TRAFFIC ASSIGNMENT

Done by
SREYA V
CIVIL DEPARTMENT

Route Assignment

- A route is simply a chain of links between an origin and destination .
- The final Route assignment, route choice, or traffic assignment concerns the selection of routes between origins and destinations in transportation networks. It is the fourth step in the conventional transportation forecasting model, following trip generation, trip distribution, and mode choice.

Route Assignment

- Between the two zones A and B, there maybe alternate routes to follow, having different lengths and characteristics. The estimation of what proportion of total forecasted trips between A and B, shall use the available alternate routes is known as "Route Assignment".
- In the route assignment:-
i) The route to be travelled is determined.
ii) The interzonal trips are assigned to the selected routes.

Route Assignment

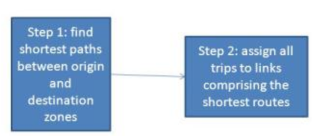
- To determine facility needs and costs and benefits, we need to know the number of travellers on each route and link of the network. We need to undertake traffic (or trip) assignment.
- Suppose there is a network of highways and transit systems and a proposed addition. We first want to know the present pattern of traffic delay and then what would happen if the addition were made.

All-or-nothing assignment method

- This is the simplest technique, in which all trips for a zone are assigned the minimum path connecting the nodes. The minimum path is the route which has the least travel time, travel cost or distance. The technique assumes that the capacity of each link is infinite so that the volume of traffic does not affect the time of travel or cost of travel.
- In the first stage, the network description and tree building is made. The next stage is to assign the traffic flows to the minimum path tree.

All or nothing assignment

Simple all-or-nothing method is the fundamental building block in traffic assignment procedures.



All-or-nothing assignment method

Limitations

1. If time alone is used as the governing factor in selecting the minimum path, the other important factors like cost, distance, safety will be neglected.
2. In a network with two or more parallel and close links, the link which is only marginally quicker will be allocated all the trips. The resulting flow pattern may lead to an unrealistic situation.
3. Too many vehicles tend to be assigned to more attractive routes. This may cause increasing congestion on these routes, and the technique takes

All-or-nothing assignment method

Limitations

4. All facilities in the network are not effectively utilised.
5. If a superior facility is available, say, for example a motorway people tend to prefer to use this facility for longer journeys. This technique does not reflect this tendency

Capacity restraint assignment techniques

- The capacity restrained assignment technique involves a sequence of all-or-nothing minimum path assignments where the sequence is iterated until the traffic volumes assigned to each links are comparable with the link travel time assumed in the minimum path tree building phase.
- The link travel time used in assignment is a function of speed on that link, which again is independent on the traffic flow being assigned.
- Because of the iterative nature of the calculation involved this technique is carried out entirely by

Capacity restraint assignment techniques

The TRC trip assignment model

- The value of tr, for iterations is found by the following equation:-

$$t_r = t_{rc}\frac{d(V_r - V_{rc})}{V_{rc}} \times L_r$$

where, trc=unit travel time at the critical volume (min/mile)
tr=travel time on route r (minutes)
Vr=Volume of traffic on route r (vehicle/hour/lane)
Vrc=critical volume for route r (vehicle /hour/lane)
Lr=Length of route r (km)

Capacity restraint assignment techniques

The TRC trip assignment model

- This model involves two travel time versus volume relationships used iteratively, to arrive at prediction of volumes on separate routes between any two zones. The equation used for predicting the volume on a route r is given as under:-

$$V_r = \frac{\frac{1}{t_r}}{\sum_{r=1}^{m}\frac{1}{t_r}} \times V$$

where, Vr=volume of traffic on route r (vehicles per hour per lane)
V=total volume of traffic (trips) from zone i to zone j on all routes m
tr=travel time on route r (minutes)

Multi-route assignment technique

- Mclaughlin developed one multipath traffic assignment technique as under:
- A driver's route selection criteria is used which is a function of :-

(i) Travel time
(ii) Travel cost
(iii) Accident potential

Multiroute assignment technique

- All road users may not be able to judge the minimum path for themselves.
- It may also happen that all road users may not have the same criteria for judging the shortest route.
- These limitations of tall-or-nothing approach are recognised in the multiple route assignment technique.
- The method consists of assigning the interzonal flow to a series of routes, the proportion of the total flow assigned to each being a function of the length of that route in relation to the shortest route.

Multi-route assignment technique

- The minimum resistance path between origin and destination pair are calculated with all the link resistances set to values which correspond to a zero traffic volume.
- The minimum resistance value between O-D pair is increased by 30% .
- All the path between O-D pair with resistance values less than this maximum value are identified.

Direction curve method

- Diversion curves method is one of the frequently used assignment techniques.
- This method predicts the percentage of trips that is likely to use a proposed new facility (bypass, new expressway, new arterial street, etc.) based on distance saved or time saved or cost saved.
- The data collected from the pattern of road usage in the past serve to build up such curves.

Direction curve method

- Diversion curves can be constructed using the following variables:-

1. Travel time saved
2. Distance saved
3. Travel time ratio
4. Distance ratio
5. Travel time and distance saved
6. Travel cost ratio
7. Distance and speed ratio

THANK YOU

UNIT 5

1. ROUTE CHOICE MODELLING

Modeling route choice behavior is problematic, but essential to appraise travelers' perceptions of route characteristics, to forecast travelers' behavior under hypothetical scenarios, to predict future traffic conditions on transportation networks and to understand travelers' reaction and adaptation to sources of information.

Route choice models not only help analyzing and understanding travelers' behavior, but also constitute the essential part of traffic assignment methods. In the deterministic user equilibrium (DUE) problem, a simple route choice model assumes unrealistically that travelers have perfect knowledge about path costs and choose the route that minimizes their travel costs.

A route choice model has two components:

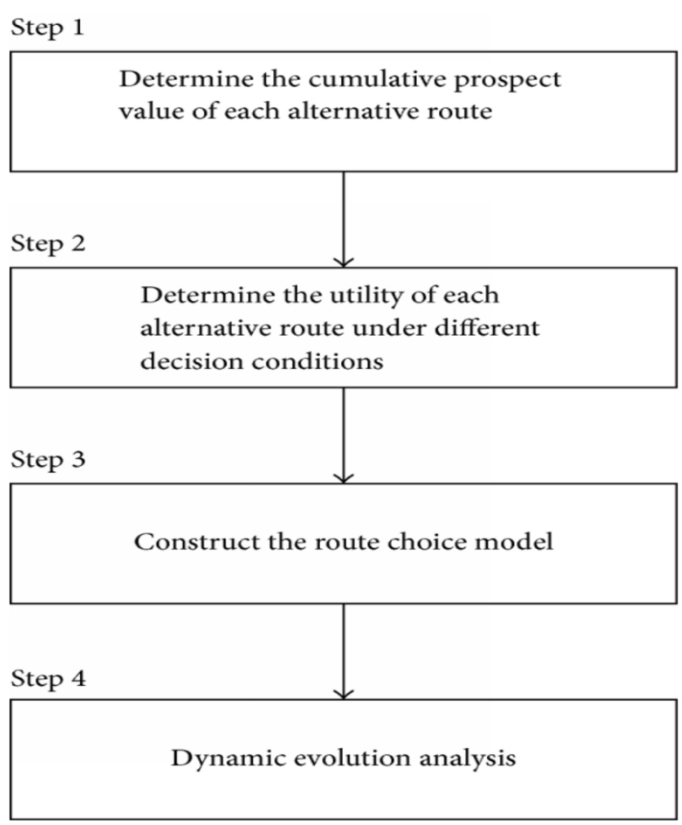
1. The generation of a choice set of alternative routes; and
2. The choice of route among the alternatives in the choice set.

The route choice models used in traffic equilibrium tend to be very simple with implicit generation of very large path choice sets. The advent of Intelligent Transportation Systems has renewed the interest in modeling the effects of traffic information systems on route choice behavior. Developments in discrete choice methods have also led to the more sophisticated route choice models.

Route choice modeling is typically divided into a two-stage process. First, possible alternative routes are generated to form the choice set. Then the probability a given route is chosen from a specified choice set is calculated. These two procedures may correspond to non-compensatory and compensatory decision rules. The two-step methodology we present has the advantage that by explicitly specifying the set of available routes, we can examine possible se1ection criteria, and reduce computational time by not generating unrealistic routes. With a finite, known choice set, we can apply theoretically-based corrections for route overlapping.

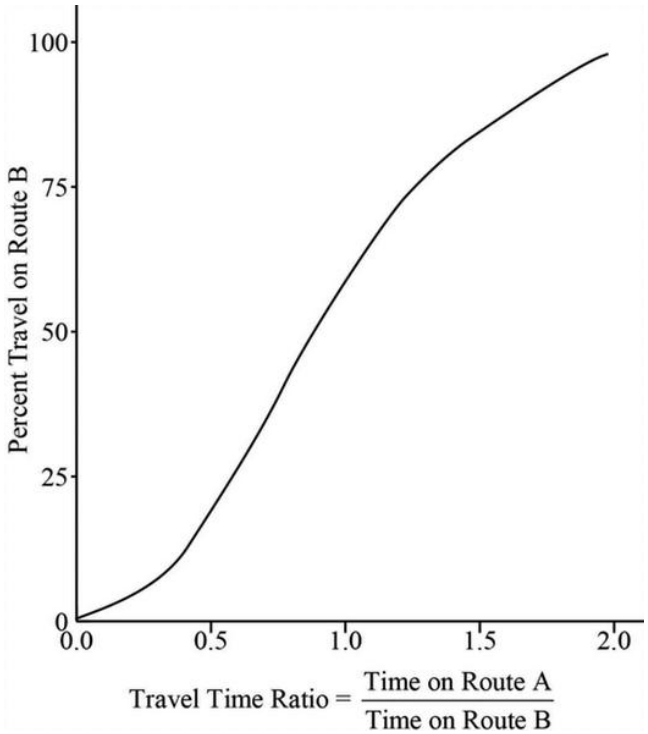
Generating Alternative Routes

In a roadway network, there may be numerous alternative routes. However, many of these possible routes may be overly circuitous, or otherwise unsuitable for a particular origin-destination pair. Since our modeling task is to predict route choice from among the routes that a particular traveler considers, we would like to identify all the routes that any traveler might consider. Specifically, we want to be able to identify algorithmic rules for generating the observed routes to avoid introducing biases in the estimation procedure, and to have useful algorithms for navigation systems. Such algorithms should be able to reflect drivers' knowledge of the transportation network and their perceptions of travel times and other network variables. Further, there is no benefit to enumerating routes that no traveler would consider. That is, computational effort is one criterion by which to evaluate potential path generation algorithms. We define the effectiveness of different path generation techniques in terms of the generated routes' *coverage* of the observed routes. Ideally, a generated route would match the observed route link-for-link; in this case, we would say that the algorithm has *replicated* the survey route. Other routes may not be replicated, so we consider the distance that the generated route shares in common with the survey route. We call this the *overlap,* and typically express it as a percentage of the survey route distance. We may then define coverage as the percentage of observations for which an algorithm or set of algorithms has generated a route that meets a particular threshold for overlap.



2. DIVERSION CURVES

Diversion curve is the basic approach used for the traffic assignment purposes. The method is similar to the mode choice curve. Traffic between two routes can be computed as a function of relative cost or travel time. Show the diversion curve based on the travel time ratio in the figure below.



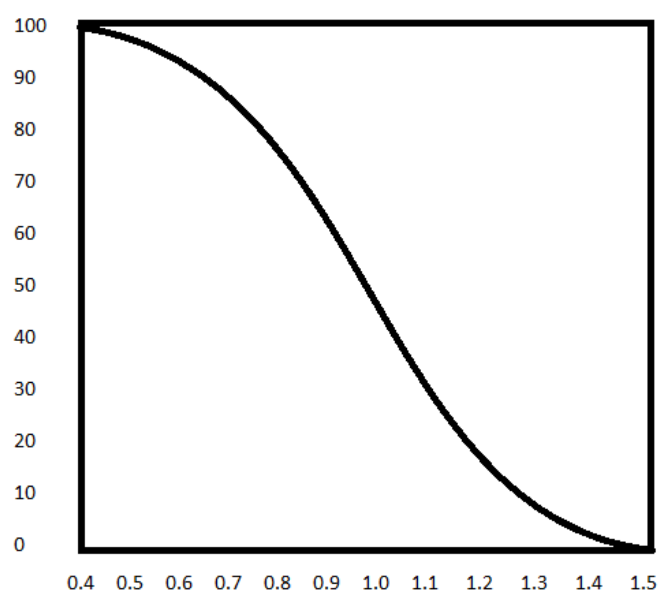
The curve was developed in 1950 in order to determine how many drivers would divert from main streets to the freeway. They are helpful in decision making for capacity determination and geometric design of urban freeways. It is also used for justifying the need for bypass roads built around the major cities by computing the percentage of traffic volume would pass through bypass. It is developed using the expert system analysis. Having a key knowledge of these data will be necessary for the Transportation Engineer. The analysis will deliver an effective result for different type of situations, like an urban and also the rural freeway. Diversion curve models are developed to compute the percentage of trips that will be made along freeway in the route between any two points. It is easier to obtain data and array results. They are utilized by the highway authorities before any major road is built.

- Diversion curves method is one of the frequently used assignment techniques
- This method predicts the percentage of trips that is likely to use a proposed new facility (bypass, new expressway, new Arterial Street, etc.) based on distance saved or time saved or cost saved.
- The data collected from the pattern of road usage in the past serve to build up such curves.

Diversion curves can be constructed using the following variables:-

1. Travel time saved
2. Distance saved
3. Travel time ratio
4. Distance ratio
5. Travel time and distance saved
6. Travel cost ratio
7. Distance and speed ratio

Bureau of Public Roads Diversion Curve



The following formula has been fitted to this type of curves

$$\mathbf{P= 100 \div 1+ TR^{6}}$$

Where,

P= percentage of traffic diverted to new system

TR= travel time ratio

TR = travel time on new system/travel time on old system

3. BASIC ELEMENTS OF TRANSPORTATION NETWORK SYSTEMS

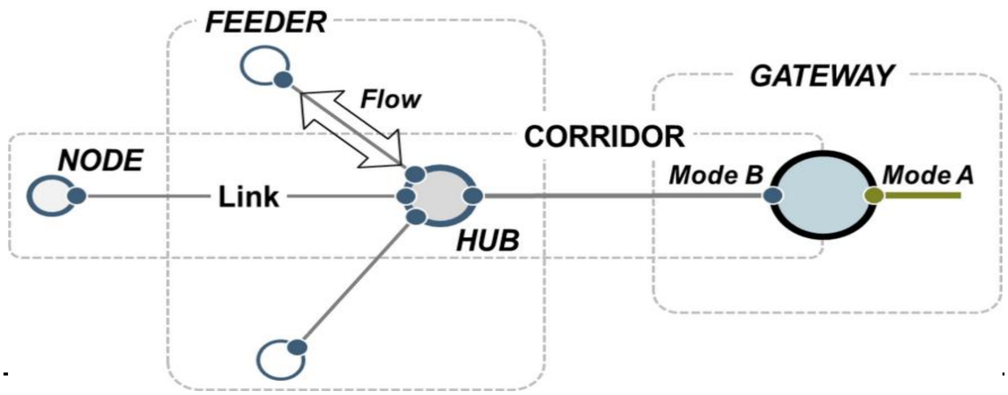
Transportation systems are commonly represented using networks as an analogy for their structure and flows. Transport networks belong to the wider category of spatial networks because their design and evolution are physically constrained as opposed to non-spatial networks such as social interactions, corporate organization, and biological systems, which are usually constrained by other factors and where space plays a lesser role.

The term **network** refers to the framework of routes within a system of locations, identified as nodes. A **route** is a single link between two nodes that are part of a larger network that can refer to tangible routes such as roads and rails, or less tangible routes such as air and sea corridors.

The setting of networks is the outcome of various strategies, such as providing access and mobility to a region, reinforcing a specific trade corridor or technological developments making a specific mode and its network more advantageous over others.

A transport network denotes either a permanent track (e.g. roads, rail, and canals) or a scheduled service (e.g. airline, public transit, train). It can be extended to cover various types of links between points along which mobility can take place. The relevance of a network is related to its connectivity. **Metcalfe's law** states that the value of a network is proportional to the square of connected nodes so that complex networks are exponentially more valuable than simple networks since they offer a large number of options in connecting locations.

In transport geography, it is common to identify several types of transport structures that are linked with transportation networks with key elements such as nodes, links, flows, hubs or corridors. Network structure ranges from centripetal to centrifugal in terms of the accessibility they provide to locations. A centripetal network favors a limited number of locations while a centrifugal network tends not to convey any specific location advantages. Network structures can also be direct or indirect in their connectivity. The most directly connected networks are **point-to-point networks** where a service originates and ends in a single location. A more complex form involves a **route network** where there is a sequence of intermediary locations that are serviced along a linear sequence.



The main structural components of transport networks are:

- **Node**. Any location that has access to a transportation network.
- **Link**. Physical transport infrastructures enabling two nodes to be connected.
- **Flow**. The amount of traffic that circulates on a link between two nodes and the amount of traffic going through a node. Flows can thus be modal, intermodal (between modes) and transmittal (between components of the same mode).
- **Gateway**. A node that is connecting two different systems of circulation that are usually separate networks (modes) and which acts as compulsory passage for various flows. An intermodal function is performed so that passengers or freight are transferred from one network to the other.
- **Hub.** A node that is handling a substantial amount of traffic and connects elements of the same transport network, or different scales of the network (e.g. regional and international).
- **Feeder.** A node that is linked to a hub. It organizes the direction of flows along a corridor and can be considered as a consolidation and distribution point.

- **Corridor.** A sequence of nodes and links supporting modal flows of passengers or freight. They are generally concentrated along a communication axis, have a linear orientation and connected to a gateway.

Networks are also labeled depending on their overall properties:

- **Regular network**. A network where all nodes have the same number of edges. In the same vein, a random network is a network that is formed by random processes. While regular networks tend to be linked with high levels of spatial organization (e.g. a city grid), random networks tend to be linked with opportunistic development opportunities such as accessing a resource.
- **Small-world network**. A network with dense connections among close neighbors and few but crucial connections among distant neighbors. Such networks are particularly vulnerable to catastrophic failures around large hubs.
- **Scale-free network**. A network having a strong hierarchical dimension, with few vertices having many connections and many vertices having few connections. Such networks evolve through the dynamic of preferential attachment by which new nodes added to the network will primarily connect larger nodes instead of being connected randomly.

Some crucial aspects and problems related to inter-network relations may be as follows:

- **Coevolution**. Different transport networks might follow similar or different paths based on spatial proximity and path-dependence of economic development, with a wider variety of networks in core regions than in peripheral regions.
- **Complementarity**. Some locations may be central in one network but peripheral in another, depending on their specialization and function and on the scale of analysis (terminal, city, region, country); the complementarily between networks can be measured based on the number of common nodes and links.
- **Interoperability**. Typically, cargo flows from a maritime network to a road network shift from a scale-free structure to a regular structure, thus following different topologies that are not easily combined; air and sea terminals remain few in the world due to the

difficulty combining and integrating technically air and sea networks physically at the same locations.

- **Vulnerability**. How do changes in one network affect the other network, on a global level (entire network) or local level (single node or region)? This is particularly important for two networks sharing common nodes, such as global cities, logistics platforms, and multilayered hubs in the case of abrupt conjunctures (e.g. natural disasters, targeted attacks, labor disputes, security, and geopolitical tensions), thus posing the problem of rerouting flows through alternative routes and locations.

In order to have a spatial continuity in a transport network, three conditions are necessary:

- **Ubiquity**. The possibility to reach any location from any other location on the network thus providing general access. Access can be a simple matter of vehicle ownership or bidding on the market to purchase a thoroughfare from one location to another. Some networks are **continuous**, implying that they can be accessed at any location they service. Roads are the most salient example of a continuous network. Other networks are **discrete**, implying that they can only be accessed at specific locations, commonly at a terminal. Rail, maritime and rail networks are considered discrete networks since they can only be accessed through their terminals.
- **Fractionalization**. The possibility for a traveler or a unit of freight to be transported without depending on a group. It becomes a balance between the price advantages of economies of scale and the convenience of dedicated service.
- **Instantaneity**. The possibility to undertake transportation at the desired or most convenient moment. There is a direct relationship between fractionalization and instantaneity since the more fractionalized a transport system is, the more likely time convenience can be accommodated.

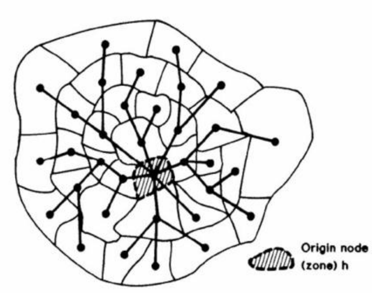
4. MINIMUM PATH TREES

In many transportation problems, shortest path problems of different kinds need to be solved. These include both classical problems, for example to determine shortest paths (under various measures, such as length, cost and so on) between some given origin/destination pairs in a certain area, and also non standard versions, for example to compute shortest paths either under additional constraints or on particular structured graphs. Due to the nature of the applications, transportation scientists need very flexible and efficient shortest path procedures, both from the running time point of view and in terms of memory requirements. Since no "best" algorithm exists for every kind of transportation problem, Le. no algorithm exists which shows the same practical behavior independently of the structure of the graph, of its size and of the cost measure used for evaluating the paths, research in this field has recently moved to the design and the implementation of "ad hoc" shortest path procedures, which are able to capture the peculiarities of the problems under consideration.

Shortest path-min. tree building

- what is a tree?
  - If for each origin node h, at the completion of a pass through the algorithm all other nodes in the network are arrived at by one link only, the set of paths from h to the nodes is called “a tree”. The process of determining the minimum cost path is called “tree building”. The tree together with the minimum path costs from the origin node to all destination nodes is referred to as “skimmed tree” (giving rise to the term “skim table” in TDF)

An example tree



5. TRAFFIC ASSIGNMENTS

Traffic assignment models are used to estimate the traffic flows on a network. These models take as input a matrix of flows that indicate the volume of traffic between origin and destination (O-D) pairs. They also take input on the network topology, link characteristics, and link performance functions. The flows for each O-D pair are loaded onto the network based on the travel time or impedance of the alternative paths that could carry this traffic.

Traffic assignment is a key element in the urban travel demand forecasting process. The traffic assignment model predicts the network flows that are associated with future planning scenarios, and generates estimates of the link travel times and related attributes that are the basis for benefits estimation and air quality impacts. The traffic assignment model is also used to generate the estimates of network performance that are used in the mode choice and trip distribution or destination choice stages of many models.