Wireless Ad-Hoc and Sensor Networks
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Lecture - 12
Mobility Models for MANETs

So the lecture that we are going to cover now is on the topic of mobility models for mobile Ad-Hoc networks.

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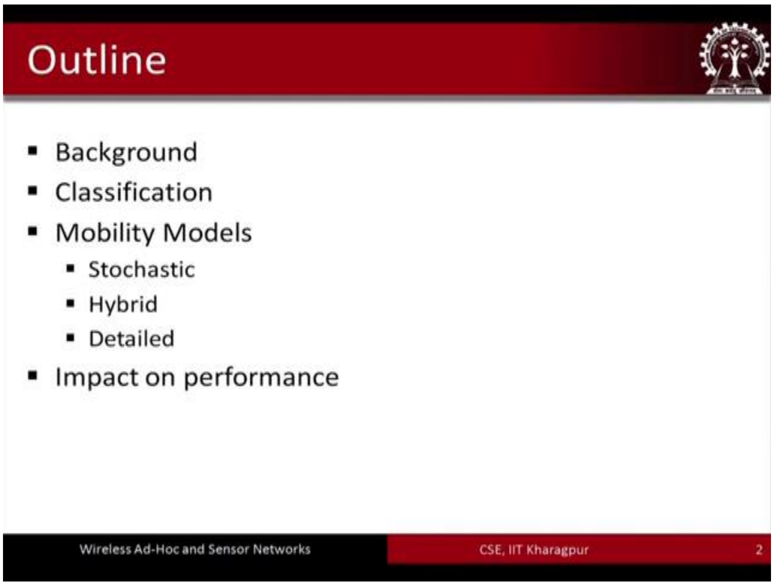

So, brief outline of how I am going to what I am going to cover now. So, we will start with the background some of the background information it is required to understand the topic. Here after the classification of the mobility models which mobility models can be classified into stochastic hybrid and detailed and some of the performance issues using each of these mobility models.

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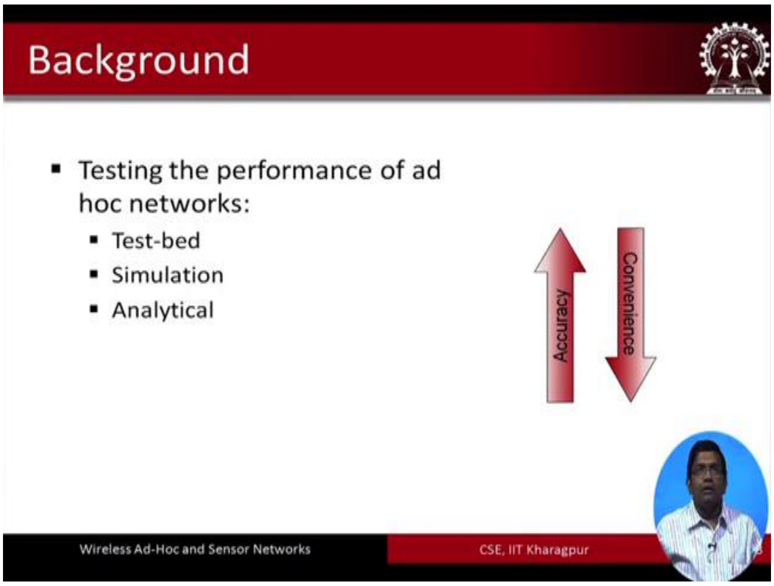

In terms of assessing the performance of an Ad-Hoc network, the Ad-Hoc network can be performance an Ad-Hoc network can be analyzed in 3 different ways, using test beds using simulations or analytical methods. So, there is a tradeoff between which method is used and with respect to accuracy and convenience there is tradeoff between the each of the use of each of these different methods whereas, the test bed based methods are the least convenient, and the analytical methods are the most convenient. In terms of accuracy on the other hand the test bed based methods would lead to the most accurate results of the performance of Ad-Hoc networks, compared to the simulation based means or the analytical based means.

So, in terms of accuracy test bed based methods are the most accurate. Most accurate in the sense that because they are capturing the real scenario. So, this results would lead to real more accurate results. And the results that are obtained using the test bed based performance evaluations they are going to lead to more accurate results compared to the simulation and analytical means. And on the other hand as I said before that in terms of convenience analytical models are the most convenient. Because you know we are talking about designing mathematical models mathematical equations which are easiest easier to perform compared to simulations running simulations or the most difficult ones are to design the test beds. These are the most difficult wants to achieve and, but if one is able to design the test beds that on the results that are obtained using the test beds are the most accurate.

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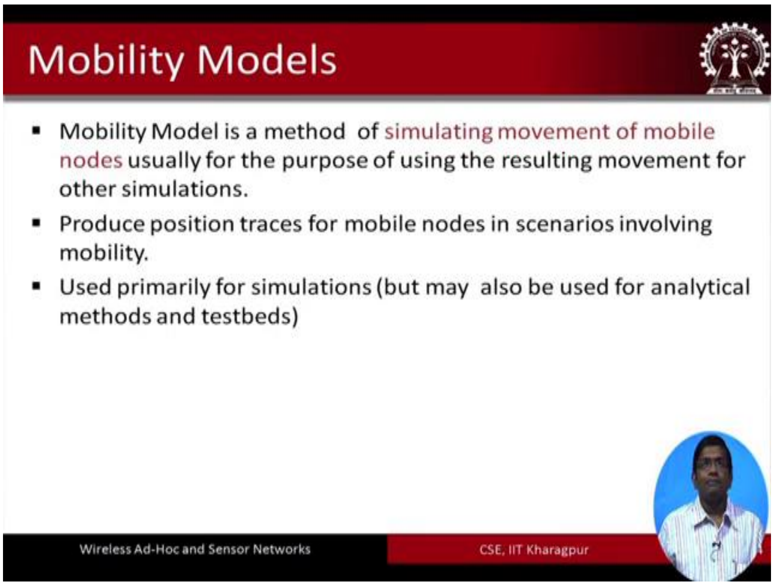

A mobility model is a method of simulating the movement of mobile nodes usually for the purpose of using the resulting movement for other simulations.

So, what happens is the nodes that are going to because we are talking about Ad-Hoc networks. Mobile Ad-Hoc networks in a mobile Ad-Hoc network the nodes move. So, what is required is to understand. So, when we want to simulate we want to understand that how these nodes are going to move. So, in reality the movement might be very different. Different in the sense that it is often not very much possible to predict how the nodes are going to move in reality; however, there are different ways there are different models which can be adopted to predict the mobility of the different nodes.

So, this is what the mobility models do. So, the mobility models will help in simulating the movement of the mobile nodes. They produce position traces for the mobile nodes in scenarios involving mobility, which means that poison traces means that when the node moves in a particular terrain, the traces are going to capture the different positions at different instants of time of the nodes. And those stresses can help in understanding the capturing of the stresses can understanding can help in understanding the performance of the different protocols that are that are designed for these networks.

So, these are used primarily for simulations in mobility models are used primarily for simulations; however, they can also be used for other methods like you know displaced based methods or analytical methods.

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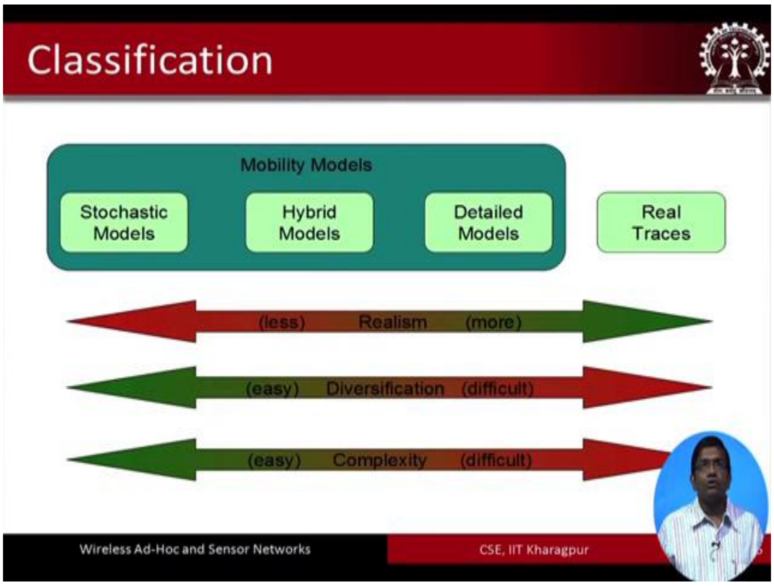

So, mobility models can be classified into 3 different types. Stochastic models hybrid models and detailed models. Additionally, as I mentioned just a while back that there could be traces that could be captured from a real life mobile scenario. So, these real traces can also help in understanding the how a particular protocol a particular algorithm or a scheme that is designed for these networks they perform. So, if we think if we look at these 3 classes of mobility models the stochastic models hybrid models and the detailed models. In terms of really realism the stochastic models are the re least realistic. On the other hand, the detailed models are the most realistic

So, stochastic models are the least realistic. Whereas, the detailed models are the most realistic. And on the other extremity the real traces; obviously, are more realistic because they. In fact, have been captured from the real movement of nodes in an actual setting. In terms of diversification, the stochastic models are the easiest to be diversified. And then comes the hybrid models and among all the mobility models the most difficult wants to diversify are the detailed models; obviously, real traces are the most difficult to diversify. They are even more difficult to diversify than a detailed mobility model.

In terms of the complexity the complexity is the list in the stochastic models, whereas, they are the most in the case of the detailed models or even more in the case of real traces. So, in case of real traces and detailed models detailed mobility models the complexity is much more is a maximum compared to the hybrid models and the stochastic models.

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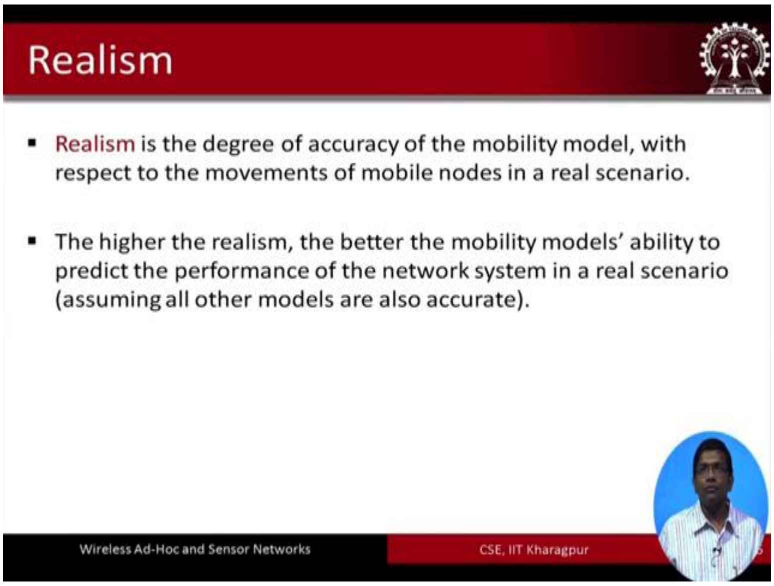

So, let us now go through exactly what is meant by these terms realism, diversification and complexity. Realism is the degree of accuracy of the mobility model with respect to the movement of the mobile nodes. In a real scenario in reality what is going to happen and trying to capture the degree of accuracy of the mobility model with respect to what is going to happen in a real scenario. So, basically the higher the realism the better is the mobility models ability to predict the performance of the network system in a real scenario. And that is quite obvious I do not think that I need to elaborate further on this.

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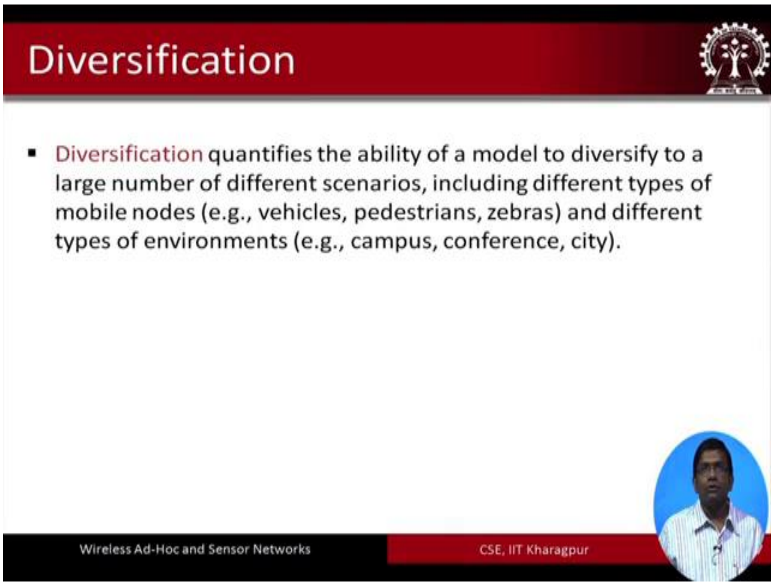

In terms of diversification this is an attribute that quantifies the ability of a model to diversify to a large number of different scenarios.

So, for example, mobile nodes in vehicles pedestrians' zebras are all different. So, basically if somebody is capturing an environment involving vehicles pedestrians and zebras, those cannot probably or more likely be applied in environments such as a campus of a university a conference or a city environment.

So, this is basically that the you know if the mobility model captures if the mobility model captures a particular type of scenario whether it can be diversified and be applied and be used in other types of scenarios.

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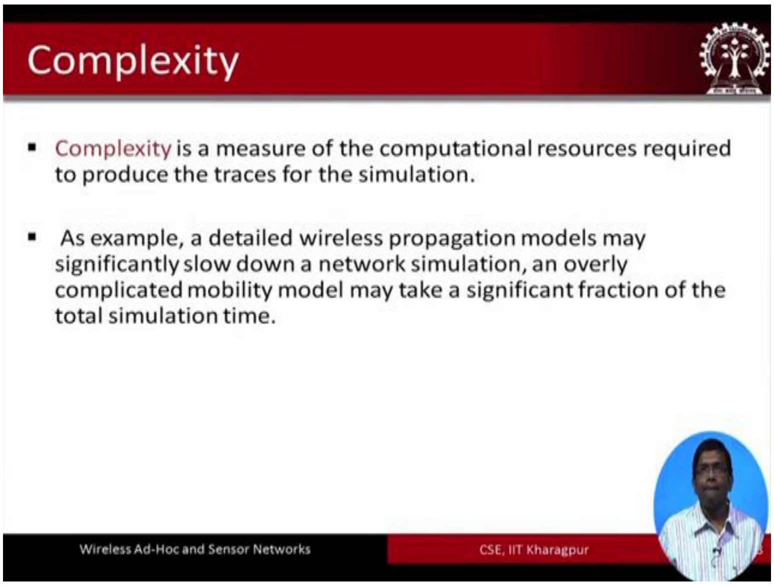

Complexity is basically the measure of the computational resources that are required to produce the traces of simulation. So, for example, a detailed wireless propagation model, may significantly slow down a network simulation and overly complicated mobility model may take a significant fraction of the total simulation time. So, complexity basically increases in such cases.

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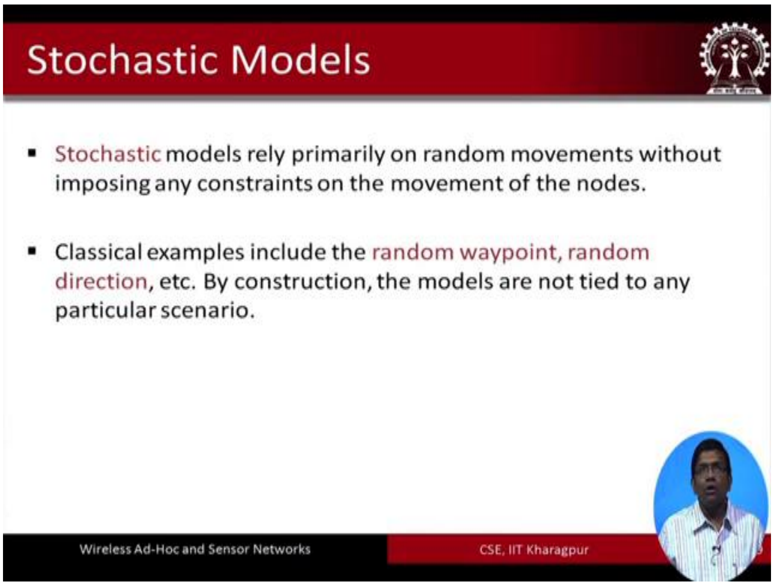

Stochastic models basically rely on the random movement of the nodes, and they do not impose too many constraints on the movement of the nodes. So, some of the examples of stochastic models include the random way point model, the random direction model and so on.

So, we are going to go through some of them by construction these models are not tied to any particular scenario. So, basically they can be they are so much generic in nature that they can be applied and we adopted in different types of environments. So in fact, let me put it more clearly that one can apply one can use the random waypoint model or the random direction model in campus environments, in hospital environments, in the case of you know tracing of pedestrians in a public place in the case of zebras the mobility of zebras and so on. So, all of them are assumed to be having some similar characteristics in terms of mobility and a similar kind of movement pattern is adopted in all of them.

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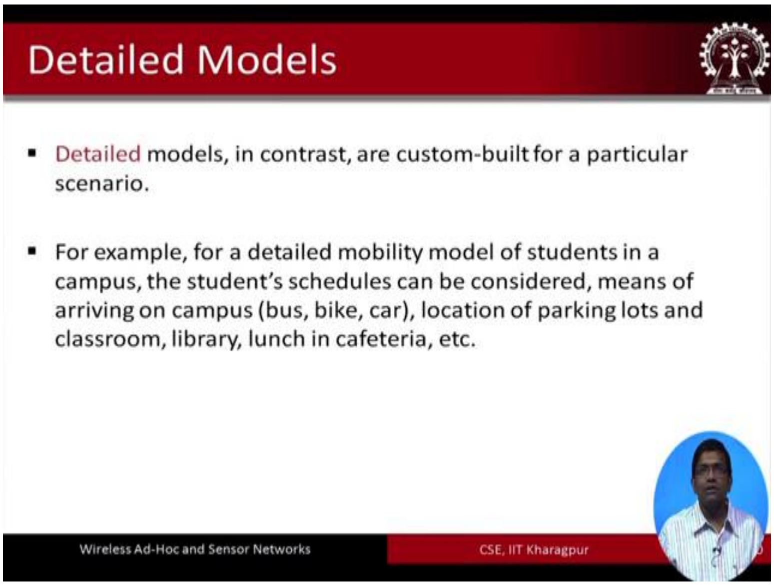

So, they are not very much scenario specific. Detailed models on the other hand are very much custom designed they are built for a particular scenario keeping a particular scenario in mind.

So, for example, a detailed mobility model of students in a campus the student schedules can be considered means of arriving on the campus, whether in a bus using a car or any other means a bike and so on. The location of the parking lots and classroom library lunch in cafeteria. So, all of these different you know. So, different entities all of these can be considered and how the students are going to move around these different entities in a particular scenario are all captured in details in these classes of mobility models.

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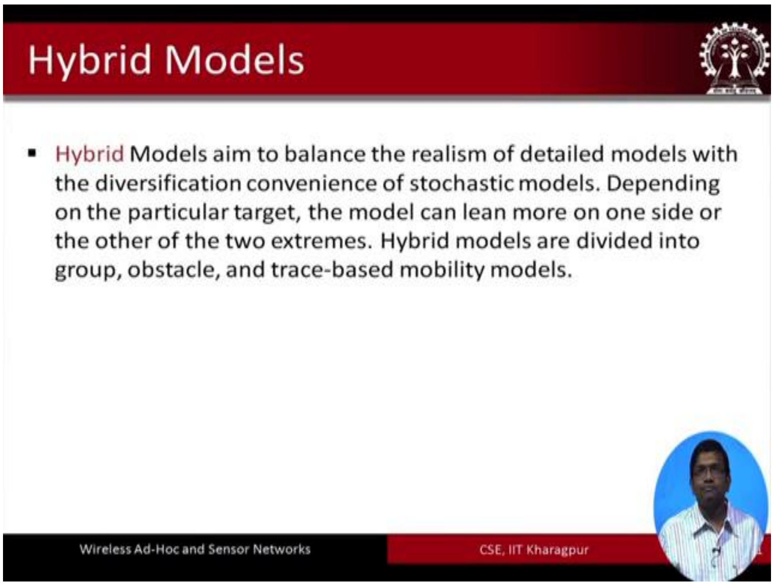

The detailed mobility models; Hybrid model and as this name suggests they basically are designed to balance the realism of detailed models with the diversification convenience of the stochastic models.

So, depending on the particular target the model can lean more on one side or the other of the 2 extremes. Hybrid models are divided into group based models obstacle based models and trace based mobility models some of which we are going to elaborate further today.

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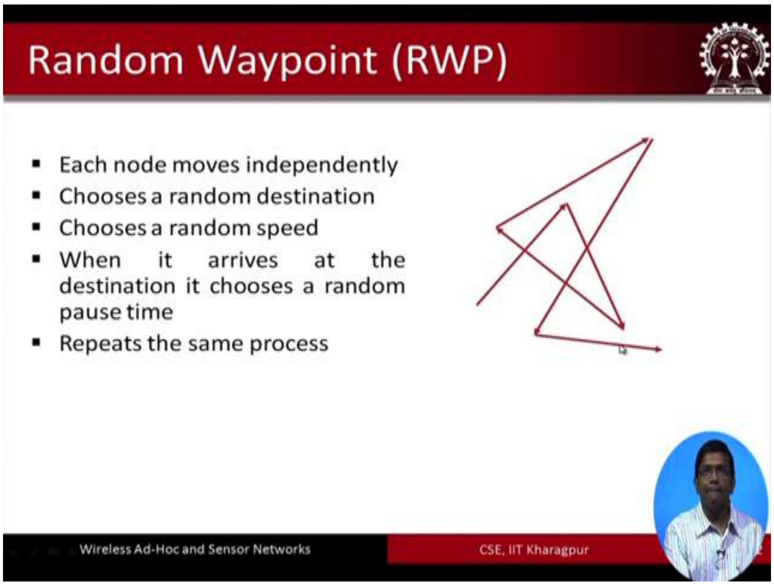

The random waypoint model is a stochastic model and these are easily diversified the easiest to diversify and are easier to implement as well. So, here in the RWP mobility models each node basically moves independently of the others.

So, a particular node or rather each and every node we choose a random direction and a random speed and when the node arrives at the destination it to this a random pause time. So, a random destination is chosen from a particular point and a random speed is chosen the node starts from a particular point in the terrain using the random speed that is chosen and the direction that is chosen the node is going to come to the new position.

When it comes to the new position it waits is there it pauses there for a certain duration of time which is technically known as pause time in the literature, and the process repeats like this. So, this is how the random mobility model looks like. So, as we saw in the animation. So, the node started from here took a specific direction, alpha and a random velocity, we came to this random destination then it applied the same thing came to this random destination along using a particular speed and it continues to do the same for the rest of the journey.

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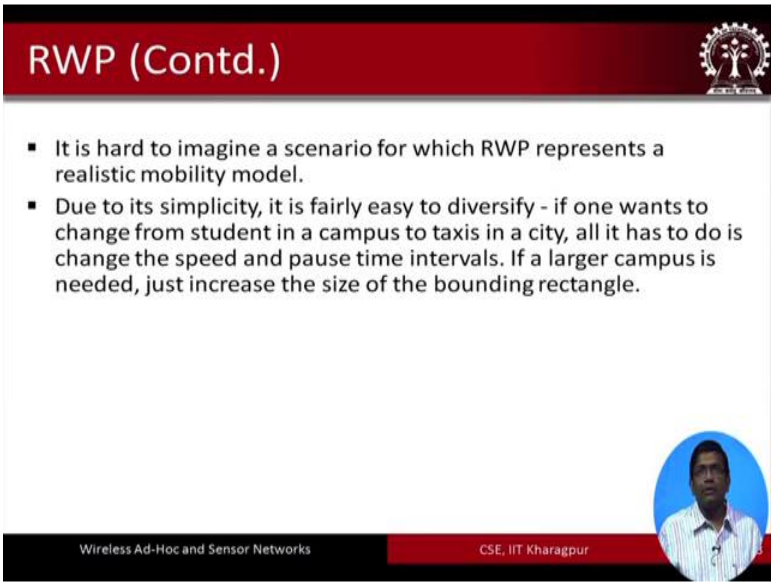

So, it is hard to imagine a scenario for which RWP represents a realistic mobility model. I mean this kind of. So, what is meant basically is that this kind of mobility model are not so realistic. So, seldom you will be able to find real scenarios where RWP would be exactly applicable, but due to the simplicity of this model. It is easier to implement them it is easier to diversify this model. So, diversification in this particular case once again means that.

So, let us say that you have a scenario of an of the students moving in the campus, and then you apply the RWP model get the performance results how the protocol that we have designed performs using this particular mode mobility model and then you shift it and apply the same thing for the same protocol in an environment like a city where the taxis are moving for incidence. So, what is meant by this diversification easier to diversify is that these models can be easily the results that are obtained by applying this RWP model in a school scenario. They can be translated and be used when you change the scenario to the city environment and the mobility of the taxis in such environment.

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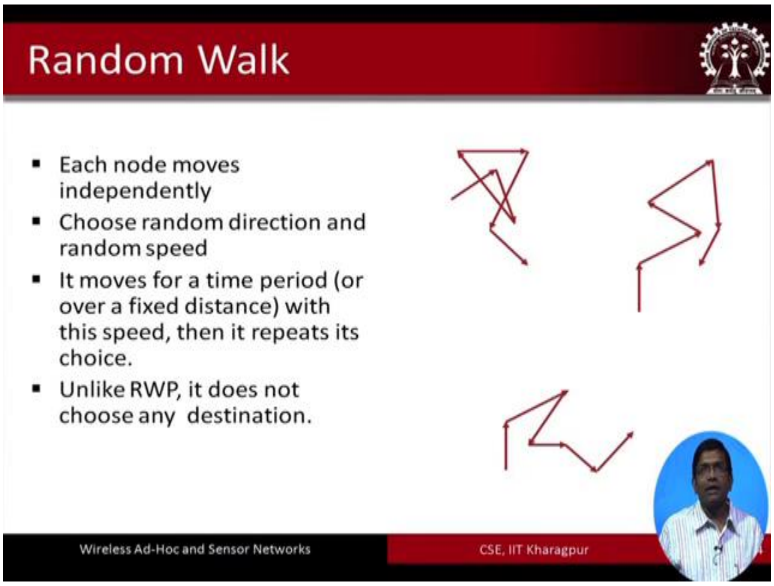

Next comes the random walk mobility model here each node moves independently. So, if every node to just a random direction and a random speed. The node moves for a time period or over a fixed distance with the speed then it repeats it is choice the only difference I mean these 2 are quite similar in functionality; however, unlike the random waypoint model the random walk model does not choose any destination. So, earlier if you recall the RWP model basically assumes that the destination is chosen randomly. So, that is basically not adopted in the case of such a strategy is not adopted in the case of the random walk mobility model.

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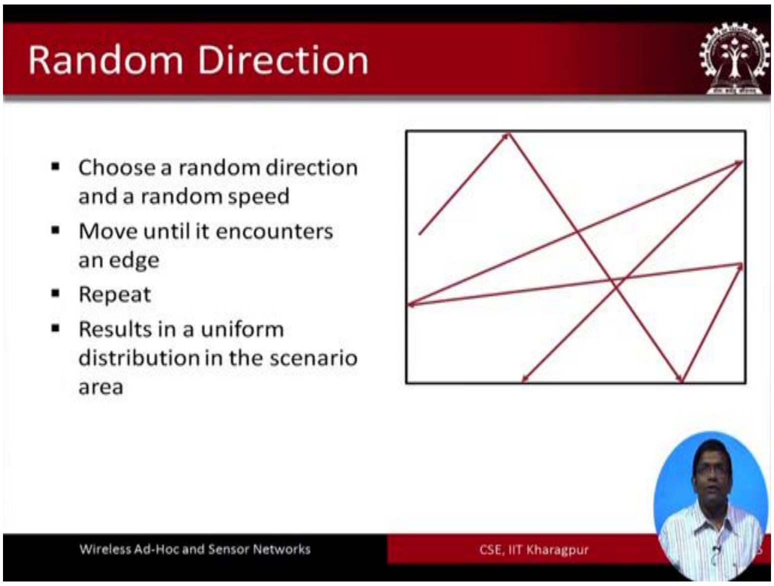

Now, we see in front of us how the random direction mobility model works. So, in the random direction model as the name suggests again the node basically chooses a random direction and a random speed and it moves until it encounters an edge. So, this is what we just saw. So, random direction alpha random speed v. So, the node keeps on traveling. So, the random destination is not chosen here. So, their destination is basically when this node hit is the boundary. So, it hit is the boundary and then it continues to repeat the same.

So, this sort of mobility model results in a uniform distribution in the scenario area.

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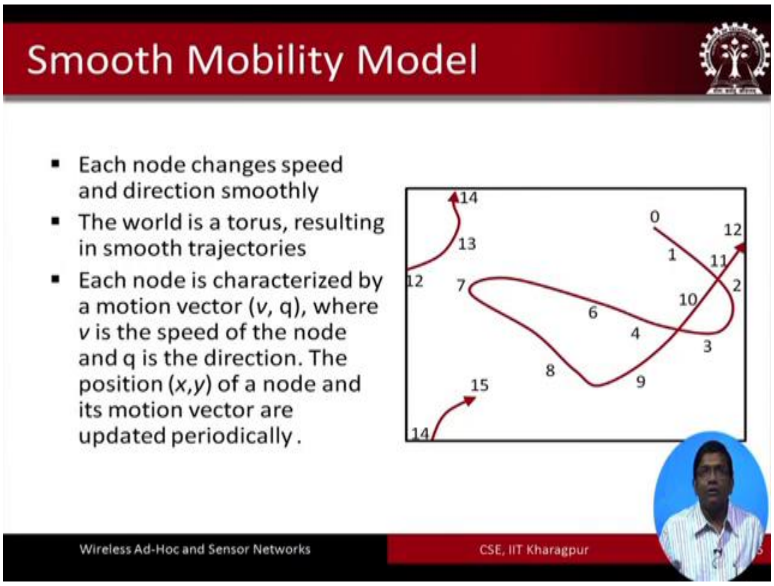

The smooth mobility model looks like what is shown in the figure in front of you. Where each node changes the speed and direction smoothly. Earlier if you recall in all the mobility models the nodes where going through in a straight line. So, it either it would go and hit the node would start for a particular position, choose a random alpha the direction with a random speed it would go and it would either hit the boundary of the region and then it is going to get reflected from there, or what it is going to do is it is going to choose a random destination and change it is position from there.

So, these in the previous models the ones that I just mentioned all of them result in straight line vectors; however, if we look at the figure in front of us for the smooth mobility model for each of the nodes which moves we find that the trajectory is basically a smooth trajectory smooth trajectory not a straight line or anything like that. So, here each node is characterized by a motion vector v q where v is the speed of the node and q is the direction the position x y of a node and it is motion vector are updated regularly or periodically rather.

So, a certain interval of time both the positions x and y and the motion vector; that means, v q. So, these are basically updated. So, v q means like the velocity of the node and the and the direction in which it is moving. So, so all of these they basically change over time due to which we get a pattern like this we do not have straight trajectories like the previous models, but we have the curved mobility patterns in the region.

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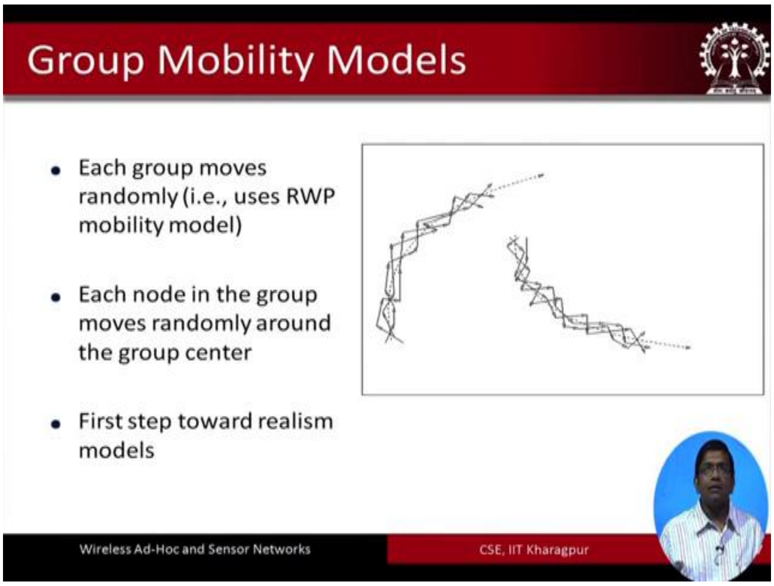

Now, what we see is the group mobility model. So, here each group moves randomly. So, the previous models that we have seen. So, far here basically we considered the mobility of a single entity the mobility of a single node; however, in practice in real life, we encounter scenarios where groups of people may walk in a particular pattern, where there are flux off birds that fly in a particular pattern and so on.

So, basically what is also required is apart from the single mobility model single node mobility models, it is required to have mobility models for the groups as well. So, here each group moves randomly that is using the RWP mobility model, each node in the group moves randomly around the group center. So, if you look at this particular case we have a group like this. So, around the group center all the nodes in the group they move around and finally, the group moves as a whole and what we see over here is the group mobility model. So, this is the first model towards realism. So, this is the first step that has been taken towards develop designing realistic models, group based mobility models, because these are the models that exist in reality in real life scenarios.

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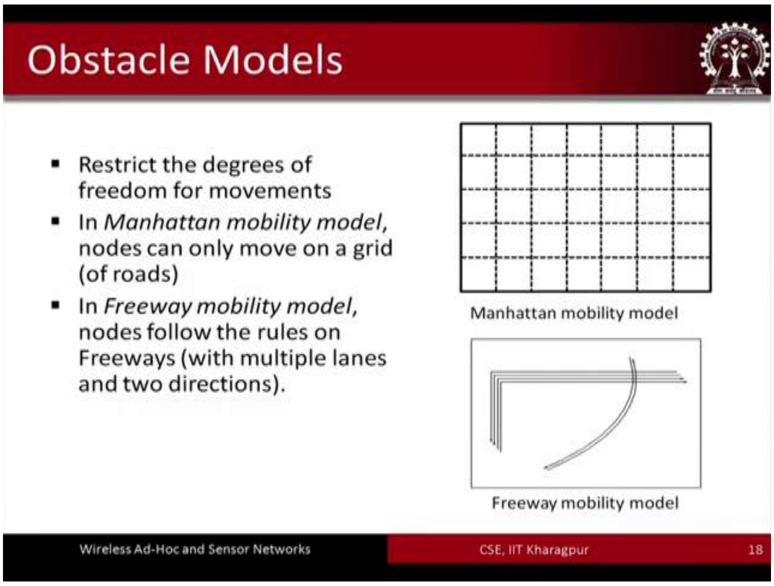

Then we have the obstacle models which basically as the name suggests again, which basically and assume that the degree of freedom of the movement of the nodes are restricted from obstacles from obstacles. So, these are 2 examples that are shown in the figure in front of you. So, one the first one on the top is the Manhattan mobility model. And this looks like moving on a grid of roads. So, as this name suggests Manhattan in US have a pattern of roads like what is what is shown in the figure.

So, what we have is north south east west 2 sets of lines or roads cutting each other. So, giving a grid like pattern of roads and that is why these nodes these mobility models that follow this kind of pattern in the movement of the nodes are known as the Manhattan mobility models. The bottom figure shows the freeway mobility model, where the nodes follow the rules on freeways with multiple lanes and 2 directions and that is also quite visible from here. If you see here if you look at here carefully, we have these freeways running in 2 completely different opposite directions and the mobility of the nodes basically are carried on using this kind of mobility model.

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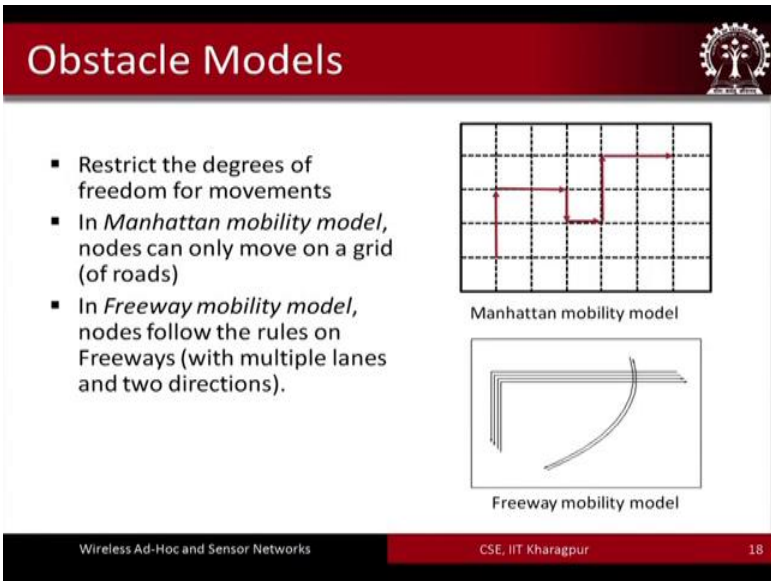

So, in both the directions the nodes can move.

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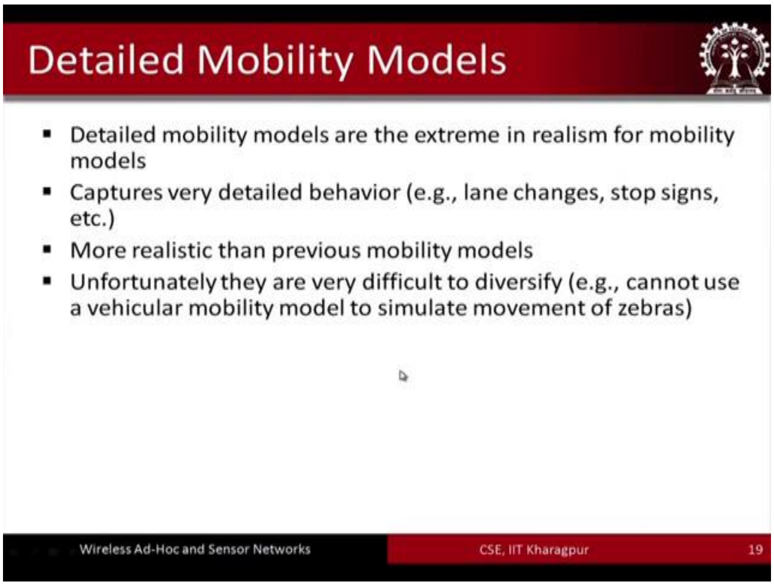

Detailed mobility models are basically the extreme in terms of realism these are the most among all the mobility models these are the most realistic ones they capture the very detailed behavior in terms of things like lane changes stop signs etcetera. They are more realistic than the previous mobility models; however, unfortunately they are very difficult to diversify. Example one cannot use a vehicular mobility model to simulate movement of zebras in a forest trace.

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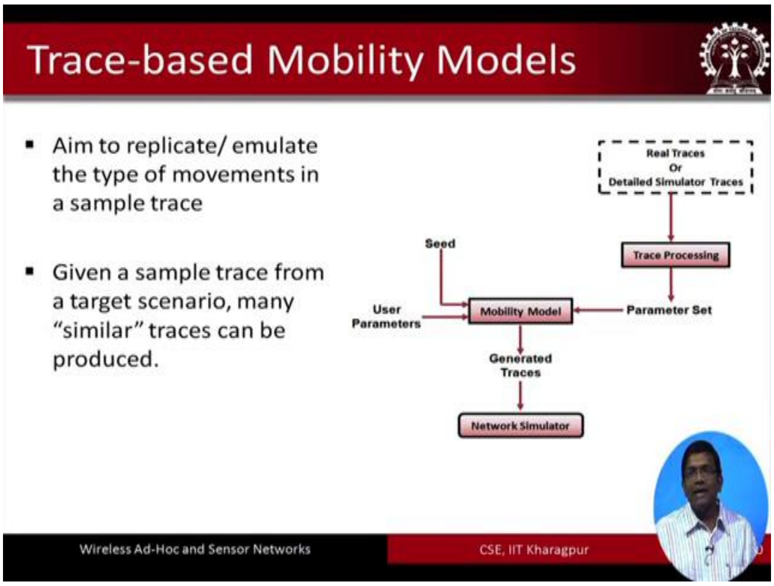

Based mobility models as I told you before, they talk about extracting or generating the traces from the movement of nodes in real life. So, the aim to replicate or emulate the type of movements in a sample trace given a sample trace from a single from a target scenario many similar traces can be produced. So, this is an observation. So, you have a repository of traces of real traces.

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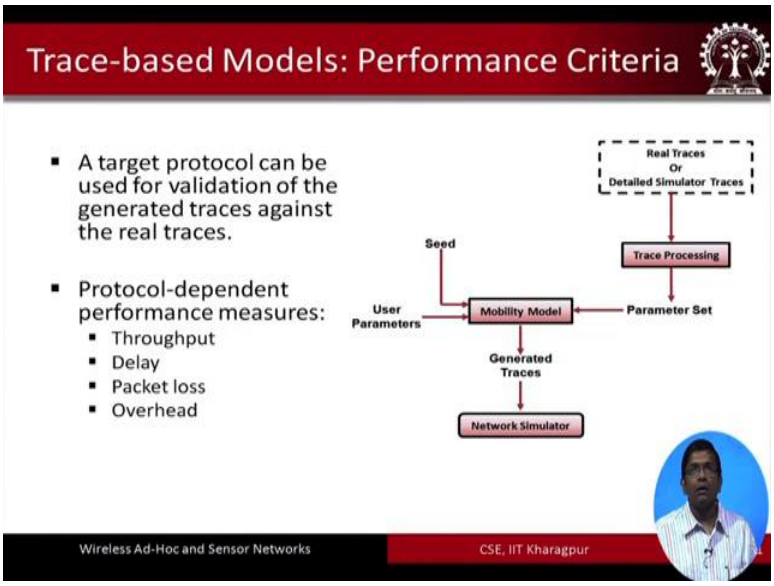

So, when we talk about these mobility models, the performance of these models have to be compared. They can be compared with the help of the performance evaluation of the target protocol that could be run using them. So, different measures such as throughput delay packet loss overhead etcetera they all can be considered as the different performance measures that can be used to understand the performance of the mobility models the ones that we just went through.

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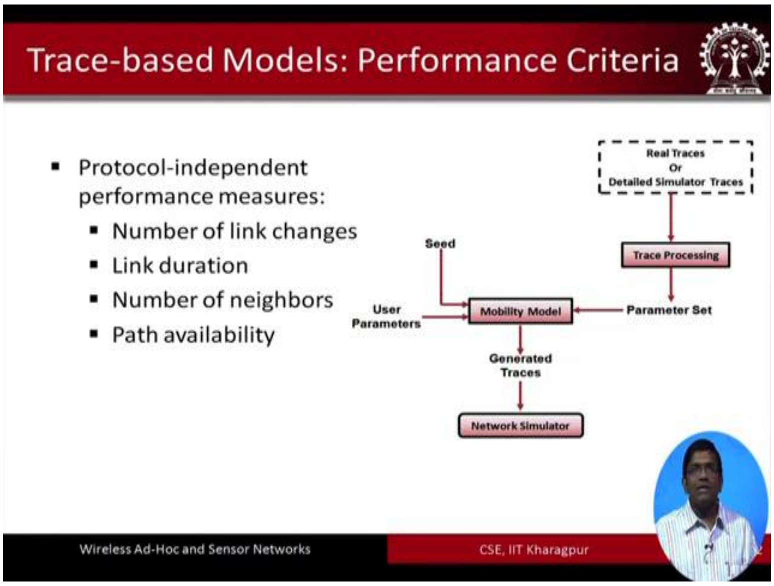

There are some performance measures which are protocol independent for example, the number of link changes the link duration number of neighbors' path availability and so on. So, these are the different other mobility different other independent protocol independent performance measures that can also be used.

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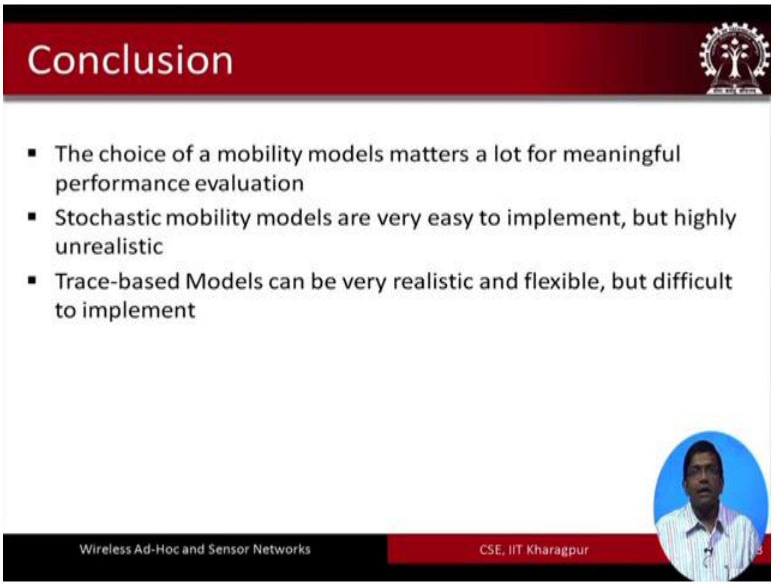

So, basically one cannot say that a particular type of mobility model is the best or is better than another. It all depends the choice of a mobility model which is very important and is very important for performance evaluation of a particular protocol.

So, this is important for evaluating the performance of a particular protocol that is designed and it basically the mobility model that is used basically influences the overall performance of the network or the protocol, it is designed to run on the network stochastic mobility models are very easy to implement, but are highly unrealistic trace based models can be very realistic and flexible, but are difficult to implement.

So, with this we again come to the end of this lecture. So, with this we will complete mobility models. So, mobility models as we have seen are very important. They are very important to understand how a particular node is going to move in reality and these movement models these mobility models the mobility traces from a real life scenario, these can be used these can be. So, in the case of traces one can build mobility traces or mobility repository trace repositories, and from these trace repositories using these mobility models or mobility traces, one can basically assess the performance of the different protocols that are going to run using the MANETs. So, we come to an end of this.

Thank you.