Urban Transportation Systems Planning
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Lecture - 41
Introduction to Traffic Assignment

Welcome to module F lecture 1, this module F relates to traffic assignment and in the first lecture we shall give you an introduction to traffic assignment and some of the essential components that you should know before we discuss in details about the traffic assignment technique.

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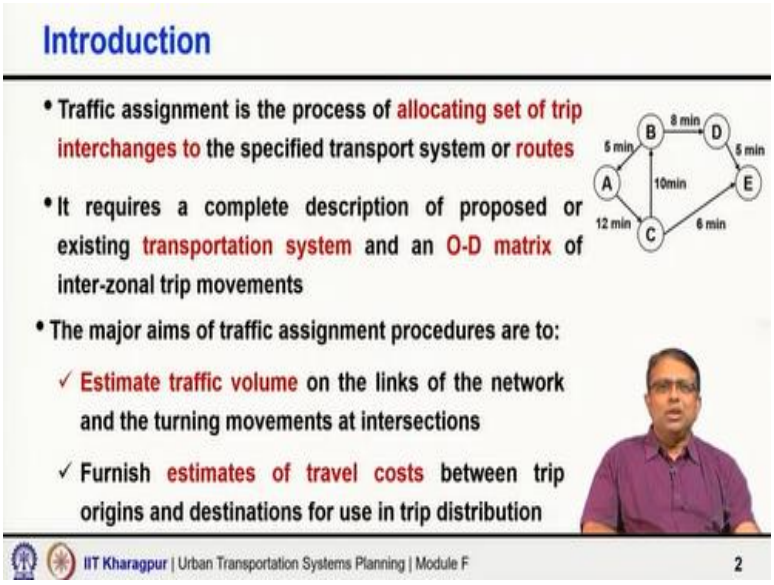

Traffic assignment is the process of allocating set of trip interchanges to the specified transportation systems or routes. In trip generation we have estimated how many trips are getting produced or getting attracted to or from or to a zone, then in the distribution we have connected the trips the interchanges we have linked that if trip is producing getting produced in a zone how that those trips are getting distributed to different zones or if a zone is attracting certain number of trips then where from those trips are coming.

Then, in more choice we converted person trips into vehicular trips and this is the fourth stage or stage four where we want to distribute this demand between different O-D pairs to alternative routes. So, that brings actually altogether so many vehicles at a given time at a given location.

So, because we want to finally load this matrix or the demand and where we are loading? We are loading it to the transport network.

So, the traffic assignment process requires a complete description of the proposed or existing transportation system on the network and an O-D matrix of inter zonal trip movements, because that is the O-D matrix which is the demand matrix that we want to load and we want to load it to the transportation network. So, we need complete description of transportation network and also the O-D matrix.

Now, why we do traffic assignments and what are the benefits of doing traffic assignment? There are multiple benefits or multiple things that are important in this regard. Say for establishment or estimating the traffic volume on the links of the network and the turning movements at intersections. Once we are able to tell the routes once we know the routes that how the O-D matrix are getting distributed.

Then we know they are getting distributed through different links and then you know series of links rather than only on one link and then there are different such O-D movements that are happening different O-D pairs. So, altogether the total volume how much volume total volume is coming on a given link or expected to come on a given link we can understand then if you take a junction or intersection we know then in the junction also how the traffic is getting distributed.

That means, how much are going straight how many of the vehicles are growing taking right turn how many are taking left turn. So, the turning movements we know and because we know the likely traffic volume, so we also know what will be the travel cost? The cost is a generalized depiction it may be time, it may be actual vehicle operating cost, but since we know the volume we know how many or what will be the travel time what will be the actual cost of travel all these are actually known.

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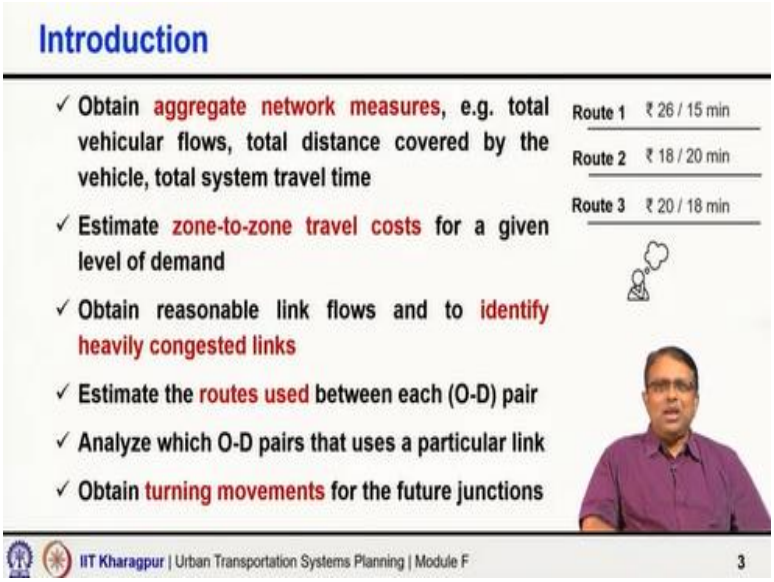

Then also to obtain aggregate network measure since, the whole network basis we know that how the vehicle movements are taking place. So, we know that how much is the total vehicle flow that is happening or how many vehicles are totally utilizing the network, what is the aggregate travel time, what is the total distance vehicle kilometer distance that is happening. So, gross aggregate level measures which are of important.

The importance are which are important to us, we can get those values. Also, we know that how the vehicle is or vehicles are moving between a particular origin to a particular destination. So, we know that zone to zone travel time or travel cost that is also is possible, because we know the demand. We can also tell that which are the links that are likely to become congested because, we know that where more demand.

And not the same link will every link will have equal amount of vehicular demand. So, we know that where more vehicles are going to come and as compared to the width of the road or the available capacity of the road, where the demand is going to be more and which are the links that are likely to be more congested. We can also estimate obtained reasonable link flow and heavily congested links therefore.

Estimate the routes used between O-D pair we know that how really which are the routes that are taken by vehicles when trying to move from a particular origin to a particular destination and you know future projections, turning volumes and all other things.

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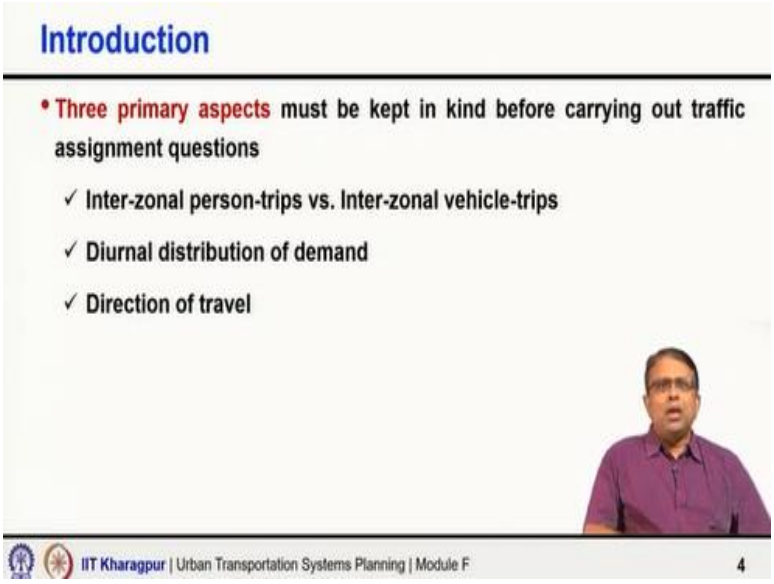

Now, so there are altogether multiple reasons why we need actually to estimate this traffic volumes and the resulting other outcomes from a network, that is happening because of the demand supply interaction the vehicles are using the available transportation network or the available capacity of road links, intersections and then finally how much is the condition and where the condition is occurring.

How much is the travel time, travel cost and for all future further planning preparedness those information will be useful. Now, when we do the traffic assignment or try to answer any questions related to traffic assignment there are three primary aspects which we should bear in mind, we should keep those things in mind, one inter zonal person trips verse inter zonal vehicle trips. So, basically person trips versus vehicle trips.

Second the diurnal distribution of the demand or time of the day variation of the demand. Third, the direction of travel, all these three aspects are very important and when we are trying to answer to any questions related to the traffic assignment we must bear these three aspects in mind.

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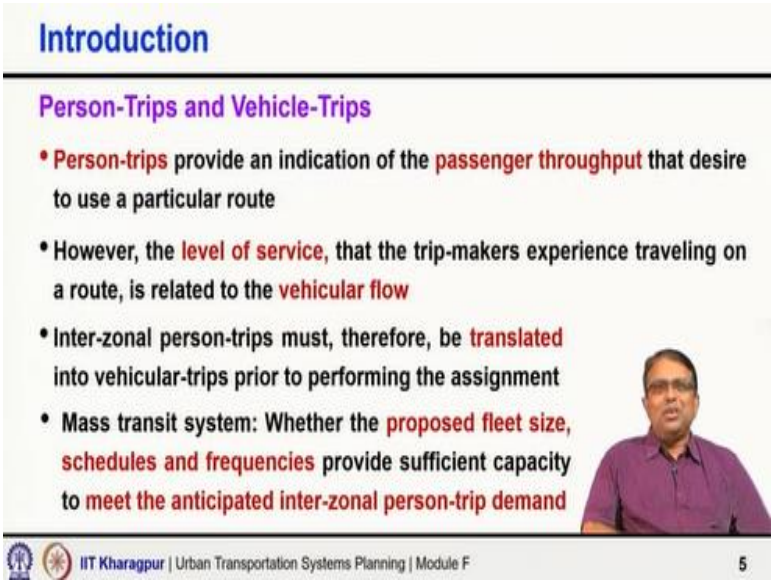

First going to person trips and vehicle trips person trips provide an indication on the passenger throughput that desires to use a particular route. People desire to travel you know person trips indicate that from where to where they want to go or even using which path, but remember that finally the level of service that trip makers experience while traveling on a route that is getting controlled by the vehicle flow.

So, the end of the day or for traffic assignment purpose particularly the vehicular flow is very important because how a link is getting congested to what level it does not depend on directly how many people are using the link rather how many vehicles are trying to use the link, I must also try to point out one particular thing which is again important, at the back of the mind we also should remember that it is the person trips.

Our basic objective is to you know move it is to satisfy the requirement for movement of people rather than the movement of vehicle the bigger goal is movement of people. So, the more choice is very important. Let us not get confused with that aspect, so that is again very, very important the more choice that is why is very is playing a very crucial role in the overall urban transportation planning process.

But, when we are ultimately assigning the doing the traffic assignment then the vehicle is important because at finally it is the vehicle how much will be the travel time on a link is not going to depend directly on how many people are using the link rather you know it is basically how many vehicles are trying to use the link. So, level of service that what a trip maker or to makers are experiencing while travelling on a route that is related to directly related to vehicular flow.

So, inter zonal person trips must therefore be translated into vehicular trips prior to performing the assignment. So, we cannot that is the reason that why we cannot go for traffic assignment or route assignment unless we have converted personage or person trips into vehicular trips. So, that conversion has to be done before we go for the traffic assignment, when we are talking about the mass transportation system say bus system or a BRTS system, in little bit advanced form.

Then in that context, whether the proposed fleet size schedules and frequencies provide sufficient capacity to meet the anticipated inter zonal person trip demand that aspect also need to be checked. So, we must keep that in mind so the road capacity is important but when we are talking about the mass transit system it is with the proposed fleet slide at what schedule or frequencies I want to operate the public transport system or service.

That will decide what is my public transport capacity now that has to be commensurate with the total person trip demand, there was n thousand peoples are trying to use public transit in a particular hour. So, my fleet size frequency all those should be able to handle this many persons should be able to carry this person also with the required or desired level of service that is another aspect, not just carrying people but with certain level of sufficient capacity.

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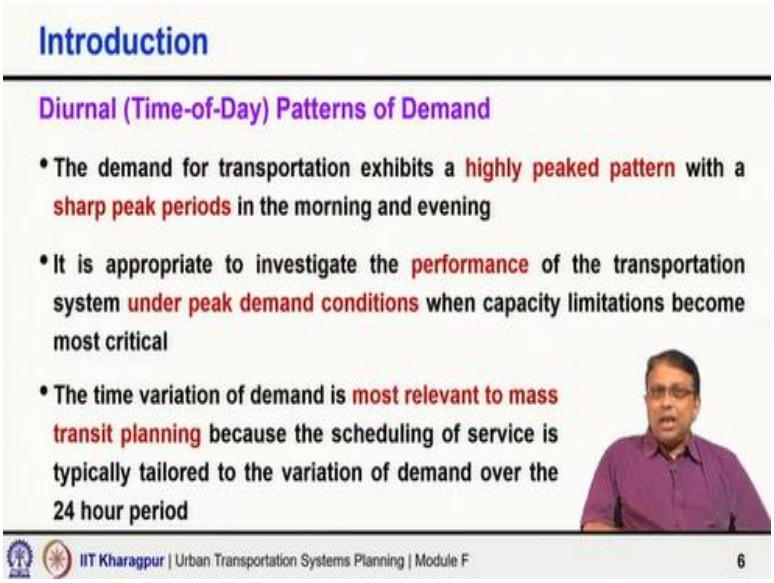

Next important thing is the diurnal or time of the day pattern of demand. As you all know, number of times I have mentioned in this course that the total demand is high that is not the real problem the demand is high during certain hours of the day is the problem. So, transportation demand or the demand for transportation exhibits a highly picked pattern with a sharp peak periods in the morning and in the evening.

So, if you see early morning the demand is low, so absolutely no problem, roads are all fine, no congestion there is practically no impact and very good you feel, very good when you travel but then the slowly the office hours will start or a peak hour will start or peak period will start then the peak period continued so typically which is due to the work trip, people start going to office and that is the point where lot of problems happen.

Again, the same way the off peak beyond work hours or beyond office hours in the morning the demand may again little bit come down depends how much will come demand will come down that depends on and that may vary from city to city. If you say the Bombay situation it is very different, then the situation probably what is what you can observe in Chennai or in Calcutta or in Delhi.

So, you know city to city even you go to next level city maybe you go to Hyderabad or maybe any other Pune or even in Bangalore things may be very different. So, it depends on how much

will come down, how much demand will come down how sharp will be the peak as compared to the off peak it depends on the city, but obviously one thing is very true in every city context the peak hour demand is very high.

And, therefore it is appropriate to investigate the performance of the transportation system under peak demand condition when capacity limitations become most critical. We know that during other hours anyhow transport system will perform better because simply the demand will be less. So, what we are interested we are interested to find out when the capacity limitations become most critical.

That means when the demand is maximum during that peak hour what is the kind of performance that is happening that we are expected to get and therefore our analysis should be during that period. The time variation of demand is most relevant also to mass transit planning for external condition is also important but overall for mass transit planning it is very important because during different hours of the day the demand may not be same.

And, therefore the scheduling of the service typically tailored to the variation in the demand over 24 hour period you will not find maybe in the midnight of course some city may still offer but with a significantly longer headway because night time or beyond peak hour also the travel opportunity should be provided but most cases the night service may not be available, so after 10 o'clock public transport do not is not available or maybe after depending again on the city.

Sometimes after 10 o'clock, sometimes up to 12 o'clock some cities may even whole night the service may operate, but the demand is certainly not going to be same during 24 hours in a day and therefore scheduling of service is typically tailored to the variation of demand over the 24 hours. So, the diurnal or the time of the day pattern of demand is very important both in general context and also in the context of the public transport.

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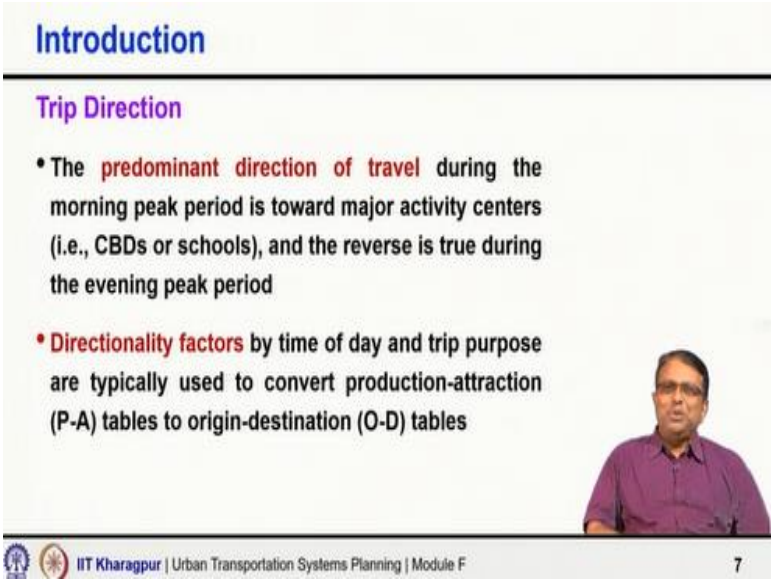

Trip direction is the next point, the predominant direction of travel during the morning peak is towards the major activity center typically the CBD area or the city center and the reverse is true during the evening peak period, because most cities the offices are located in one particular catchment which is normally typically the CBD and people all travel are happening towards the CBD.

So, there the condition and you consider the roads are many of the roads are divided roads or you know upstream and downstream movements are physically segregated, so the directional part is very important. Now, the directionality factors by time of the day and trip purpose are typically used to convert production attraction tables to origin destination table. You remember that, this discussion was also done in when we talked initially about the trip distribution.

So, the tip distribution one is the production attraction matrix, the other is the origin destination table or origin destination matrix. So, here we will deal with origin destination matrix because the direction of travel is included here, because when people are you know there is a difference like a trip happening from office to home the production is still in moment and the attraction is in the office end but origin is office destination is home.

So, the directional part is very important and please remember that whenever you are using traffic assignment we say the matrix but this matrix is basically the origin destination matrix that should be taken.

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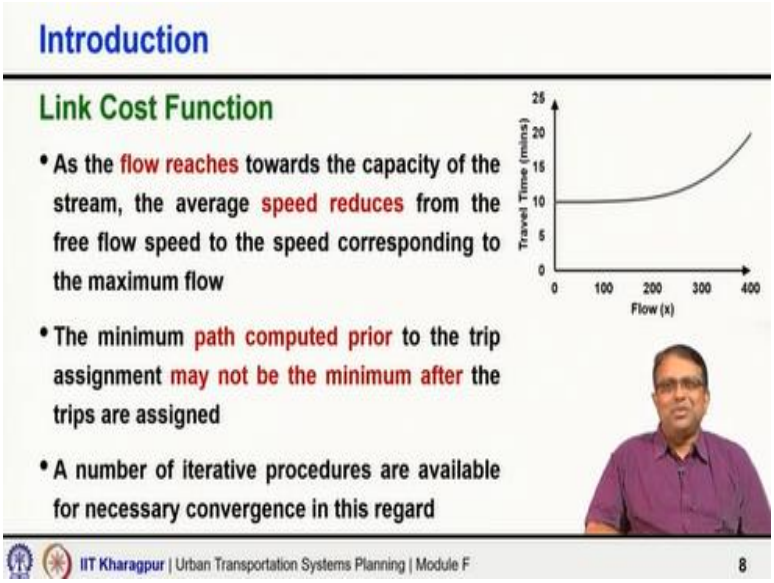

Now, coming to another very important aspect is what is called as link cost function. Now, why the problem occurs during the peak hours? Why the transportation system we find that there are so many problems in the peak hour? The road is same, so what is changing if the road is same physical feature is same. Generally, we can assume that the capacity also will be same, it is a physical facility.

So, how many lines are there accordingly the capacity will be decided. So, what? Why then the time is more during the peak hour? Why it is less during the different levels of a peak? Why this variation is happening? The only thing what is changing is basically the demand, the flow. The demand is changing, so that means time or the travel time is a function of the flow that is what is represented by the link cost function.

As a link or a road is getting loaded with vehicles more and more vehicles are trying to use it, so loading is becoming more and more so the travel time also will increase. How they increase? Is it that starting from if I add from 1 vehicle to 2 vehicle and then 2 to 3, 3 to 4 every unit increment

of vehicle the increase in travel time is going to be same or every per addition of 10 vehicles every time the travel time is going to increase in the same manner? No.

That does not happen. Most cases one can sometimes assume that it is a simplicity you can assume that it is a linear function but it is never a linear function. It typically is a non-linear function, initially you will not find the travel time is changing if there are 5 vehicle, 10 vehicles, 15 vehicles may not change travel time may not change because all vehicles are still enjoying very high freedom of movement and they are using the road very nicely without anything.

And, enjoying high level of service but beyond certain threshold then it will start increasing and then when the flow is around the or near the capacity that time every even small increment the impact may be increasingly bigger in terms of increase in the travel time. So, I have shown here one typical link cost function, where the x axis you know the flow is given and y axis travel time is mentioned.

Do not worry about the numbers what I have written 100 to 200, 300, 400 just assume that we only wanted to show that as the volume increases the travel time increases. At what value how much travel time will come that will depend on what is the capacity of the road. So, effect of a demand on one line road single line road or a two line road or a full line dual carriageway on a six line or eight line delayed grill carriageway may be entirely different.

Because, it is basically the not just volume but the volume and also the capacity of the road which are important, but for a given road with a fixed capacity the flow changes or the volume changes and the travel time changes. So, it is just a generalized representation of that do not look at the value or even 5 minute, 10 minute, 15 minute it also again depends on the link. So, this is just a representation.

So, because of this the travel time with zero flow that means in the absolute lean period or when there is no traffic or just very few vehicles are there and the travel time in the congested peak hour during the peak hour are going to be different. So, whatever is the shortest path during a

low demand time that after loading vehicles the peak hour vehicles that path may not be any more the shortest path because, the travel time will increase.

So, the travel time and which one is going to be the shortest path also will depend on how many demands are actually trying to be accommodated or how much demand we are trying to accommodate within that facility. So, there are iterative procedures which are applied to get this.

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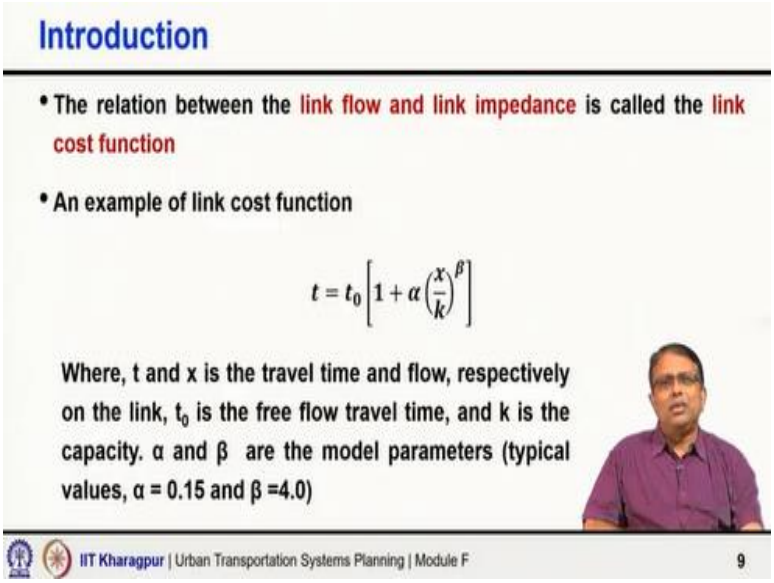

And here, I have shown the relation between the link flow and the link impedance that is called the link cost function, cost here is a generalized term again cost means maybe travel time, cost may mean even the you know actual vehicle operating cost, but most cases to start with let us take it a time. That is what actually changes very drastically and we are all interested about the time so and here i have given an example of the link cost function.

This is typically known as BPR equation where the value of alpha is 0.5 and beta is taken as 4 but let me tell you it is not the same value of alpha beta it again depends on the roadway traffic and control condition. For one road you will calibrate this function you will get a value of alpha and beta and then another road the alpha and beta value may be different, it all depends what is the roadway what is the traffic and what is the control condition.

But, this is a generalized form and this particular form is very popularly used among transportation planets when we are trying to calculate the link travel time as a function of link flow and the capacity. Remember that, x is the flow and k is the capacity, so it is the volume to capacity ratio that is that becomes important. So, there are of course there are many other functional form.

So, there are several other link cost function and people have developed researchers have developed and this is just an example of this.

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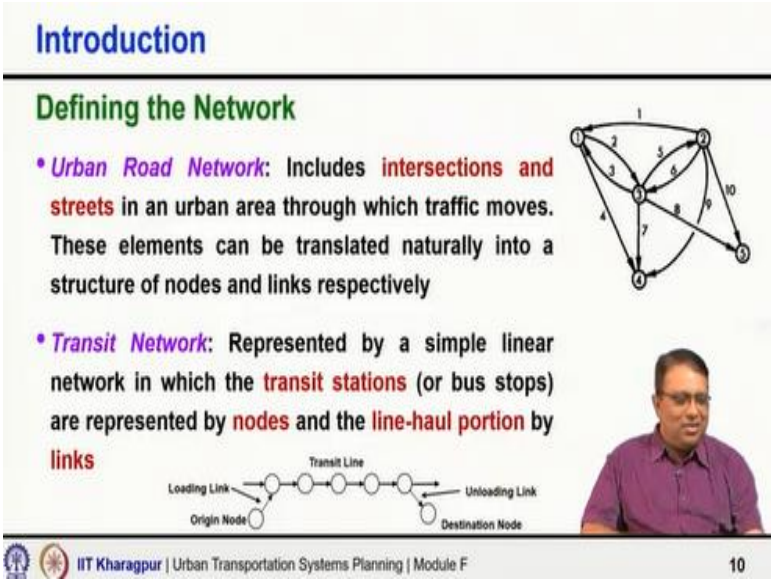

Now, we would like to define a few thing and in urban road network, typically what is there it includes intersections and streets in an urban area through which the traffic movements take place. So, therefore these elements can easily be translated into a structure of nodal link, so right side I am showing you can typically represent an intersection by a node and a link and you know a street in between intersections in an urban area using a link.

So, the simple depiction of urban road network is through the representation what we called as link node diagram. For roads transport network that is fine but for transit it is slightly different because what happens bus will keep moving along you know a sequence of links following a sequence of links and stopping at all the designated stops. So, the stops will be number will be much higher than the number of link in one link there could be even multiple stop.

So, transit network is typically represented by a simple linear network in which the transit stations or bus stops typically in the case of bus are represented by nodes and the line haul portion in between bus stops by the link. That is what the way the typically transit is represented in a network.

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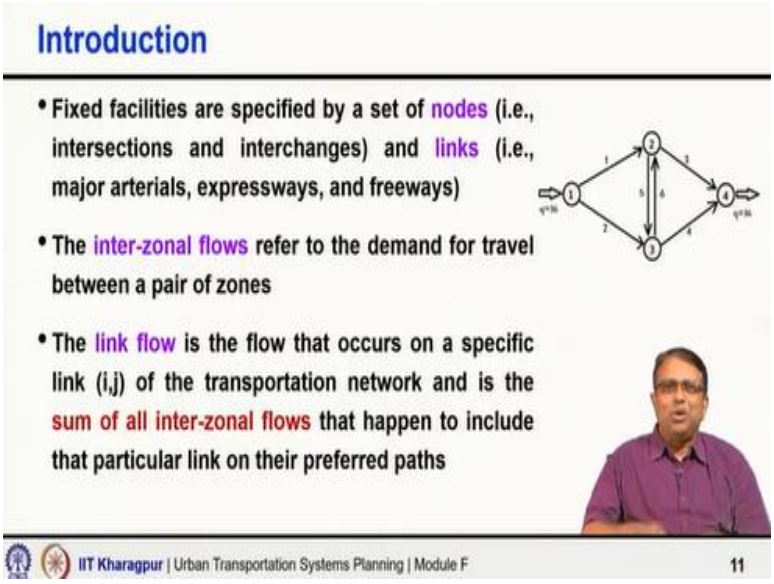

Now fixed facilities are specified by a set of nodes, nodes may be intersections or interchange or two roads are meeting typical what you see where a typical signal is installed that is represented by a node and the links are in between portion it could be major arterial may be freeway and typically in urban case all other categories of road, that arterial may be collector streets maybe even a local street.

And the inter zonal flow referred to the demand for travel between a pair of zones. So, between a particular origin and a particular destination how much demand is happening and by along a certain route that means sequence of paths and all are getting loaded all links in that sequence which are there along the path are getting loaded. So, you can calculate the link flow is the flow that occurs on specific link of the transportation network.

And, it is the sum of the all inter zonal flows that happen to include that particular link on their preferred path so maybe 1 to 2 then 1 to 3, 5 to 7, 9 to 10, 11 to 14 but all these movements are

probably using some common link, so that common link will have total flow as per the O-D of all these O-D pairs, how much total demand that is coming because the link may be part of multiple paths and this paths with respect to different O-D pairs.

So, if I have to get how much is the total link flow? I have to sum up all those which are you know passing through that link all the O-D pairs which are passing through that link.

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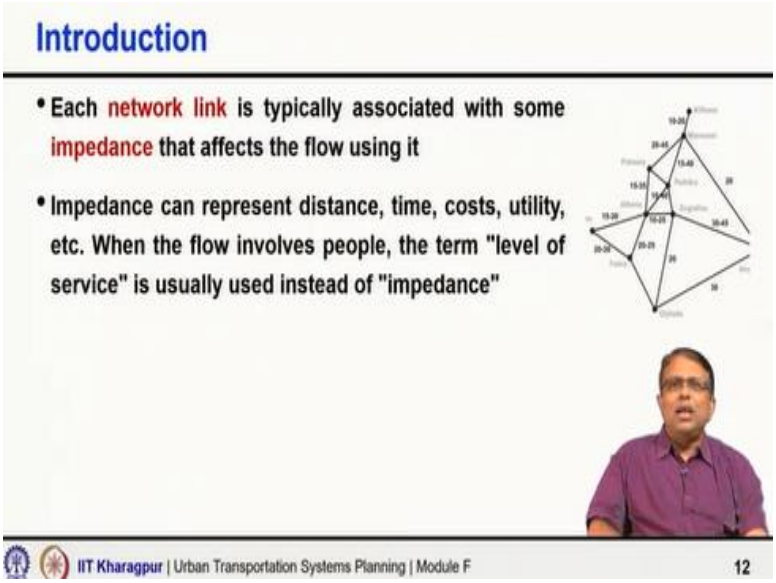

And, each network link is typically associated with some impedance that affect the flow and impedance when people are involved typically we express it with the level of service that is what we do it.

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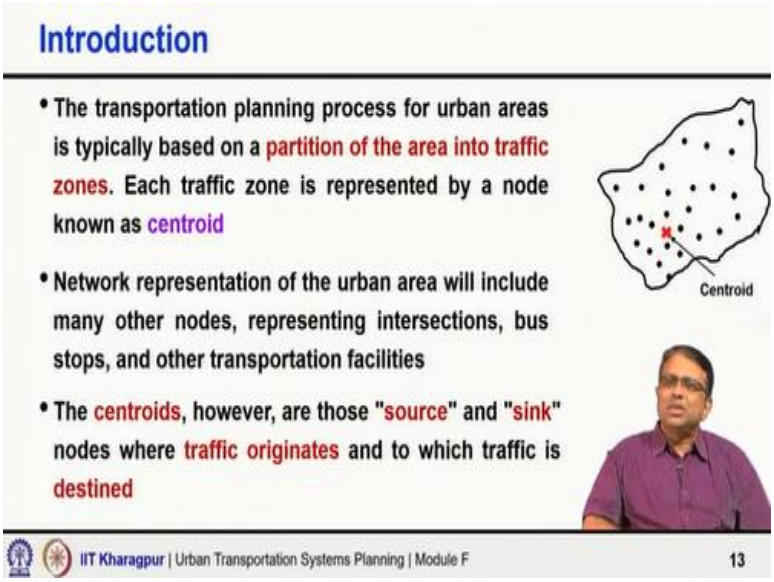

You know the traffic is generated from where? From origin? A zone? Typically where zone centroid already is known to you and where it goes? It goes to another zone where the final termination happens, it is again in a zone and particularly in a zone where it is the centroid. There is you know actually it may get distributed within that zone trips will get distributed within the zone but for simplicity what we assume that a zone is represented by a zone centroid.

So, every trip with respect to that zone getting started from that particular node and every trip which is terminating in that zone is getting terminated at that particular point which is the zones centroid. So, the centroids are therefore the source and sink nodes where the traffic originates and to which the traffic is destined.

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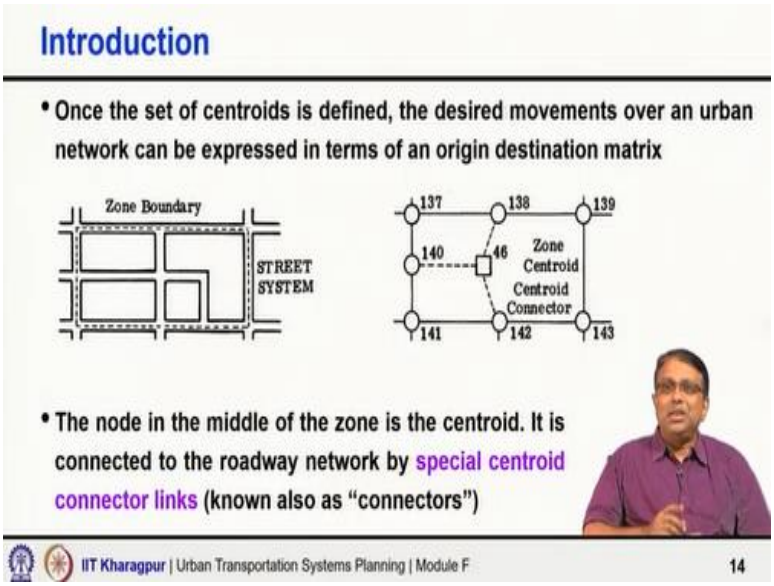

Therefore, it typically represent a network like this where you have you know zone boundaries are there, so typically the zone boundaries will have the roads. Roads are there in the zone boundary and in between you have a zone centroid. So, what we have to do we have to connect the zones centroid to the transportation network, these were all discussed earlier also. So, I am not elaborating this too much at this stage.

We said in the beginning when we talked about what are the data requirements and transport network we discussed also in that context, so there we mentioned. So, the zone centroid has to be connected to the road link or the primary roads using some dummy connector because zone centroid is a representation. So, if how the trip physically can take place from zone centroid to the network, I have to connect it.

So, there are special centroid connected links which are used to provide the connectivity to the network, actual road network and the zone centroids. So, if a zone and then there are three or four roads around that we may connect it to all four nodes, all four links using the special centroid connectors or generally we call them as just a connector. So, connector is not actually physical road but is it is just connecting the zone centroid to the actual transportation network.

So, eventually that also becomes part of the transport network representation because every node is to be connected to the transportation network because trip originates from nodes origin nodes

and or a centroid node, trips are again terminated also to a centroid node and in between they are using the transport network. So, all this connectivity we have to ensure.

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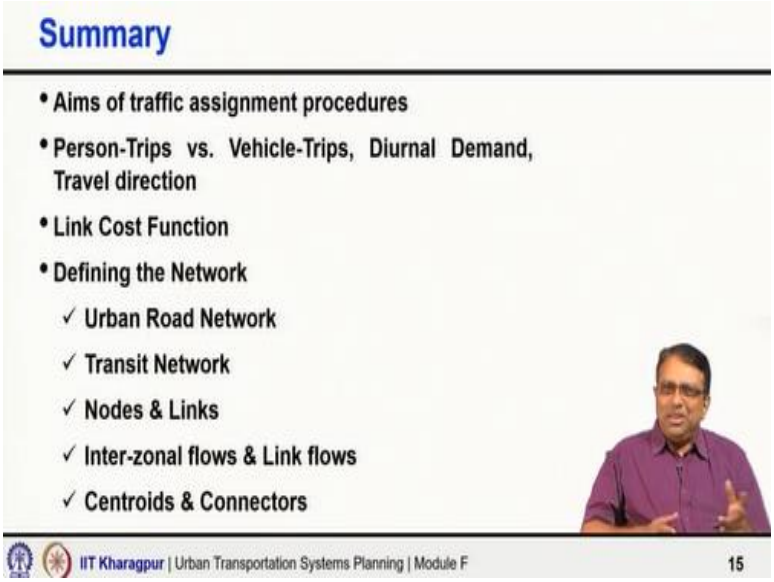

So, with this what we discussed then we told you clearly what are our aims of traffic assignment procedures, what are the all outcomes that we expect and how they are useful, then person trips versus vehicular trips and also the time variation of the demand of the diurnal pattern of the transport demand. The direction of travel and therefore the use of O-D matrix is very, very important.

So, these three aspects we should we will always bear in mind, then we understood also the importance of the link cost function, why it is important and why what is actually link cost function and then we said how the network is defined in terms of urban road network, transit network, nodes and links and then inter zonal flow and link flow and then finally the centroids and the centroid connectors. So, with this we close we shall continue our discussion in lecture 2.