Modeling & Simulation of Discrete Event Systems
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Lecture – 01
Introduction to Simulation

Good morning everyone, I am DR. Pradeep Kumar Jha; I will be engaging this course on modeling and simulation of discrete event systems. So, this is a course related to simulation studies of discrete events, and this is a 20-hour course. In this course, we will have the dealing with the different kinds of simulation techniques, different you know probability distribution functions, you have again the random number generations, you have further the simulation using Monte-Carlo and all that. So, I hope you have gone through the syllabus of this course, and being the first introductory lecture of this course this is lecture one and in this we will have the introduction to simulation. So, first of all we will have the definition about simulation the course on simulation and modeling of discrete event systems. So, in that the first word is simulation and modeling anyway.

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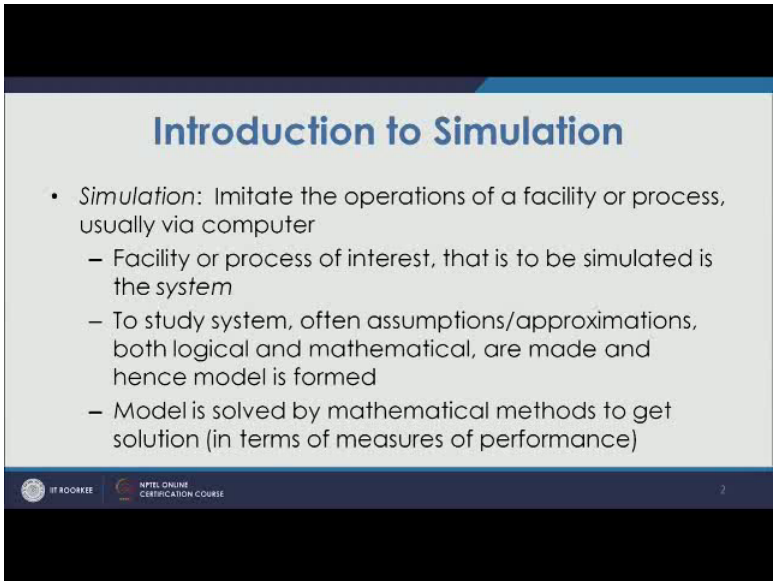

So, what is simulation? Simulation is nothing but to imitate the operations of a facility or process usually via computer. So, what happens in nowadays you have many systems which you want to imitate; you want to reproduce it now that is known as simulation. And basically simulation whenever we talked about the term simulation, it means there is

use of computer to represent the process, to duplicate the process. Further, the purpose of duplication is to know the intricacies of the process to know the interrelationships inside the process, so that you can further predict the different outcomes and that will be known as the measures of performance, so that we will see in the long run.

So, what we see simulator is imitation of the operations of a facility or a process usually via computer now the facility or the process of interest that is known as the system. So, whatever we are going to study that will be a system. So, suppose you want to predict about the behavior of customers or behavior of the processes which is going on in a bank. So, a bank is a system. So, whatever you are trying to imitate the whole thing is known as a system.

Now, what we see is that when you want to study any system, you need to have some assumptions or approximation because most of the times the whole approach or taking everything into consideration may not be possible. So, we are basically taking certain approximations to make the things easier, so that you can compute on or you can get the realistic solution. So, for that you are making approximations or assumptions. Now, they may be both logical as well as mathematical. Now, in that case when you are formulating a system, when you are trying to study a system, and if the system is governed by certain laws for that you have a approximations or assumptions, in that case what you make that is known as a model, so that is how model comes into picture. And from there, there is modeling.

Now model is basically solved by mathematical methods to get the solution. So, as we discussed that once you have the science behind it, once you have the theories behind it, you try to solve it. So, for solving you may use the mathematical methods and that is how after the solution you get certain parameters which you want to achieve or which you are intending to know and they are known as measures of performance. So, whatever you want to know whatever is the output, they are known as measures of performance or output measures of performance.

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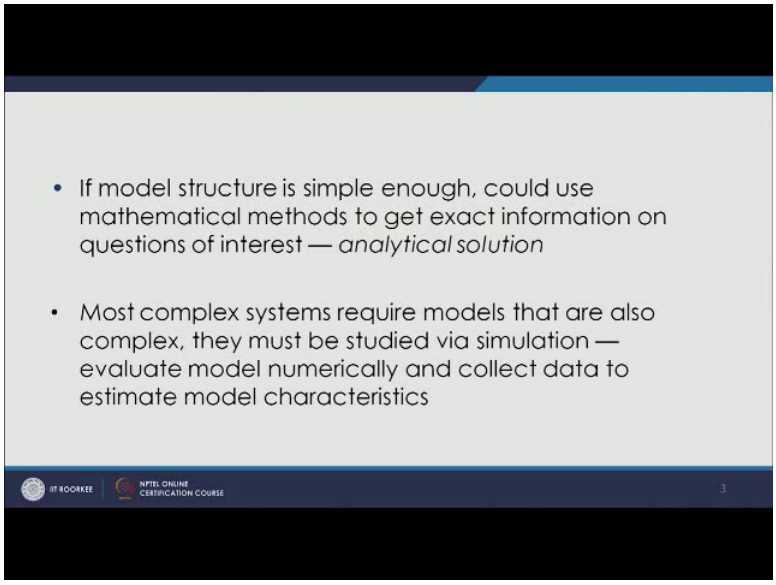

So, what we see, whatever we do now that is a model. And we can see that in normal case, you may have a very simplified model or you may have a very complex model. Suppose, you want to find the velocity of any component or anybody which is thrown up and it will go up to certain height and then it will come down at every point, you want to find its velocity; at every height you want to find its velocity that is also is driven by a model. So, this model will be nothing but it will be governed by a certain set of equation which will be solved and you may get the results. So, you may have the simple equations with you can solve and you can get the results. So, when you have the equations which you can solve and you can get unique solutions which solutions are possible in an easy manner, these are known as analytical solutions.

Now, many a times and in most of the cases when we try to imitate the real world processes, these processes are normally very, very complex there are many things which are there while studying this system or this process. So, for predicting certain output performance measures, you have to make it simplified by having certain assumptions by having you know certain approximations and then after that even the equations are many or they are very complex; and in that case, it is very difficult to solve it so easily. So, in that case, the solution takes a large amount of time if you try to solve on your own. So, in those cases, it is better to use the computers, you can you must study the systems or you must solve the set of equations using the computers and that is how the simulation concept came into picture, and that is how the simulation is carried out. And when we do it using the computers, we talk it like we do the numerical simulations and we estimate the model characteristics.

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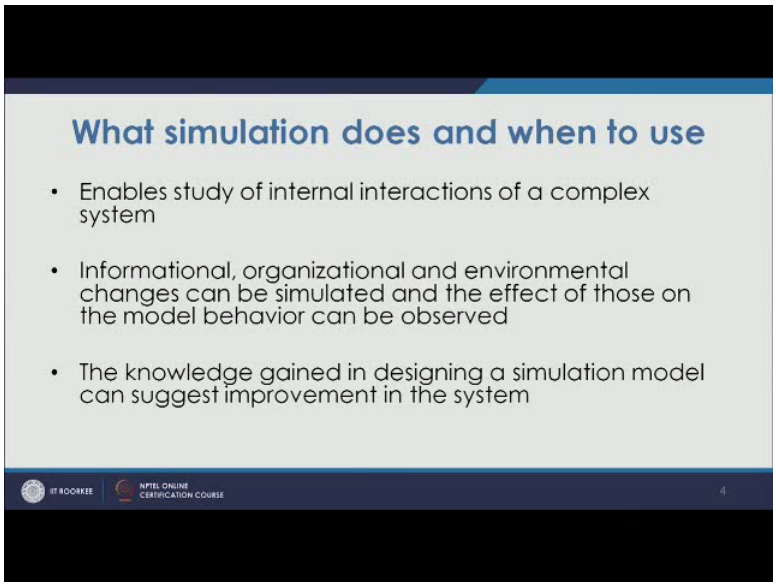

Now, what simulation does and when we should use it. So, what it does? Now, this basically enables study of internal interactions of a complex system. As we discussed when we try to study a system, there are many kind of interactions inside the system. Now, there may be those interactions may be very complex; and how it is going to affect the performance of the system, how it is going to affect the performance measures of the system that you can study, that you can get by the simulation.

Informational, organizational and environmental changes can be simulated and the effect of those on the model behavior can be observed. So, what is clear from this point is that you have different kind of changes which go on. And these changes have certain bearings on the outcome of the model. Now, all these changes can be simulated. Many a times, when we talk about a larger systems or a system like you have certain restaurants to be opened in a plant or so, there may many kind of factors which are important during the operation. Like the behavior of persons or there is random component or there are movement of the persons from one floor to other or so. So, all these changes how they are going to be modeled how they are going to affect the performance of the system that basically or how they are going to affect the model behavior that can be studied using the simulation.

Knowledge gained in designing a simulation model can suggest improvement in the system. So, this point tells that when you are making a model when you are doing the

stimulation during the course of study, you get a lot of knowledge regarding the system and that basically can help you in the better design of the system. So, this way simulation is useful and this should be used.

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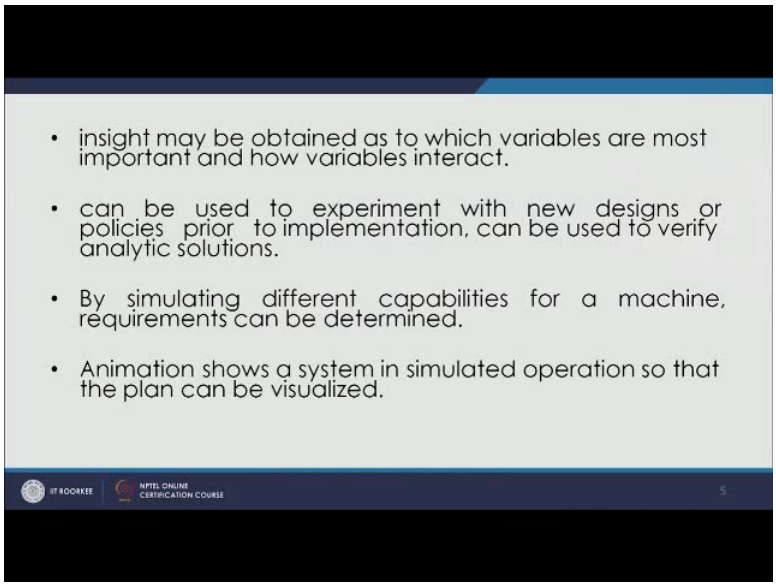

Insight may be obtained as to which variables are the most important and how variables interact. Now, as we know that when we study a system you have different entities and they interact and they have the bearings or they have the effect on the model performance or the output performance measures. Now, which of the variables or which of the parameters have larger say on the output performance measures or which are less important or which do not have any importance on the effect of the model behavior. So, in that case that can be studied using the simulation methods.

So, what happens after the simulation, you can try to see or even you can find that what any particular parameter has effect on the overall performance of the system. So, in this way you can segregate these are the important parameters which have the large say on the overall you know quality improvement. And some of the parameters may have less say and they may have insignificant you know contribution towards improving the quality of the system or so. So, in that case, you can prioritize and you can have more focus on those parameters which have more say, so that way the simulation helps you to identify such parameters.

Can be used to experiment with new designs or policies prior to implementation and can be used to verify analytics solutions. So, this point tells that you know many a times the experimentation is very, very costly and may be that infeasible. So, what you can try that you can have new designs on policies. From these new designs and policies, you can have the simulation getting done and you can see that if the new design is adopted how it is going to have the effect. So, before the experimentation, you can have the feelings or you can have a feel that the change in the design whether it is going to be beneficial for the system or whether it is detrimental for the system. Based on that you have the decision making with you and then in that case you have this flexibility that by doing the simulation you can save a lot and that will be beneficial.

Animation shows a system in simulator operation, so that the plan can be visualized. Now, in the recent times, the technology with computers has evolved a lot and there has been animations possible. So, with the animation possible, you can have a better visualization of how the changes are taking place. Like suppose we are going to design that the road or you are going to have a proper you know design for the vehicle traffic, in that case if you have the animation system, you can show that if the design of the roads or the ways are made in this particular manner, how it is going to be you know followed by the traffic. So, the animation in many case helps you to better understand the system.

So, once you do the study, after the simulation is carried out you can have the proper animations and that gives you a good feeling about the process which is going on. In that case, once you do the animation you have the better understanding, many things get clear, many doubts get clear about the system and then you can have more focus and more orientation towards study of the system.

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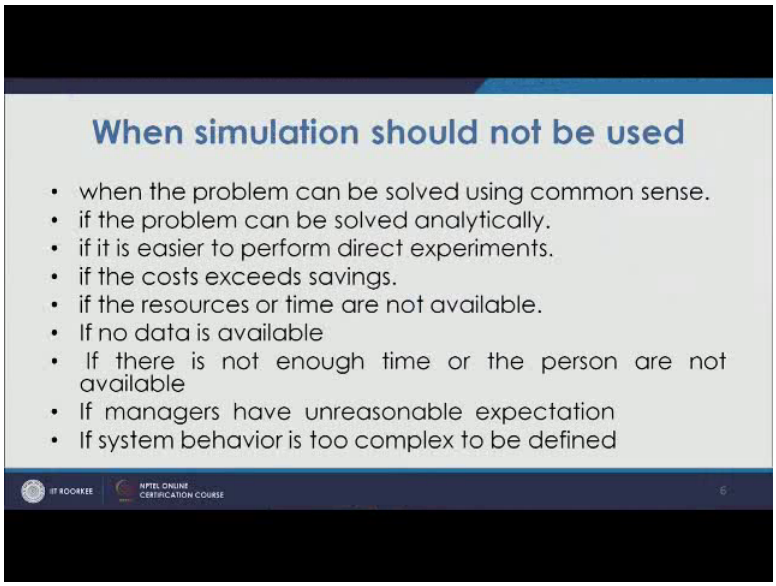

When simulation should not be used? Now, what we mean to say is that the simulation not always is beneficial. So, for everything you need not to go for simulation. Now, when the problem can be solved using common sense. As we discussed that many a times the solution is very simple and using common sense you can get it. So, at that time, there is no point in going for simulation is nothing but the wastage of time and resources. So, we must see when there is need of simulation depending upon the complexity of the process. And you have many you know parameters which are interacting and to see their effect in that case only you should advocate the use of simulation. So, where for very simple studies you need not go for simulation.

If the problem can be solved analytically same way if the solution is simple if you get the analytical solutions unique solutions also then there is no point in going for simulation studies. Simulation studies should only be practiced when the system is complex when there are complex equations, large equations, large number of you know equations to be solved, larger matrices, which are to be solved. So, in those cases the simulation is required to be adopted.

If it is easier to perform direct experiments, now in many a times will you do the stimulation and it is taking. And for simulation as we discussed you need a computer you need a good solver, you need persons who are known in that particular area. And if it is known that by doing certain experiment, you are able to predict the results more

accurately and in lesser time then there is no point in going for simulation. So, we must be able to differentiate the processes where the experimentation is easy and the experiment does not gives you more accurate results, more predictable results than the simulation. In that case, it is advisable not to go for simulation rather than doing the experiment and do the predictions more accurately and more practical.

If the costs exceeds savings, as we discussed that in simulation, you need the setup, you need a computer, you need solver, you need personal who are trained in using this then further there are many you know intermediate processes which are required in a good simulation study. So, in those cases, you must be able to justify what you save because if the cost is more than the savings there is no point in going for it. So, the simulation is done keeping that in the keeping long run you know or long term planning in mind. So, you must have a larger goal, you must have the prediction that it will save you a lot then it costs now. So, when that is the case then only the simulation would be you know justified. So, you must be in a position to justify this point.

If the resources or time are not available, so in those cases, certainly I mean if you do not have much of the time or resources in those cases you need a set of computers and that case you can have the predictions. Suppose, many a times the processes which occur practically in the plant or so, so if you try to see by doing the experiment you need a large amount of resources. And also that needs time, but simulation that way that does not require that much of resources or time. If you are the expert one if you have the system you can do the simulation and get the result in a very less time as compared to if you do experimentally in the real you know environment. So, in that case that is must be the situation when you have the resources or time, availability constraint is there then you I mean that way you should not use it I mean pardon me. This is about that when you do not have these resources available. In that case you may think of not using it means that if you do not have the computers or the softwares. You know in that case or you do not have time that time you cannot afford to even go for using these simulation tools.

No data is available data is required for the simulation you must have proper data, so that you can use it for simulation purposes. And if there is no data how you will go for the simulation, you needs certain data either from the past or the data may be which is available with the person who is working with it. So, if the data is not there, you cannot use simulation with hypothetical, very, very hypothetical or impractical data because that

will give you a very impractical kind of output. So, the data should be there based on that it will do the simulation.

If there is not enough time or the person are not available, this is similar to that it availability of resources with you of the time or the person available then certainly there is problem or there is challenge in doing the simulations. If managers have unreasonable expectation, now simulation is a tool, which will tell you that how the system will behave, how you are going to predict about the behavior of the system. Now, if the managers have unreasonable expectation; in the sense that they feel that by simulation you can have 200 percent or 300 percent of profit or it may do wonders if that is not the case it is simply going to predict and that also depends how you are going to give the input of the data. So, that way it all depends as you will study, we will study more and more about it that simulation how good the simulation will be that depends upon how good you are approximate in the process or how good you are guessing about the activities.

So, the expectation should not be unreasonable he should not feel that this will simply be doing the wonders or this will simply be magical. So, if that being so the managers also will not appreciate this process. So, being a tool it will tell you that in what conditions it is going to improvise the system performance. And if the managers have a very high expectation level or very unreasonable expectation level, they can never say good about this process and they will always come up with the you know justification that this is a wastage. So, there must be a proper mindset about the use of simulation. Towards going to suggest you how it is going to be better for the systems, how you are going to predict better for the system.

If the system behavior is too complex to be defined, as we discussed that when the behavior is very simple you can in a very simple behavior cases you can certainly model it using the I mean normal processes and even get the analytical solutions or so. But if it is complex, you go for simulation; but if it is too complex, and there is you know not much of formulation can be even thought of there are not enough persons who can think about it in those cases the simulation becomes very difficult. It is not possible in that case to design about this process. So, basically what is done in the simulation that as we discussed you have first of all you define what you need to get and then you study about the system and you see that how you can make a model. So, model is made by having the

mathematical you know expressions between the variables or different type of entities and then these are basically solved. And once you solve them now, for solving you need to get certain data and this data either it is available or you get from the past. So, now, how accurate the past result it based on that you will have the predictions.

Now, this result what you get, this needs to be checked, this needs to be validated. So, whenever you do the simulation. Since it is not the experimental result, it is a predicted result. So, you need to validate you need to check the accuracy of this data. So, this data basically is checked against the experimental findings. And in that case for some pilot runs which are made, this pilot runs say that yes the data which you get or the result which you are getting, they have reasonable accuracy. So, if during this testing, if they say that this is reasonably accurate or correct, in that case you say that yes the simulation which you have done is trustworthy, you can go ahead with the simulation process. So, in that case, once you have verified that yes this simulation model is trustworthy you can go for further getting the results and predict the outcomes. So, in those these are the steps which are done in a simulation.

So, in that case making the model, the model making itself is a process where you need the experts. If there is not enough expertise or the person, who are working on these models, there may be you know inaccurate mathematical expressions. And once they are solved, they may give inaccurate or unreal results. And once they are validated that may not be very proper. So, what we say that the system and the complexity if it is too much it is very difficult to study about the system, taking everything you know assumptions also you have to do a lot, more and more assumptions you make that is going to basically downgrade the accuracy or you know you can say that the validity of the results. So, this way very complex you know system behavior is not suggested to be you know modeled.

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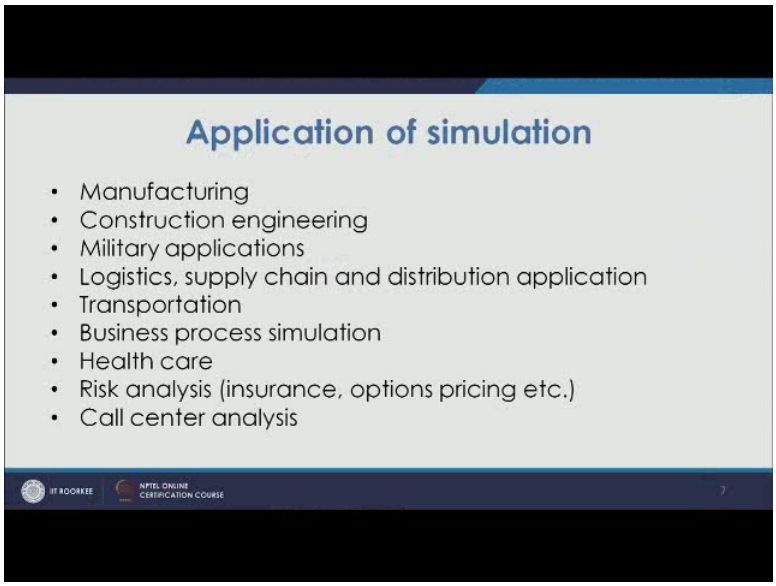

Application of simulation, now simulation has the application in many areas. And these areas are like manufacturing in manufacturing you have many areas where the simulation is used, like in manufacturing systems, plant layout or so, where to place the different kinds of machines if in a shop floor, you have different kinds of machines where to place these machines how to simulate. So, that there is minimum movement of persons or there is minimum movement of the job from one machine to other, this kind of applications are there in manufacturing or there are enough you know applications of different type in manufacturing.

Construction engineering where optimum you know use of resources, optimum use of spaces. So, this is also there in the construction engineering. Military applications, normally the optimal use of you know resource allocation in the war field, movement of persons from one place to other, optimum resources of resources used all that in military. Logistics supply chain and distribution application, so they are also you have good use of simulation where you first use that what should be the proper supply chain network, which will give you the maximum effectiveness. So, in supply chain or logistics, it is very much used.

Transportation similarly what should be the proper network what way it should go. So, there are and large number of simulation tools and they can study the different kinds of transport network which give the minimum cost. Business process simulation, healthcare

risk analysis, call centre analysis, these are the different you know reasons different areas where simulation is considered to be a very, very you know useful tool. This can predict the behavior of the system and first you can have the simulation results and based on that you can suggest that what will be the improvement in the process, if certain changes are made. So, this is all different kinds of application of the system.

Thank you.