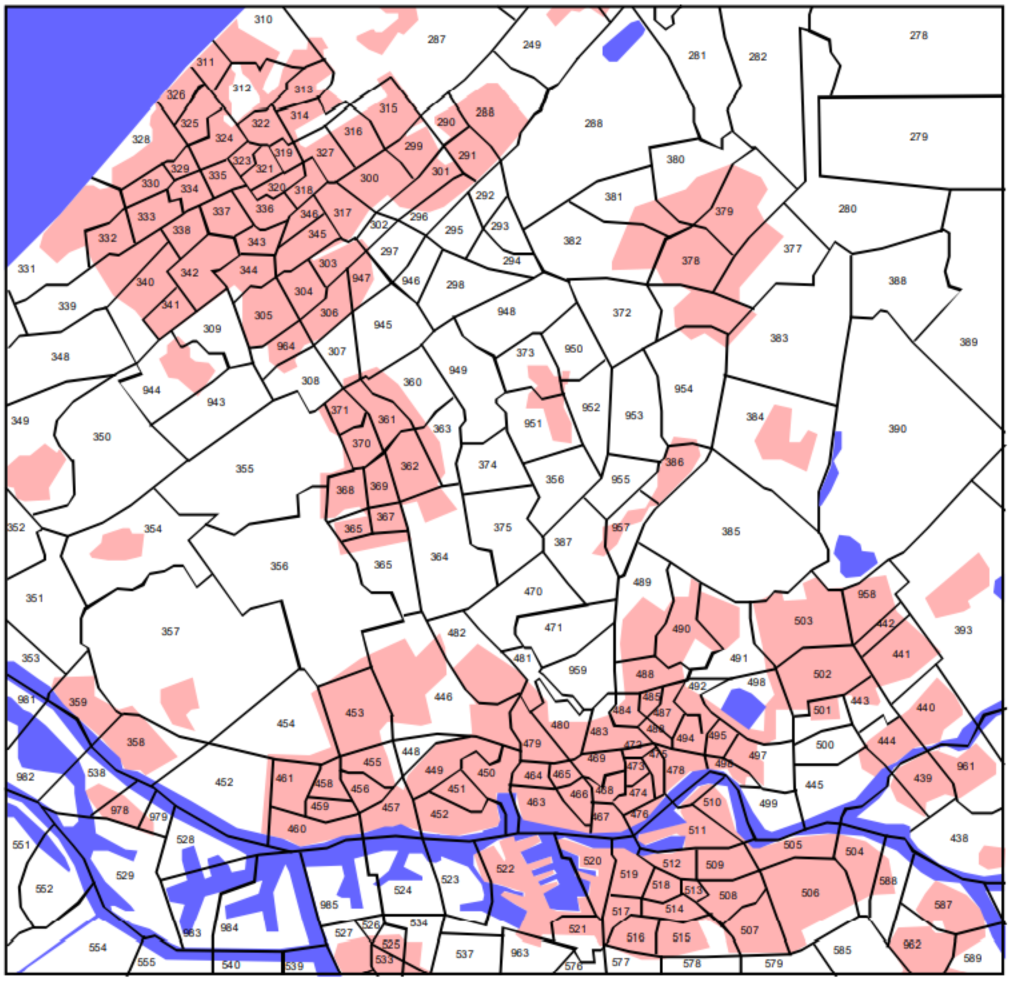

Figure 2: Zonal subdivision of region The Hague-Rotterdam in the Randstad model

Network description

Network types

In most planning cases, the final aim of the analysis is to know loads of network elements. For correct choice modeling, travel distances and times in the various networks need to be known. For these purposes a computerized description of the various networks (car, bicycle, public transport) is needed that gives the geographical relations within the network as well as enables calculations of trip characteristics such as speed, travel time etc. These networks are simplified representations of the real networks of which the level of detail depends on the problem at hand. Only the networks within the study area need to be modeled. Such networks consist of nodes and links between nodes. The structure of the networks resembles that of the original real-world network. Zonal centroids are connected to nodes of the modeled network by one or more links. In the case of private travel (pedestrian, bicycle, car) the modeled network may be directly derived from the physical one by selecting network parts or by aggregating sub networks into a single link. Nodes and links of the modeled network correspond directly to physical counterparts. In the case of public transport the situation is more complex. Apart from a physical network on which public transport vehicles run, we have a line network that defines services and their characteristics such as service type, frequency, capacity, travel time etc. In order to model choices correctly a specific type of network description is needed called a line description. The line network with its stops and transfer points as well as their line characteristics are of prime importance; the underlying physical network is not that important. So, the nodes of a line network description are the stops of the lines, while the links connecting these nodes are the distinct lines available between these stops. Special links are added representing waiting at stops and transferring between lines and stops. In most analyses today separate analyses are carried out for private and public transport networks. In the near future combined multi-modal networks will become applicable in which these networks are linked using transfer nodes which enable transferring from one type of travel (car, bicycle, bus) to another type (bus, rail). Railway stations are typical multi-modal transfer nodes. Such multi-modal networks enable integrating route and modal choice into one single choice process. A route in a multi-modal network defines automatically the use of the various modes, singly or combined.

Level of network detail

It makes no sense to include all links and nodes of a real network into the system description. It is too costly and it is not necessary in order to solve the problem efficiently. The question then is: how detailed should the description be? The coarser the modeled network, the less costs for data collection and the quicker analyses will go, but also the less accurate numerical outcomes such as travel times or traffic loads will be. Where the optimum level is depends on the problem at hand: what kind of plans need to be evaluated and what kind of impacts are considered in the assessment criteria? For the usual cases of area-wide planning, the following rules of thumb should be considered. In modeling travel demand about 75% of demand (in terms of kilometers traveled) should be part of the network analysis. The modeled network should include about 75% of the total network capacity. Because of the hierarchical nature of traffic flow, that means, most travelers try to travel as much as possible on higher order roads, this principle will lead to a sensible reduction in network size. About 20% of the network accounts for about 80% of the traveled kilometers. The modeled network for example need not include residential streets, which as a single road category already forms half of the road network. Groups of residential streets can be represented accurately enough by a single connector link. The selected network part should be a connected network in which flows are possible between all parts of the study area. In order to set up a modeled network one should make use of a functional classification of the real network. Each transportation network can be divided into a number of sub networks or layers having a distinct transportation function. Each link in the network can be attached a functional class according to the degree it serves a flow or access purpose for the trips on the link. One can distinguish about ten such functional classes.

Examples are:

- motorway (100% flow function)
- urban motorway
- arterial
- collector
- residential street (5% flow, 95% access)
- Residential cul-de sac (0% flow, 100% access).

After having defined the functional classification for the study area network at hand (which mostly is already available) the selection of the modeled network works top down. First, the top functional class is selected completely and the percentage of total capacity selected is calculated. Then, the next level is included and the selected capacity value is determined. The question now is when to stop.

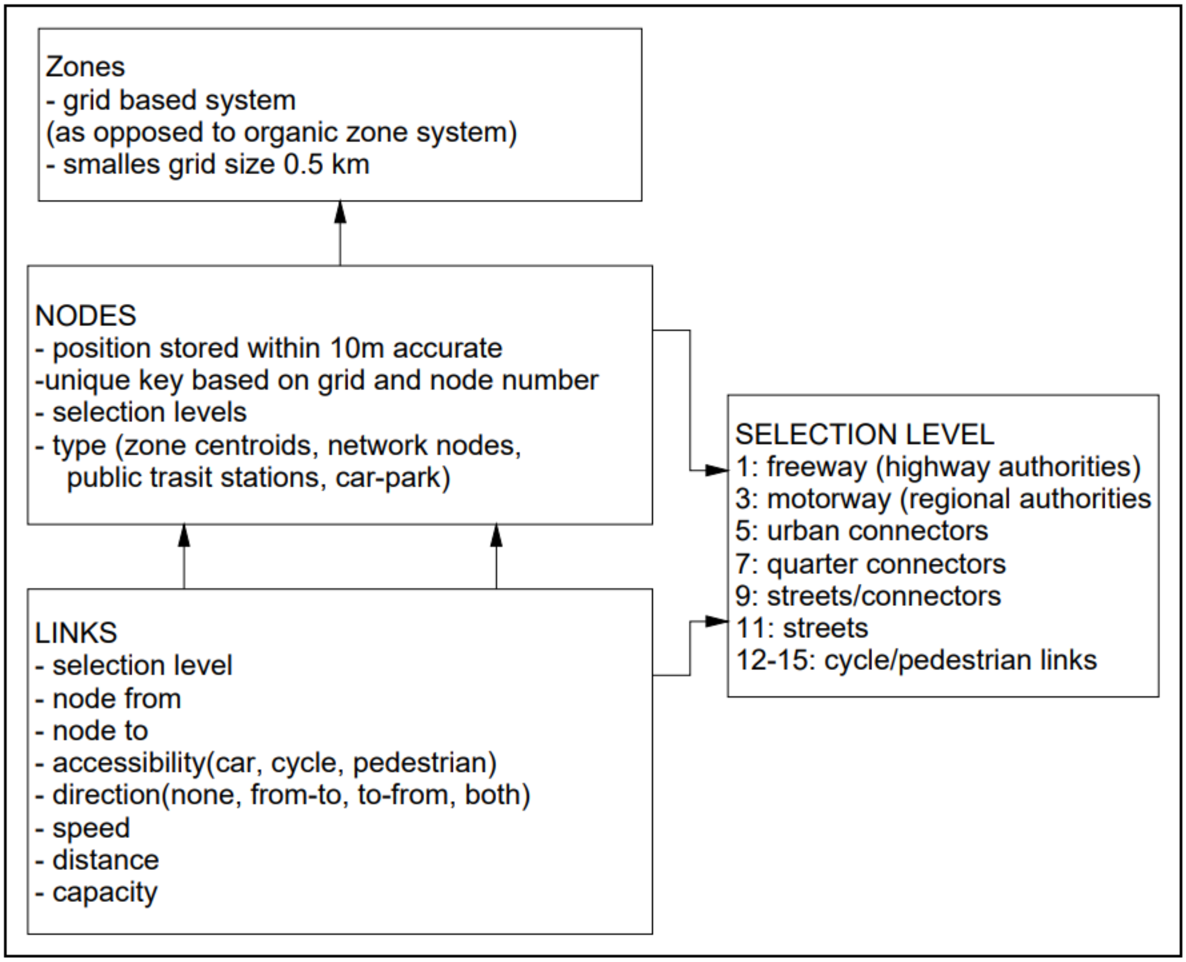

Figure 3: Basis Network (Rijkswaterstaat the Netherlands, in use since 1977, currently being upgraded.

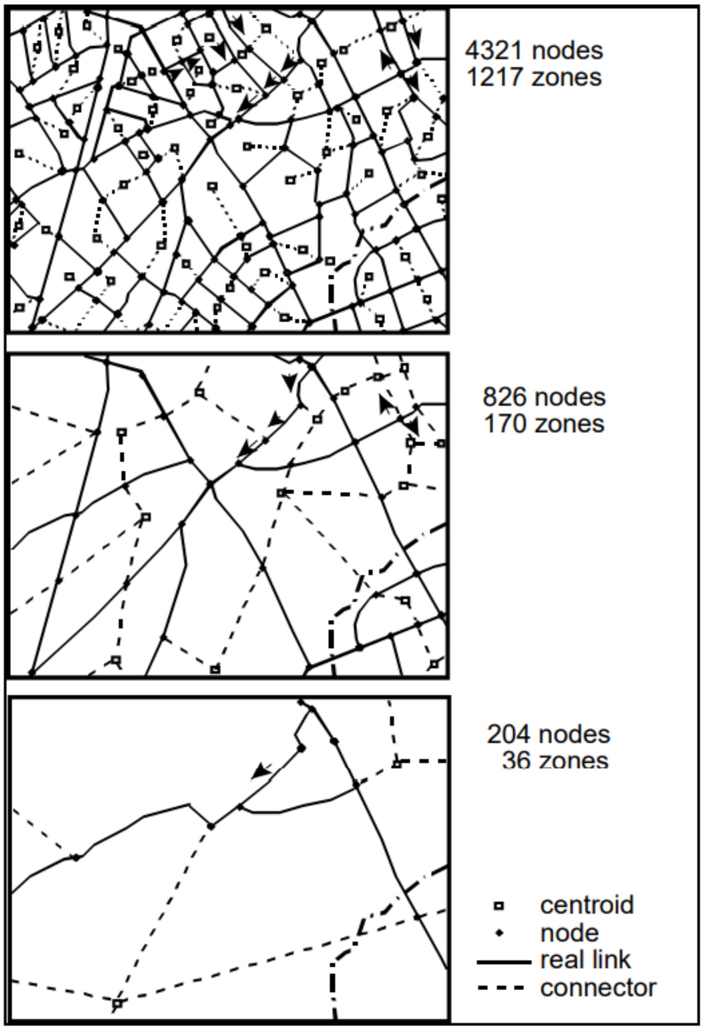

Figure 4: Description of a road network at three levels of spatial detail (Eindhoven). Source: Bovy & Jansen [1981].

At least all those network parts should be included for which detailed load figures are asked. In order to be accurate enough, the next lower functional layer of the network should be included as well because these offer routing alternatives to the studied links. So, if one is interested in arterials, one should include collector roads in the modeled network as well. If one is interested in the phenomenon of rat-running one is forced to model nearly the complete network. To be accurate enough for other purposes as well, about 75% of network capacity should be part of the modeled network. Figure 4 gives an illustration of network selection by showing three modeled descriptions of the same real network (Eindhoven): fine, moderate, and coarse level of detail. The mid-level network, having only one-fifth of the number of nodes compared to the fine level, performs best: analysis cost and computing time are only one-fifth but accuracy is nearly the same as with the fine network. In urban

networks, the nodes are the critical elements. The more nodes the more input data are required. In some software packages the number of links joining in a node is limited. This may require the definition of auxiliary nodes in order to represent reality correctly. Of special importance is the way of node coding, this means, whether or not turning movements at nodes are specified explicitly. For an illustration see Figure 6. Zonal centroids are part of the modeled
Network. These are the entry and exit points of the trips. Centroids are connected to the network by connector links. Centroids may be connected to existing nodes or to dedicated auxiliary nodes specially introduced in the links. This way of centroid connecting depends on the software package at hand. In order to achieve sufficient accuracy in modeling, the centroid should have connections in all relevant directions.

Network coding the modeled network consists of nodes and links (also called arcs). The nodes represent physical intersections or auxiliary nodes or centroids. Centroids are a special category of nodes where shortest routes start and end. Links represent physical links or auxiliary connections such as connectors. Bi-directional physical links are represented by two uni-directional links. Zonal centroids are part of the modeled network. These are the entry and exit points of the trips. Centroids are connected to the network by connector links. Centroids may be connected to existing nodes or to dedicated auxiliary nodes specially introduced in the links is way of centroid connecting depends on the software package at hand. In order to achieve sufficient accuracy in modeling, the centroid should have connections in all relevant directions.
In larger intersections travel time losses are caused due to waiting at the intersection entries. In addition, the travel time losses at the distinct turning movements may differ significantly. These travel time losses significantly influence the route choice of travelers. To model these travel times accurately enough it may be necessary to introduce in the modeled network description special links that represent these turning movements.

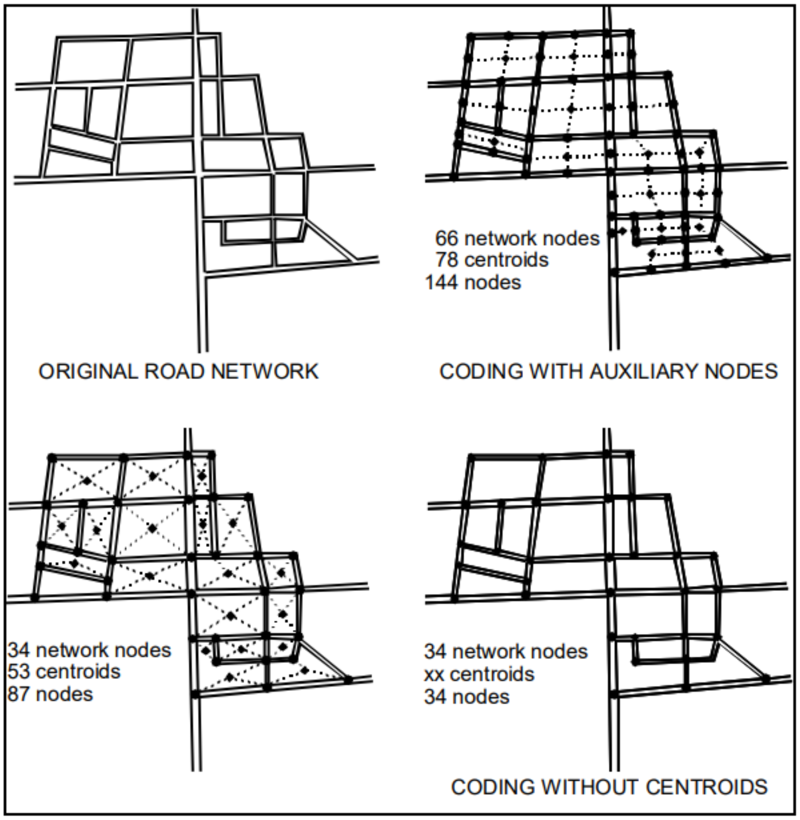

Figure 5: Examples of possible specifications of road network structure.

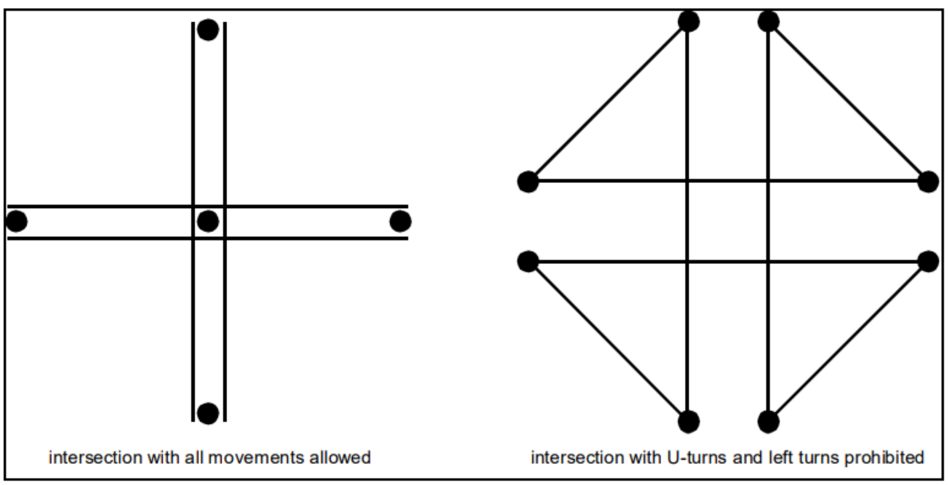

Figure 6: Forms of network coding.

TYPES OF SURVEYS

1. Home-interview survey

Home-interview survey is one of the most reliable type of surveys for collection of origin and destination data. The survey is essentially intended to yield data on the travel pattern of the residents of the household and the general characteristics of the household influencing tripmaking. The information on the travel pattern includes number of trips made, their origin and destination, purpose of trip, travel mode, time of departure from origin and time of arrival at destination and so on. The information on household characteristics includes type of dwelling unit, number of residents, age, sex, race, vehicle ownership, number of drivers, family income and so on. Based on these data it is possible to relate the amount of travel to household and zonal characteristics and develop equations for trip generation rates. It is impractical and unnecessary to interview all the residents of the study area. Since travel patterns tend to be uniform in a particular zone. The size of the sample is usually determined on the basis of the population of the study area. And the standards given by the Bureau of Public Roads as shown in below table.

Table 1 Standards for Sampling Size for Home-interview survey

Population of Study Area	Sample Size
Under 50,000	1 in 5 households
50,000 – 150, 000	1 in 8 households
150,000 – 300,000	1 in 10 households
300,000 – 500,000	1 in 15 households
500,000 – 1,000,000	1 in 20 households
Over 1,000,000	1 in 25 households

Standard Practice now is instead to calculate the sample size which will achieve the desired precision for key indicators at the required level of confidence. One such equation is given by Traffic Appraisal manual.

$$n = p(1-p)N^3/[(E/1.96)^2(N-1)+p(1-p)N^2]$$

Where,

- n = required number of households in an area of interest
- E = accuracy level

- P =Proportion of households in the area with attributes of interest.

The usual procedure is for an interviewer to call on a household on a scheduled data and to leave a copy of the home interview questionnaire. This questionnaire is broadly divided into:

- General household characteristics – number of residents, vehicles owned, income, dwelling type.
- Characteristics about family members – occupation, sex, age.
- Individual travel information – trip origin and destination, purpose, land – use, travel time and transport mode.

Once the questionnaire is ready, the next step is to conduct the actual survey with the help of enumerators. Enumerators has to be trained first by briefing them about the details of the survey and how to conduct the survey. They will be given random household addresses and the questionnaire set. They have to first get permission to be surveyed from the household. They may select a typical working day for the survey and ask the members of the household about the details required in the questionnaire. They may take care that each member of the household should answer about their own travel details, except for children below 12 years. Trip details of children below 5 years are normally ignored. Since the actual survey may take place any time during the day, the respondents are required to answer the question about the travel details of the previous day. There are many methods of the administration of the survey and some of them are discussed below:

- Telephonic: The enumerator may use telephone to an appointment and then conduct detailed telephonic interview. This is very popular in western countries where phone penetration is very high.
- Mail back: The enumerator drops the questionnaire to the respondent and asks them to fill the details and mail them back with required information. Care should be taken to design the questionnaire so that it is self-explanatory.
- Face-to-face: In this method, the enumerator visits the home of the respondent and asks the questions and fills up the questionnaire by himself. This is not a very socially acceptable method in the developed countries, as these are treated as intrusion to privacy. However, in many developed countries, especially with less educated people, this is the most effective method.

2. Commercial Vehicle Survey

A similarly styled survey of non-residential land uses could be designed to collect information on goods movements, but transport resources are rarely allocated to such an ambitious project. Instead, urban freight flows are usually measured indirectly from commercial vehicle survey. Commercial vehicle surveys are conducted to obtain information on journeys made by all commercial vehicles based within the study area. The addresses of the vehicle operators are obtained and they are contacted. Forms are issued to drivers with a request that they record the particulars of all the trips they would make.

3. Innovative Commercial Vehicle Tracking Methods

Roadside interviews are the most suitable avenue to collect data about intercity movements. However, it is impossible to use roadside surveys in an urban environment due to safety issues. In addition, with emerging privacy concerns, it is becoming increasingly difficult to conduct roadside interviews. It would be almost impossible to conduct roadside surveys in about a decade from now. MTO is currently in the process of investigating the use of non-intrusive GPS data to supplement, and eventually replace, data collected form roadside surveys. The number of trucks equipped with GPS receivers, which records the location of the vehicle every few seconds, have been increasing steadily over the past few years. In addition to providing detailed origin-destination information, The GPS technology provides many other potential benefits, including:

1. Coverage of urban freight movement with detailed route's and performance indicators.
2. Link level congestion analysis – travel time, speed
3. near real-time international border transit time monitoring.
4. Tools and reporting systems to measure economic impacts delays due to incidents.
5. Fuel consumption and pollution analysis using GPS units that include engine data retrievers.
6. Impacts of High Occupancy Vehicle (HOV) lanes on General Purpose Lane (GPL) traffic.

<u>These survey can be carried out in different ways as follows:</u>

- ❖ Direct interview survey
- ❖ Post card distribution & collection survey
- ❖ Pre-paid questionnaires distribution & collection survey.

Stop Line Survey

It is through that response bias can be overcome or is not likely to be serious. It may be possible to dispense with the interview site altogether and instead hand out the forms at a natural stop-line, Such as at traffic signals, thus avoiding all disruption to traffic.

4. Intermediate Public Transport Survey

These survey can be carried out in different ways as follows:

- Direct interview survey
- Post card distribution and collection survey
- Pre-paid questionnaires distribution and collection survey

In order to assess the number of bus passengers passing through an external cordon, the survey can either be by direct interview with the passengers or by issuing post-card questionnaires. Direct interview is likely to result in large delays and requires a large number of interviews. In order to minimize the delays, the interviewer may enter the vehicle and carry out the interviews when the vehicle is in motion. Post-card questionnaires eliminates delays, but are likely to evoke poor response or contain and element of bias. An external cordon rail survey can be carried out by interviewing the passengers on trains. Alternatively, pre-paid questionnaires may be distributed to persons residing at stations outside the survey area. These questionnaires may also be collected at the stations inside the survey area.

5. Cordon-Line Survey

These provide useful information about trips from and to external zones. For large study area, internal cordon line can be defined and surveying can be conducted. The objective of the survey is primarily to collect the origin and destination zones and for this many suitable methods can be adopted. It could be either recording the license plate number at all the external cordon points or by post-card method. Screen lines divide the study area into large natural zones, like either sides of a river, with few crossing points between them. The procedure for both cordon-line and screen-line survey are similar to road-side interview. However, these counts are primarily used for calibration and validation of the models.

6. Post-Card Questionnaire Survey

In this survey, reply-paid questionnaires are handed over to each of the drivers or a sample of them at the survey points and requesting them to complete the information and return by post. The method avoids delay caused to the drivers by the direct roadside interview method but suffers from the disadvantage that the response may not be good. For this reason its use is not generally recommended for developing countries. It is possible to get a good amount of information from this method. The method is simpler and cheaper than many others. A good amount of publicity is needed before the actual survey in order to get favorable response. It is reported that well planned and publicized post card questionnaire surveys have yielded returns of 50% or more. This method can be used on roadways with higher traffic volumes because they require less interaction time with the driver. Drivers may not have to be directed off the roadway; rather, postcards can be quickly handed out in the traffic lanes to every vehicle as they stop at the roadside station. Like the roadside interview, adequate advanced warning signs and traffic control must be in place for the safety of the drivers and observers. To complement roadside interviews, this method may be used when backups occur upstream from the interview site. In this case, postcards may be handed to the drivers and they are then permitted to leave. This will eliminate or reduce the delay and number of angry drivers who are stopped to take the interview. This method can be used as an alternative or in combination with roadside interviews (RSIs). In this method, the same information is generally collected as in RSIs, but the survey is conducted via a postcard that is handed to the driver, completed after the trip, and mailed back. A given number of personnel could hand out more questionnaires than conduct roadside interviews. The problem with this method is the lower response rate than with a roadside interview. In addition, more of the questions may be skipped or answered incorrectly. Generally, response rates for this method are between 15% and 30%. Furthermore, a lot of time has to be spent reducing returned survey forms, and more money is spent for printing them. There may be a bias in this type of survey, if non respondents (such as certain vehicle types or income levels) have different travel characteristics and demographics than respondents. For example, surveys may not be completed for several reasons: refusal to accept survey, failure to read it, failure to understand it, failure to complete it, and failure to send it back.

7. Registration – Number Survey

In the registration address technique vehicle registration numbers are recorded and their origin or destination is deduced from their registered address. Alternatively a questionnaire is sent to the registered address in order to collect information on the trip details. For commercial vehicles the registered address often bears no relationship to the trip origin or destination, particularly for vehicles engaged in long distance travel. Furthermore, a 107 mail questionnaire would be subject to a low response rate in the same way as the postcard reply technique. An added complication is that by the time a particular driver received a questionnaire the exact details of the trip may have been forgotten. First of all, the area to be surveyed is defined, and the roads intersecting cordon lines are identified. At each survey point, one or two observers are stationed to record the data in each direction of travel. One can call out the registration number of the vehicle and the other can record. Time should be recorded at regular intervals. If actual time at entry and exit are noted, an estimate of the journey speed of the vehicle can also be had. The type of vehicle and as well as the full registration number are noted. The analysis consists of tallying the numbers of vehicles at points of entry and exit.

8. License Plate Follow-Up Survey Technique

This technique uses one of methods described above in order to record license plates at a particular roadside station. A list of license plates is then supplied to the Department of Motor Vehicle (DMV) to obtain contact information for the vehicle owner. A survey is sent to the vehicle owner, who is then asked to respond to a survey of questions regarding the specific trip on which their license plate was recorded. In order to obtain contact information of vehicle owners from the DMV, the full license plate must be recorded. Depending upon the recording method and the requirements of each DMV, the license plates may or may not have to be transcribed into a specific format. Once the contact information is obtained from the motor vehicles department, a survey of the vehicle owners can be conducted. It is critical that the date, time stamp, location, direction of travel, and other relevant information (such as how their vehicle was recorded and contact information obtained) be included in the information provided to the vehicle owner. This survey is usually conducted via a telephone interview or postcard mail-out with response via mail-in, telephone, and/or internet. License plate follow-up surveys have resulted in both successful and unsuccessful OD studies. They are beneficial in that they are unobtrusive like the license plate matching technique, but detailed information (trip purpose, true origin and destination, etc.) can still be obtained from the actual driver of the vehicle using that specific road. Below figure illustrates the types of trips that can be obtained from the license plate follow-up survey technique. Like the license plate matching technique, the lighter-shaded arrows represent the trips from one entry node to all other exit nodes (E-E trips). However, instead of one dark-shaded arrow that aggregates all E-I trips from the external station to the internal TAZs, information provided from the license plate license plate survey provide information of E-I trips to each of the TAZs inside the cordon line.

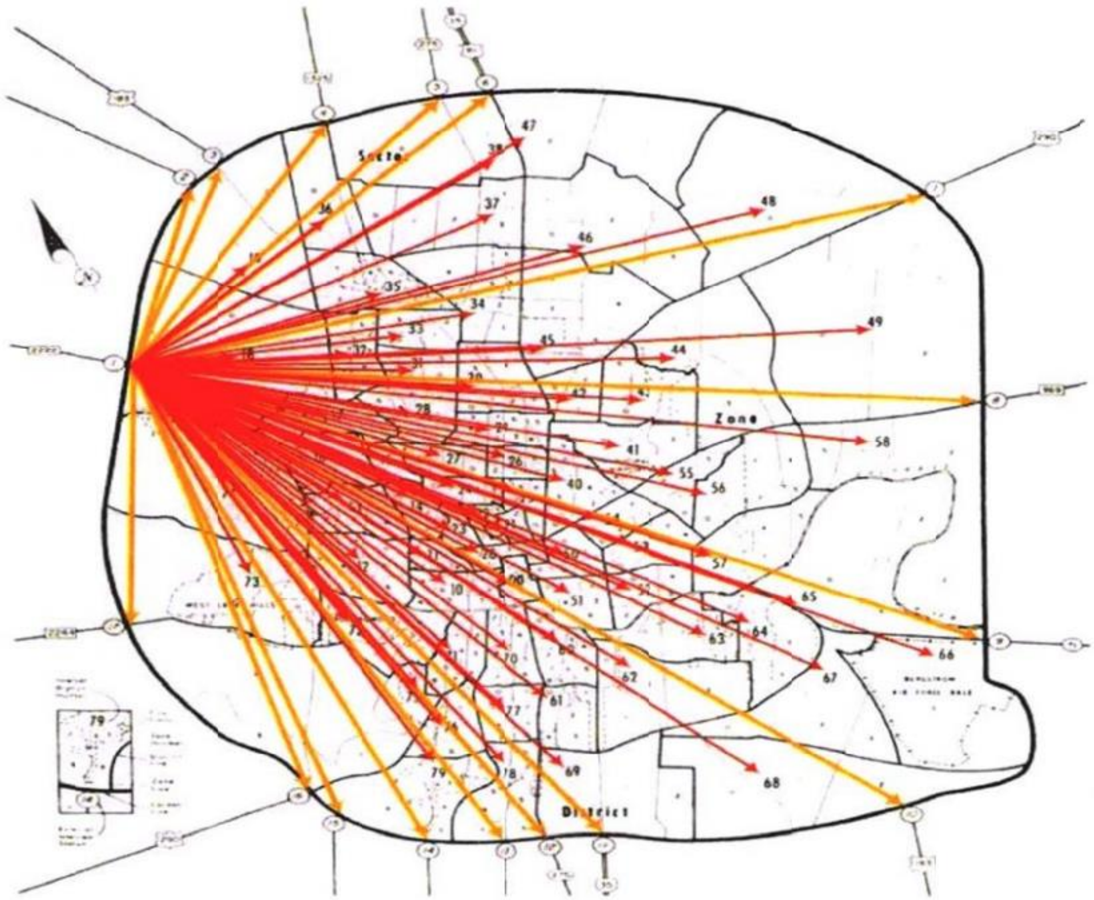

Figure 9. Types of trips from license plate follow - up survey techniques.

9. Tag on vehicle survey

In this method, drivers are stopped at roadside stations where a color-coded identifier is placed on the bumper, front window, or radio antenna of passing vehicles. Each roadside station has one unique color assigned to it. Data collectors at each station then record the passing vehicles' tag color (if it has one) to determine the percentage of vehicles coming from another station. Drivers are instructed to remove the identifier at their next destination. With this method, a time stamp will not likely be obtained. The tag-on-vehicle method is a combination of the VIS and matching techniques. Because the vehicles have to be stopped on the roadway in order for a tag to be placed on their vehicle, it is considered a VIS. However, the tags are monitored as they pass observers through subsequent stations on their trip, so it is also a type of matching technique. The advantages of the tag-on-vehicle method are that it is quicker to conduct than an RSI and easier to match between stations than license plates. However, time stamps may not be collected, unless the vehicle is stopped again at the second station to obtain that information.

On the downside, some motorists may not like the idea of physically attaching a tag to their vehicle, and may disapprove of its placement or remove it before their destination. Still other motorists may leave it attached even after they arrive at their destination, which may cause a significant number of false matches if the vehicle is spotted later in the study. In addition, litter could become a problem if tags are not secured or drivers do not dispose of them properly.