Urban Landuse and Transportation Planning
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Lecture 60
Shared Mobility

Lecture 60 will focus upon shared mobility and throw some light on the concepts related to the topic.

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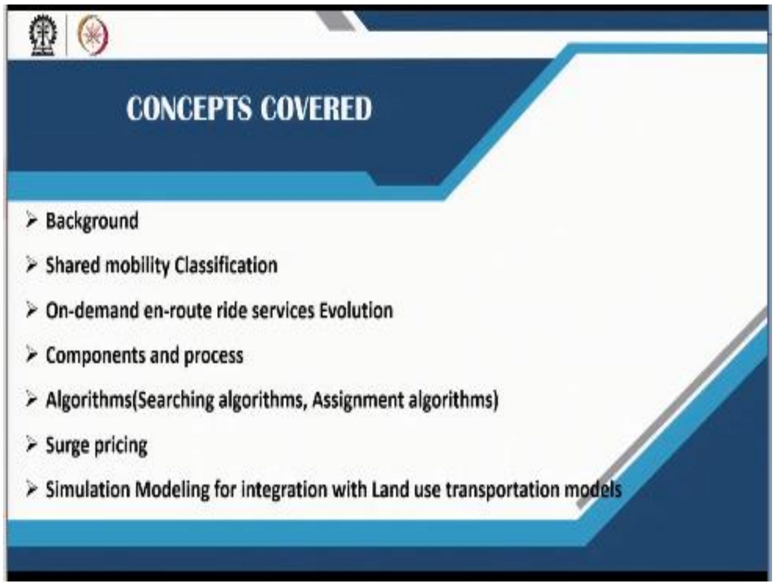

The basis of the introduction of shared mobility as a transportation option will be discussed to elucidate the background of shared mobility. The lecture will also emphasise on the classifications of shared mobility and introduce the concept of on-demand en-route ride (OnERide) services. The evolution along with the components and processes of OnERide services will also be highlighted. The lecture will also cover different types of algorithms involved in OnERide and similar services, like, searching and assignment algorithms. The basis of surge pricing in OnERide services will also be discussed. Finally, the lecture will also highlight upon the integration of such mobility options with the landuse transportation models using simulation framework.

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Background

The term ridesharing refers to the sharing of ride with other individuals who share a common origin and destination. But, at present, ridesharing encompasses a lot of different things. Ridesharing is most commonly mistaken as the services provided by Ola in our country or Uber internationally at present. Although, there are lot of similarities of the services provided by Uber or Ola with ridesharing, these services can certainly be not termed as ridesharing. But one cannot deny the fact that modern day passenger transport services by Uber or Ola are certainly variants of ridesharing. The concept of ridesharing date backs to the Second World War from when it evolved gradually in certain phases. Ridesharing was initially introduced in the form of car sharing clubs during 1942 to 1945 through a self-dispatching system. Such system of ridesharing was the introductory phase of ridesharing where people used to get the information through bulletins. The second phase of ride sharing started with the energy crisis during the 1960s. People were saving oil by travelling together which led to the growth of carpooling or van pooling. The government and the employers encouraged such carpooling options to cut down on oil consumption. Such trips made in groups came to be popularly known as casual carpooling. The basic form of formal ridesharing started during the 1980s. Towards the end of 1997, organized ride sharing schemes became popular where matchings were provided based on telephone. As the technology evolved during 1990s, the concept of ridesharing took online facilities into consideration. The users were able to book a taxi or a private vehicle online before the initiation of a trip by the end of 1999. Finally, the format of ridesharing that are common these days actually started after 2004 and such services are known as technology enabled ride-matching. These are also known as real time ride matching services, which enable the customers to book cabs based on their real-time locations.

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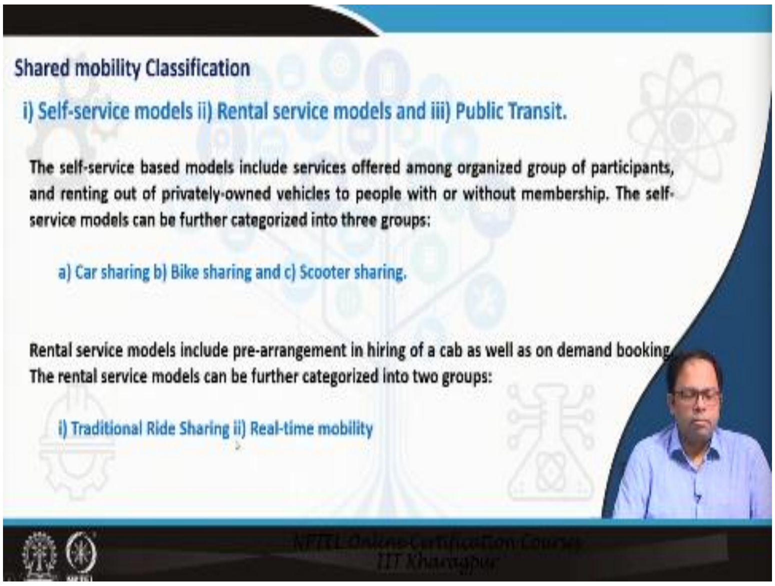

Classifications of Shared Mobility

Shared mobility can be classified into three groups, a self-service model, a rental service model and public transit. Public transit will not be discussed since it is completely a different topic and different from the other shared mobility options where ride-matching is one of the salient features. The self-service model includes services offered among organized group of participants and renting out of privately owned vehicles to people with or without membership. The self-service models can be further categorized into three groups, namely, car sharing, bike sharing, or scooter sharing. This form of sharing refers to the use of a vehicle by an individual or group of individuals where a platform offers a vehicle not service. The rental service model includes a pre-arrangement in hiring of a cab as well as on demand booking. Rental service models can also be divided into two groups like, traditional ride sharing and real time mobility. Traditional ridesharing refers to the sharing of ride in a cab, as observed in taxi services. Therefore, in traditional ride sharing a taxi can be booked online or via telephone before the initiation of the trip. In real-time mobility services the companies are not directly involved in owning the fleets. The companies can facilitate to establish connection between a customer and a driver. Therefore, a driver can be hired based on the customer's real-time locations through mobile applications, but the driver is not considered as an employee of that company.

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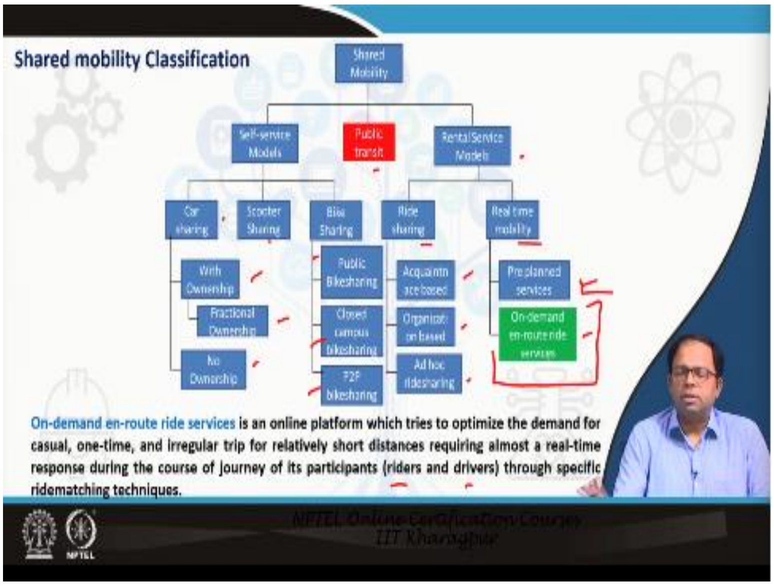

The classification discussed earlier has been represented through the diagram above. Car sharing, a self-service model could be with or without ownership. There may be a fractional ownership in car sharing because a single car can have multiple owners. Bike sharing, another example of self-service model can further be classified into public bicycle sharing, closed campus bicycle sharing and, peer to peer bicycle sharing. Therefore, I can select a bicycle from a docking station through an online platform and return it to the nearest docking station of my destination without anyone's help. As discussed earlier, ridesharing, and real-time mobility are two categories of rental service model. Ridesharing can further be classified into three categories, namely, acquaintance-based, organization-based, and ad-hoc ridesharing. This implies that ridesharing refers to sharing of ride among group of individuals. The real-time mobility can be divided into two groups, pre-planned services, and on-demand en-route ride (OnERide) services. Pre-planned services refer to those services where the vehicle can be booked beforehand. OnERide services are those services where the vehicles will arrive at your real-time location whenever you need it. So, the services which companies like Uber or Ola provide is basically OnERide services. This lecture will focus mostly on the techniques or technology adopted in OnERide services. So, OnERide services is an online platform which tries to optimize the demand for casual one time and irregular trip for relatively short distances requiring almost real-time response during the course of journey of its participants (the riders and the drivers) through specific ride matching techniques. The two primary stakeholders of OnERide services are the rider and the driver. The rider requests for a vehicle and, the available driver is matched with the rider. Such rider-driver assignment is also known as ride-matching. Once a driver is assigned, the driver picks up the rider from his real-time location and drops off the rider to the destination as specified by the rider. Such services require a real-time response because the vehicle must be assigned to a rider as soon as the rider registers a request in the mobile applications.

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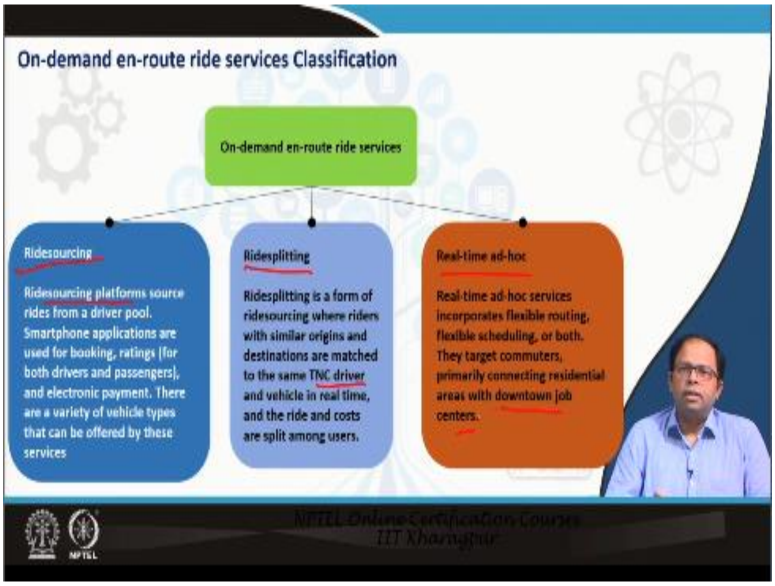

<u>On-demand en-route ride services (OnERide)</u>

OnERide services can further be subdivided into three categories, namely ridesourcing services, ridesplitting services and, real-time ad-hoc services. Transportation Network Companies (TNCs) provide ridesourcing services through a platform where the drivers can register as well as make themselves available. Smartphone applications are used for booking as well as giving ratings (for both drivers and passengers), and electronic payment. The smartphone application connects the rider with the drivers. Besides, the platform also offers multiple categories of vehicles which can be selected by the rider based on their preference. Ride splitting is a form of ride sourcing, where riders with similar origins or destinations are matched to the same TNC driver and vehicle in real-time. The ride as well as the cost is shared among the users who are going towards the same destination. The algorithms are designed such that the riders who fall along the route of a specific driver are matched to that driver. The final category is real-time ad-hoc services. Such services incorporate flexible routing, flexible scheduling, or both. They target the commuters primarily connecting residential areas with downtown job centres. Such services resemble shuttle services where a request for a specific service at specific time of the day can be generated to arrive at the destination. For example, a user can request for a service to reach his office at specific time of the day. Accordingly, the requested service can be provided by a bus. The bus will pick-up the user and drop them off at the specified destination. The cost will automatically be reduced since that service will be used by multiple users who share the same office location. In these services, the origin of the riders might not be the same, but the riders share a single destination.

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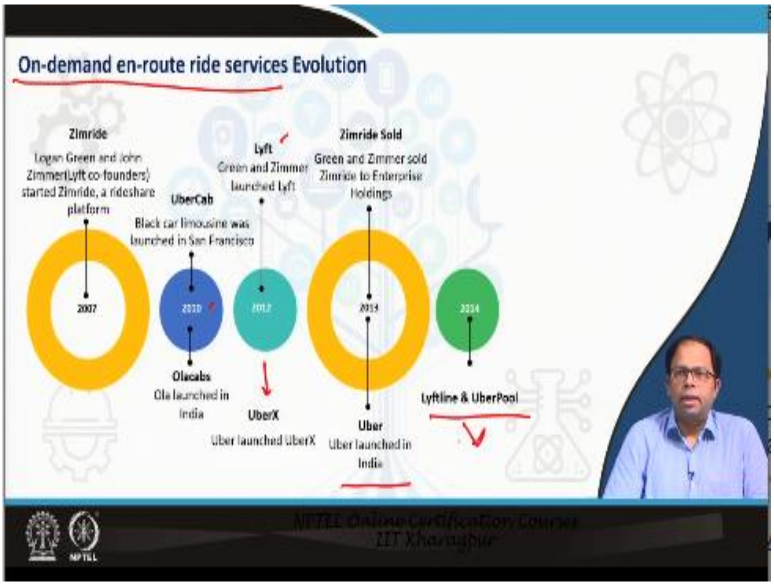

Evolution of OnERide services

Earlier, we have discussed the advent of real-time mobility services which evolved from ridesharing. Now, OnERide services initiated with the ridesourcing services. These services started with the launch of Zimride, founded by Logan Green and John Zimmer in 2007. But Zimride could not gain much popularity as an OnERide platform. A similar ridesourcing platform was launched in 2010 in the form of Uber cabs which initially provided black car limousine in San Francisco. While Uber cabs were launched in the USA, Ola cabs were launched in India during the same time period. Zimride owners, Green and Zimmer started another ridesourcing platform in 2012, which later became popular as Lyft in the USA. During the same time, a cheaper ridesourcing service UberX was also launched to attract more customers. With the inauguration of Lyft, Zimride was eventually sold in 2013. In the same year, Uber was also launched in India. Finally, the TNCs like Uber and Lyft launched ridesplitting services like Lyft line and UberPool respectively. The confusion regarding ridesourcing and ridesharing can be attributed to introduction of services like UberPool. This is because UberPool or Lyft line has similar characteristics of traditional ridesharing. Although the TNCs initially started their journey with ridesourcing services but expanded their network to provide ridesplitting services later. This primarily confused the researchers regarding the type of services offered by the TNCs.

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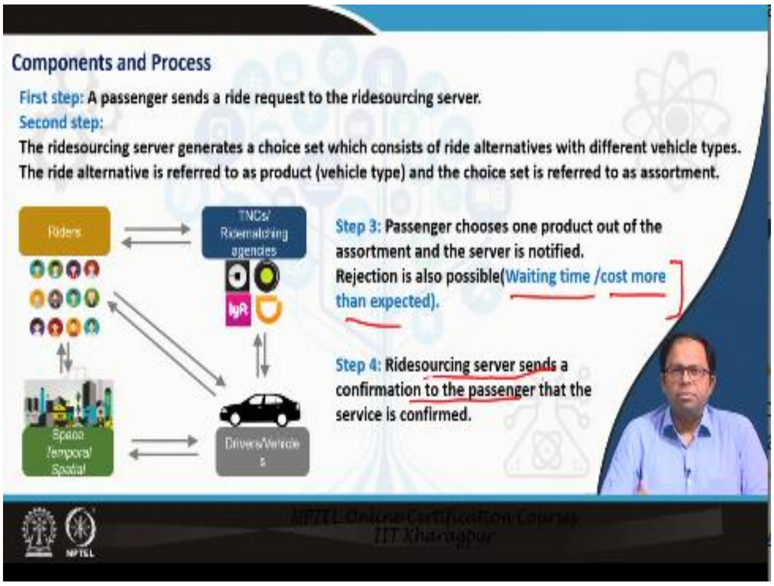

Components of OnERide services

OnERide services are quite common at present. The operational characteristics of such services follow four different steps. Let us discuss those steps in detail. The first step involves a passenger sending a ride request to a ride sourcing server. In the second step, the ride sourcing server generates a choice set which consist of a ride alternative with different vehicle types as well as fares associated with each type. The ride alternative is referred to as a product (vehicle type) and the choice set is also known as assortment. Now, in step 3, the passenger has the option to choose one of these products based on whatever he has been notified. He can also reject the product if the waiting time is high. It is noteworthy that the assortment provides the customer with the expected arrival time of the vehicle along with the fare. Based on the expected arrival time, the user can decide whether the expected arrival time will lead to a higher waiting time for him/her. Therefore, a customer can also reject such assortment based on his/her threshold for waiting or fare. Finally, once a person gives his/her choice, the server is notified, and it assigns the rider to his/her appropriate driver. A confirmation is then sent to the passenger from the server regarding the service followed by the arrival of the vehicle to initiate his/her trip. While designing any OnERide service, such components mentioned in every step need to be considered. If the demand is high and the supply is low, the waiting time will increase. Higher demand also increases the fare paid by the users. Higher waiting time will reduce customer satisfaction who will eventually leave and will be reluctant to use the service. So, a balance is required. But the problem is, whose perspectives must be considered to achieve an optimal balance between demand and supply, the company, the riders, or the drivers? Such questions can only be answered through an extensive research in this domain.

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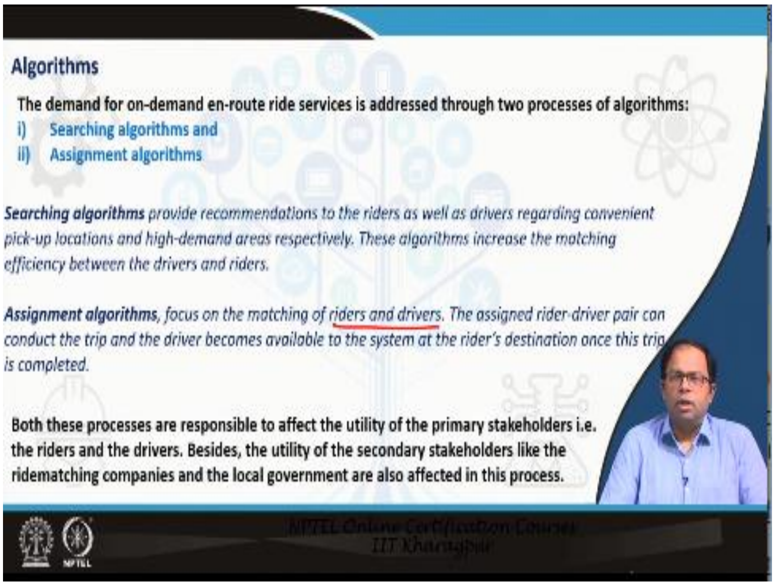

Algorithms used in OnERide services

There are two processes of algorithms which are used to handle OnERide services, namely, *searching algorithms* and *assignment algorithms*. Searching algorithms provide recommendation to the riders as well as the drivers regarding convenient pickup location. It also provides information on the hotspot locations where the driver will more likely get a ride request. Such information also increases the matching efficiency between drivers and riders. Therefore, the first group of algorithms focuses on information dissemination which will enable the matching between a rider and driver. The assignment algorithm is the second group of algorithms used in OnERide services. Such algorithms focus on the actual assignment of a waiting rider and an available driver (or about to be available) in the system. There are several heuristics which are utilized for matching these two stakeholders. Primarily, the nearest driver to a rider who is looking for a ride could be assigned. But such assignment might not be better for the drivers who may prefer for other rides to other destinations. In other words, such assignment can lead to the increment of the drivers' idle time. So, distance between the rider and the driver is not the only criteria to conduct assignment. If the decision maker wants to optimise the overall system, other criteria must be taken into consideration. In addition, the TNCs consider other parameters to conduct assignment. For example, when a driver has exceeded his working hour limits, he might be assigned trips which are near to his home location. Besides, a driver who has a poor rating would not be assigned to a rider with a high rating. Urban planners might try to optimise the overall system from a different perspective. The assignment can be optimised either by reducing the travel time between the riders and the drivers or by taking the overall demand and supply of the city into consideration. Both the processes are responsible to affect the utility of the primary stakeholders, i.e., the riders and the drivers. But the utility of the secondary stakeholders must also be considered. So, TNCs and the local governments are also affected in this process of matching riders and drivers. For example, if there is a change in the information provided, the effect of such information will be different. But the person using that information might not be aware of this change and may use the previous information to conduct an activity. It will dilute the benefit of information dissemination. Such situations may arise in practice and some information might not prove effective for certain groups when the overall city's perspective is taken into consideration. Such instances are complex and would require an advanced technology to handle this apart from the existing algorithms.

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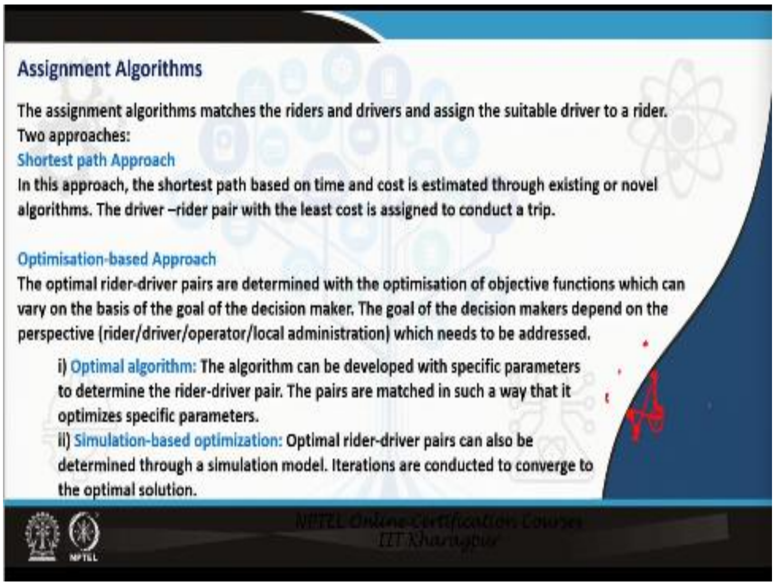

Assignment Algorithms

The assignment algorithm matches the riders and drivers and assign the suitable driver to a rider. There are two approaches, the *shortest path approach,* and the *optimization-based approach*. The first approach, i.e., the shortest path based on time and cost is estimated through existing or novel algorithms. The driver-rider pair with the least cost is assigned/matched to conduct a trip. In the optimization-based approach the optimal rider-driver pair is determined using the optimisation of certain objective functions which depends on the goal of the decision maker. The objective might depend on riders' perspective, i.e., the goal could be the reduction of rider waiting time. Objective function can also be designed to address drivers' concerns of maximising the number of rides they receive. Besides, the goal of the operator, i.e., to maximize the total number of matches can also be taken into consideration. The local administration would aim at the reduction of the total kilometres travelled through the process of assignment. Therefore, if the main goal of the assignment is to reduce the waiting time of the riders, the operator will need to engage more drivers. On the other hand, if the assignment is conducted based on city's objectives, the waiting time of the rider might increase, such that the total travelled distance in the city is reduced. Therefore, the shortest path solution may not actually lead to a global short, i.e., the overall travelled distance may not be the shortest distance. So, it is important to consider the optimization-based approaches in this regard. Optimization can also be carried out using two categories of algorithms. An *optimal algorithm* can be developed with specific parameters to determine the rider-driver pairs and the pairs can be matched in such a way that it optimizes certain parameters. The other process can explore *simulation-based optimizations*, where optimal rider and driver pairs can also be determined through simulation. Multiple iterations are conducted through the simulation to converge to an optimal solution. Based on a specific objective function, the minimum cost is selected as a feasible solution for the entire day. A standard, single optimal algorithm will generate the minimum cost for a specific time period, and not for the entire day.

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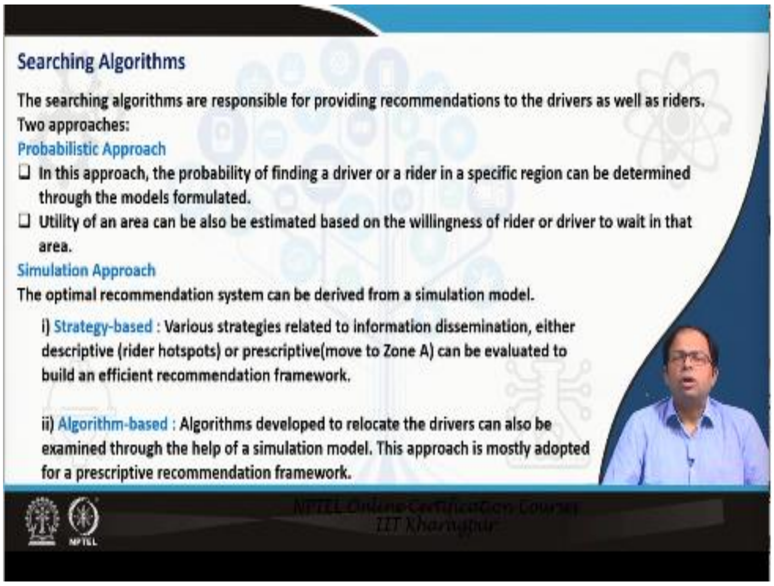

Searching Algorithms

Searching algorithms are responsible for providing recommendations to the driver as well as riders. These algorithms also adopt two approaches, a probabilistic approach, and a simulation-based approach. In the first approach, the probability of finding a driver or rider in a specific region is determined. Such models can predict the likelihood of finding a driver at pick-up locations or vice versa. In these models, the utility of an area can also be determined based on the willingness of a rider or driver to wait in that particular area. A probabilistic approach considers the above parameters while developing the model. The simulation approach can further be divided into two categories, a strategy-based approach, and an algorithm-based approach. In strategy-based approach, certain strategies related to information dissemination can be like provision of hotspot information to the riders and information dissemination to the drivers regarding high demand areas through their mobile applications. Based on the information, the drivers can decide to reach the hotspot locations. For example, the driver’s current location is zone A, and the algorithms can prescribe the driver to go to zone B. It might be a hotspot or an area where the likelihood of getting a ride request is more compared to the current location of the driver, i.e., zone A. So, such guidance helps him to decide on waiting at a particular location or travelling to other locations in search of passengers. In practice, the driver drops off a passenger and wait at that location if he feels that he might get a passenger at that location. He will drive towards those locations where he can receive a ride request based on his experience. The driver may or may not get a ride based on his experience, but accurate information regarding ride request can enable the driver to get a confirmed trip. The likelihood for receiving a ride request can be predicted using the historical data based on which the ridesourcing platform can also predict the prominent locations where there is more chance of getting passenger. Based on such prediction, the platform can provide a prescriptive instruction to the drivers to move towards zone A or B. The overall target is to increase the number of ride-matches, increase the number of trips served by each driver and increase the earnings of the drivers. Such target focuses on drivers’ objectives. So, the strategies can be designed based on the objectives we need to address. Algorithm-based models adopt algorithms that are developed to relocate the drivers which can also be evaluated using a simulation framework. Therefore, a few algorithms or methods can be proposed, and such proposed methods can be assessed through a simulation. A simulation would help us to determine the effect of the information, and the strategies devised to disseminate information. Such approach is mostly adapted from a prescriptive recommendation framework. In order to provide a prescriptive framework a simulation can be utilised to observe the impacts of the proposed policies. The research conducted in the domain of searching algorithms is quite limited and such algorithms have not been detailed out by the researchers till date. In this particular lecture, different strategies that are used in OnERide services are highlighted broadly.

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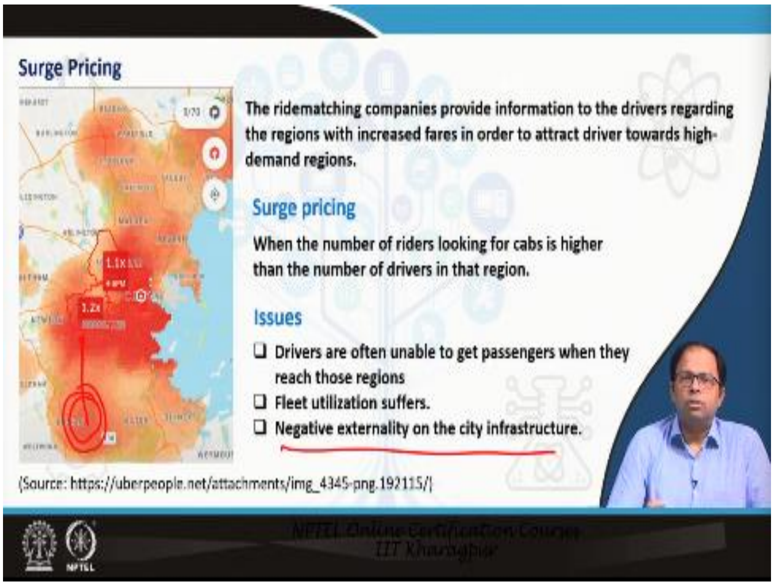

Surge Pricing

The surge pricing policy is specific to OnERide services and is not available in other services similar to OnERide. The TNCs introduced such policy to maintain equilibrium between demand and supply. In certain locations where the demand is higher than the supply, a fare multiplier is used, popularly known as surge pricing. But such a pricing mechanism has two aspects. The positive aspect of the policy is that, the drivers can be lured to drive towards these locations because they can earn more money and therefore the supply in those areas can be increased. As the supply increases in these locations, the waiting time of the riders looking for a cab can be reduced, and the users can be served with a better level of service even at times of spike in demand. The negative aspect of such mechanism is that the riders who are waiting at those locations will have to pay higher fare than usual. So, if people are willing to pay higher fare, such mechanism can be effective. But if the people perceive the fare multiplier to be too high, they might look for other options apart from OnERide services. Such scenario can reduce the demand in those locations and the drivers might not get passengers once they reach those locations. As the demand reduces, the fleet utilization also suffers because the drivers will have to stay idle without any rides as they have accumulated at these locations. For example, in the map shown above, there is a mild peak towards the south-western region. But no fare multiplier is applied in this region. On other hand, the surge pricing is applicable in regions with higher peaks. So, the drivers from the south-western region also drive towards the central zone and automatically the south-western region will remain unserved. On the other hand, the drivers moving to central area might not find passengers which can lead to the reduction in fleet utilization. Besides, such movement of the drivers can also have negative externality on the city's infrastructure because the drivers need to travel extra miles to reach these locations since they are redirected towards these locations.

Such movements can lead to the increment of the total greenhouse gas emissions. These aspects will play an important role in determining the type as well as information dissemination framework for OnERide services.

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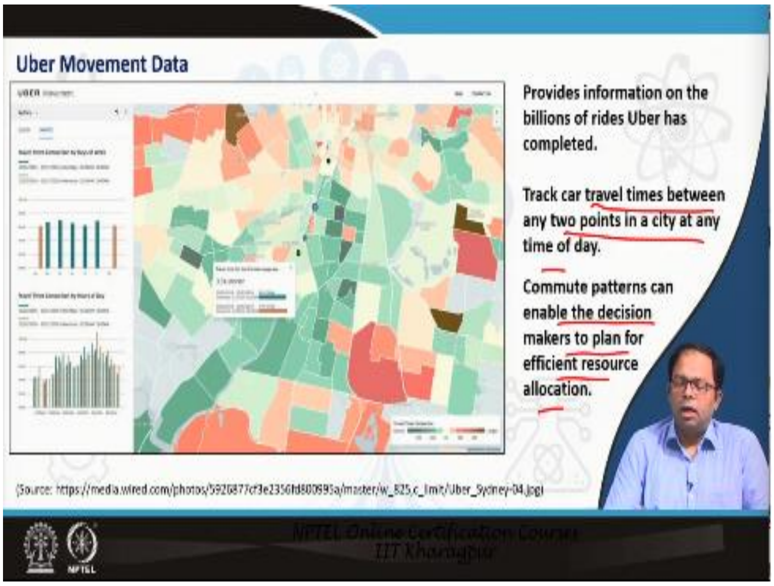

Uber Movement Data

Although Uber is a private company, Uber provides some information accessible for public through its online platform, Uber Movement. Apart from Uber, Ola also provides Application Programming Interface (API) access which can be used by the developers who build their own applications. With this access, information on the estimates of travel time and waiting time at specific spatio-temporal location can be obtained. Such information is based on the huge number of trips that are conducted by the drivers engaged with a particular company. Such data does not disclose the individual information related to the riders or the drivers. Uber Movement data only aim at highlighting the travel time at different traffic analysis zones (TAZs). So, the data disseminated is an aggregated one and can be utilised to track car travel times between any two points in a city at any time of the day. Such data can also be used to analyse the commute patterns in a city which can enable the decision makers to plan for efficient resource allocation. So, OnERide services are growing at a very fast pace. In developed countries, it is growing at around 20% per year. Even in India, the rate of growth is quite similar, but the rate of adoption is much lower compared to developed countries. The primary concern regarding these services is that it is provided by a private entity. So, although the demand can be estimated from a travel demand model i.e., the estimate of the number of people using OnERide service at different spatio-temporal locations, it is difficult to get the estimate of the supply. This is because the TNCs act as aggregators and do not maintain its own fleet. Therefore, decision makers do not have any idea about the supply provided by the company. Although such data from the TNCs can help the urban planners to estimate the travel time at various locations, the data available on Uber Movement not adequate to provide other information specific to OnERide services which can enable the decision makers to assess the overall impact of such systems on the urban environment.

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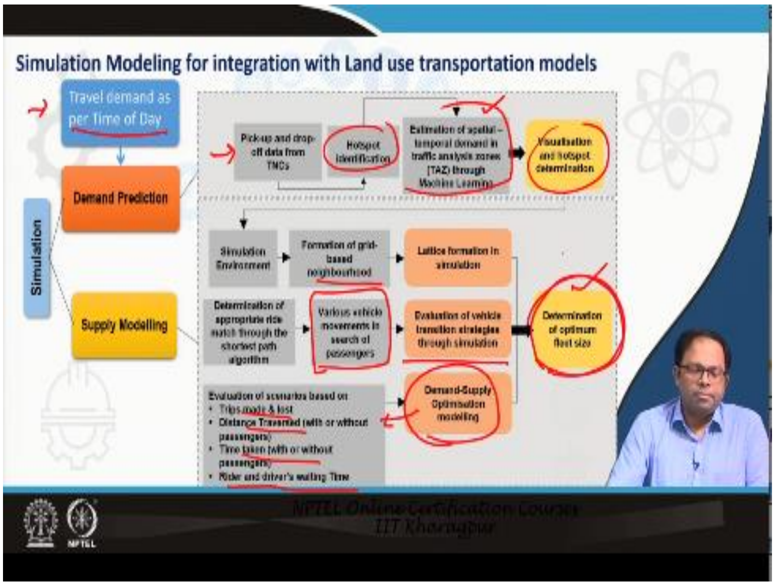

<u>Integration with Landuse Transportation models using Simulation</u>

As a transportation professional, our primary goal is to reduce the total amount of travel, reduce emission by reducing the vehicle kilometers travelled or to reduce the waiting time for the passengers. The combined goal of the drivers and the companies will be to increase the number of ride-matches or to maximise the amount of profit. In order to provide a comprehensive transportation system, it is essential to integrate such privately supplied system into our entire transportation supply in a particular urban area. In transit assignment, (although not covered in detail in this course), the bus routes and schedules are determined based on the demand along that route. Therefore, the demand served by the existing bus fleet can be determined. Accordingly, the required bus fleet to serve the estimated demand can also be determined. Although the public transit is provided by private companies as well as government companies, we have detailed information about the characteristics of buses, number of buses along each route, and location of each bus based on GPS information. But OnERide services are offered entirely by the private companies who do not release such information. So, there is a need to develop certain simulation models, which could be integrated within our landuse transportation model as auxiliary models where the total demand for OnERide services can be evaluated. Besides, the supply that will be required to determine an optimal balance for the existing travel demand determined from our mode choice models can also be solved using an integrated model. As highlighted in the image above, the travel demand for each time period of the day can be derived from the demand prediction module developed based on the pick-up and drop-off data shared by the TNCs. Based on such data, the spatio-temporal hotspots can be determined based on data mining techniques and machine learning algorithms. The trip data from these companies will provide the details regarding the trips which have been served. The origin-destination data will not include the ride requests which were left unserved. So, the choices of the riders must be determined through a stated preference survey. The modelling of the choices can determine the likelihood of individuals using these services. Based on the simulation, we will be able to determine the optimum supply for an urban area. The simulation will also help us to estimate the waiting time experienced by different riders which will again influence the mode choice of the riders. In the simulation environment, the estimated demand can be taken as an input variable and the entire environment can be divided into different grids which can represent a city structure. Such grids are usually hexagonal grids since they can easily replicate the movement patterns across different grids. The estimated demand is distributed in each of these grids. Based on the demand, the number of vehicles which are free to serve this particular demand can also be estimated. Each vehicle in the system can adopt different vehicle movement strategies like whether the vehicle will wait for a passenger or roam freely or move to a specific location. An appropriate ride matching algorithm can be adopted to match a vehicle with a rider in the system. Such vehicle movement strategies can be evaluated by simulation and based on various scenarios the optimum fleet size can also be determined. Now, the optimization model can aim to optimise the total number of trips made and lost, the distance travelled, the total travel time, or the waiting time for the riders and drivers. So, there can be multiple objectives which we can be optimised for an urban area that will give us an effective fleet size for an urban area. The fleet size will eventually help us to determine the waiting time for passengers as well as the cost for passengers which can provide feedback to the demand module developed using the mode choice models. The link assignment can also be updated accordingly.

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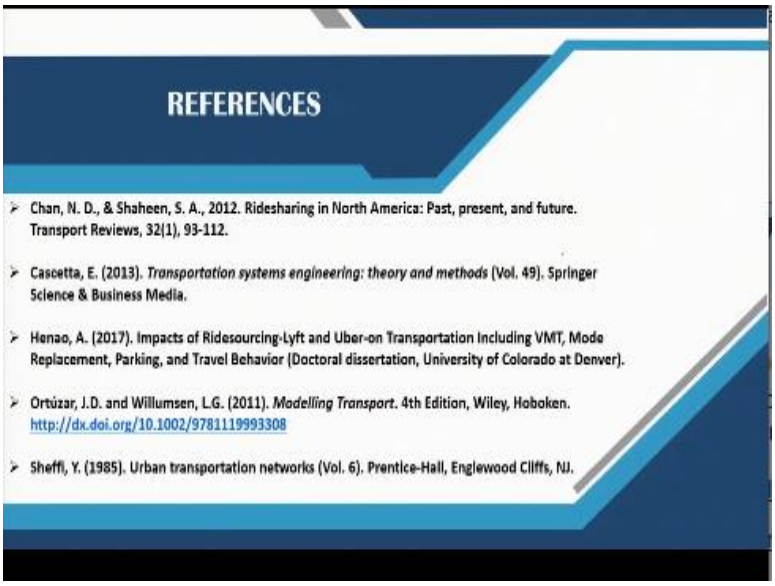

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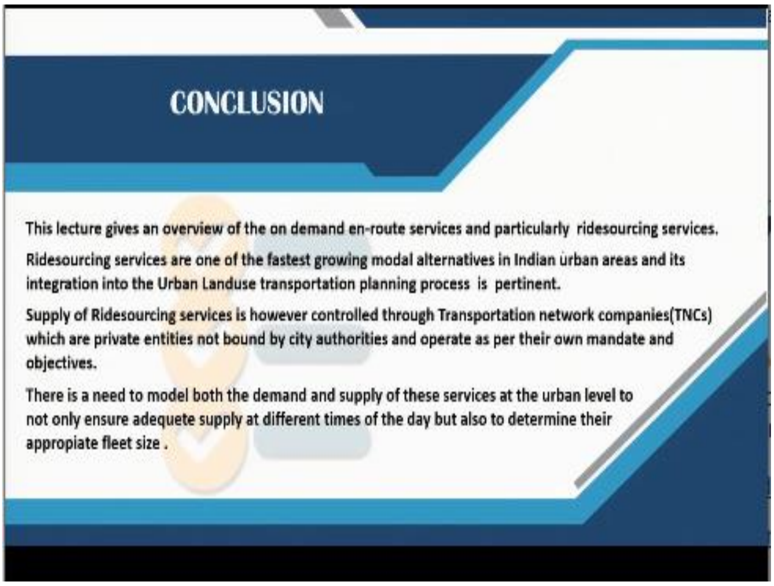

<u>Conclusion</u>

Ride sourcing services are one of the fastest growing modal alternatives in Indian urban areas and its integration into the Urban Landuse transportation planning processes are pertinent. So, the mode share of these services in developed countries is already around 20 to 27%. In India, we are also heading towards the same direction. Moreover, the supply of ride sourcing services is controlled through the transportation network companies, which are private entities, not bound by the city authorities and operate as per their own mandate and objectives. This is an important concern for the urban planners since supply for such services cannot be determined and must be taken into consideration for efficient resource allocation. Besides, there is a need to model both the demand and supply of these services at the urban level not only to ensure adequate supply at different times of the day, but to determine the appropriate fleet size for such services. Thank you.