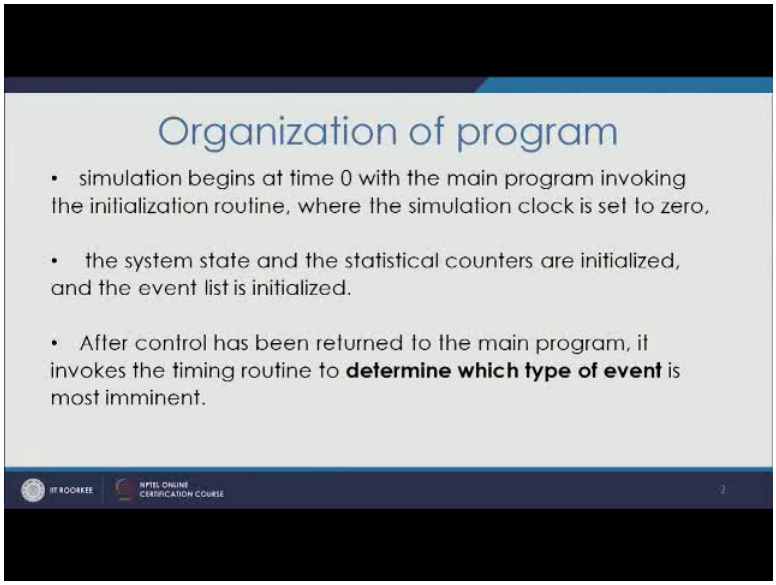
Modeling & Simulation of Discrete Event Systems

Dr. Pradeep K Jha
Department of Mechanical and Industrial Engineering
Indian Institute of Technology, Roorkee

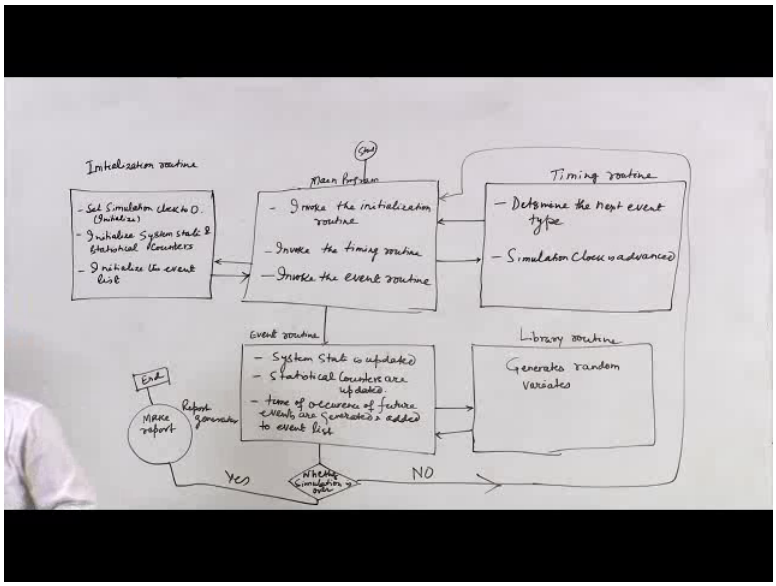
Lecture – 04
Program Organization and Logic, Steps in a Simulation Study

(Refer Slide Time: 00:42)



Welcome to lecture four of the modelling and simulation of discrete event systems. In this lecture we are going to discuss about the program organization and logic, and also steps in a sound simulation study. So, what we say we have discussed about the components of a program and here we will see that how they are organized logically, so that you make a good program and you are able to predict the performance measures. Now, how it does. So, the simulation will begin at time 0 with the main program invoking the initialization routine, where the simulation clock is set to zero.

(Refer Slide Time: 01:12)

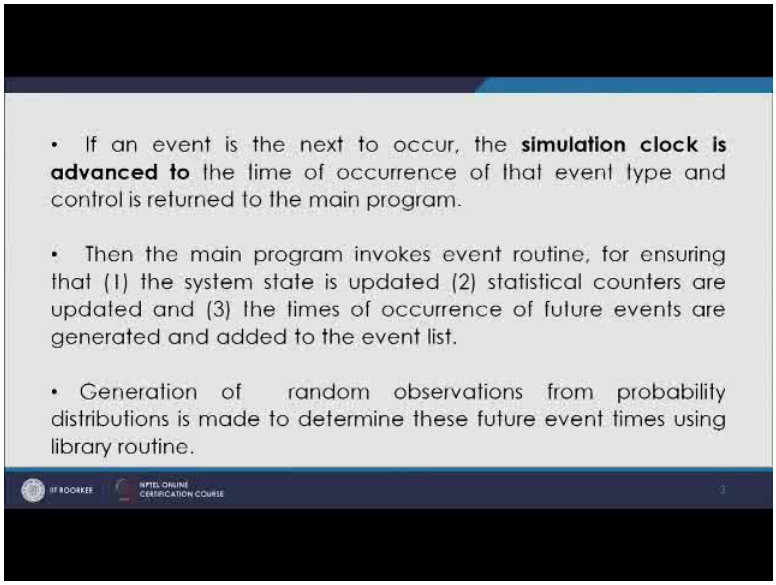


So, what happens you have the main program and it will start. So, once you have the start it will go to main program. So, this is your main program. Now, this one program as it is written that the simulation will start at time zero and the main program will be invoking or the calling forth the initialization routine. So, you have it will ask the initialization routine to be active. So, this is the routine known as initialization routine. So, this routine is invoked by the main program. What it does? So, it is initialization routine, it will set the simulation clock to zero. So, it will set simulation clock to zero or initialize the simulation clock to zero. It will also the system state and the statistical counters are initialized. So, it will initialize, so that is also initialize, there it will also initialize the system state and the statistical counters. So, the main program will be invoking with this initialization sub routine and then it will also initialize the event list. So, initialize the event list. So, this information will go to the main program.

Now from that once this control is given to the main program, then it invokes the timing routine. So, once the system is initialized, so basically what you do is you are basically invoking the initialization routine. So, this happens first. So, you are invoking with this and this routine will initialize the simulation clock to 0, it will initialized the system state and statistical counters, and it will also initialize the event list. So, once this control has come back to the main program, then for that it is written that once the control has been returned to main program it invokes the timing routine to determine which type of event is most imminent.

So, now what it will do is it will invoke the timing routine. So, you have this routine as the timing routine. So, in the timing routine, it will determine. So, what it does is. So, you have invoke the timing routine. So, once the invoking is done with the timing routine then in that case, it will determine which type of event is next imminent. So, determine the next event type. So, it will invoke the timing routine and it will go for that.

(Refer Slide Time: 05:25)

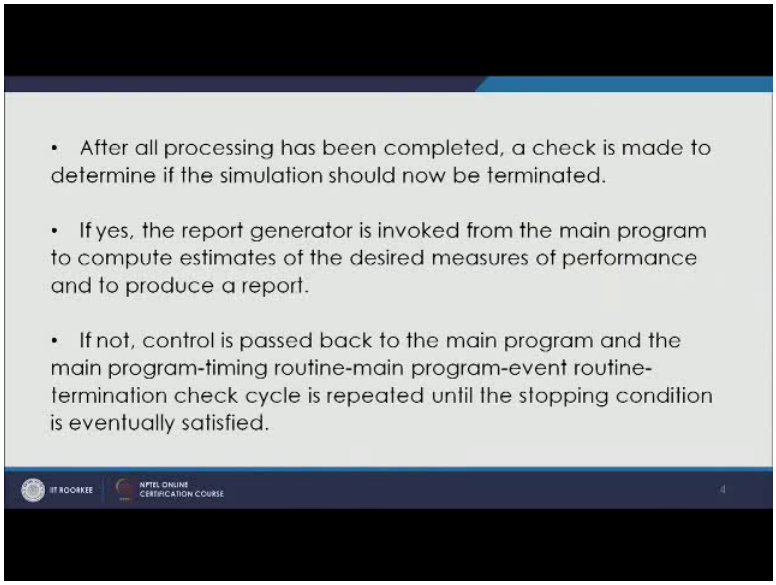


Now, in this case if an event is the next to occur, simulation clock is advanced to the time of occurrence of that event type and control is returned to main program. So, next is simulation clock is advance to that time of occurrence. So, simulation clock is advanced to that next time, where the next event is occurring and then that that way again this control will come back again to the main program. Now, this main program, so we have seen that first it will invoke the initialization subroutine then it will go to invoke the timing routine. Now, after that main program invokes the event routine. So, there will be invoking of invoke the event routine. So, you have further here the event routine. So, this is your event routine.

Now, in this case you are ensuring three things one is the system state is updated. So, you have to ensure that the system state is updated. The next thing, which is occurring is the statistical counters are updated. And the third one is the time of occurrence of future events are generated, so time of occurrence of future events are generated, so that is done with the help of the library routine and there is use of random variates so and added to

event list. So, basically for that it is having the correspondence with the library routine, so that library routine basically generates the random variates. The random variate generation is done using this library routine and it will generate these random numbers which will be representing the event types like it may be for the arrival or for the departure or maybe in other cases like time to failure or depending upon the different situations. So, it will have the data from here and then it will update the system state statistical counters that is what we have you know that measures of performances and then the time of occurrence of future events are generated here and then added to the event list.

(Refer Slide Time: 09:27)

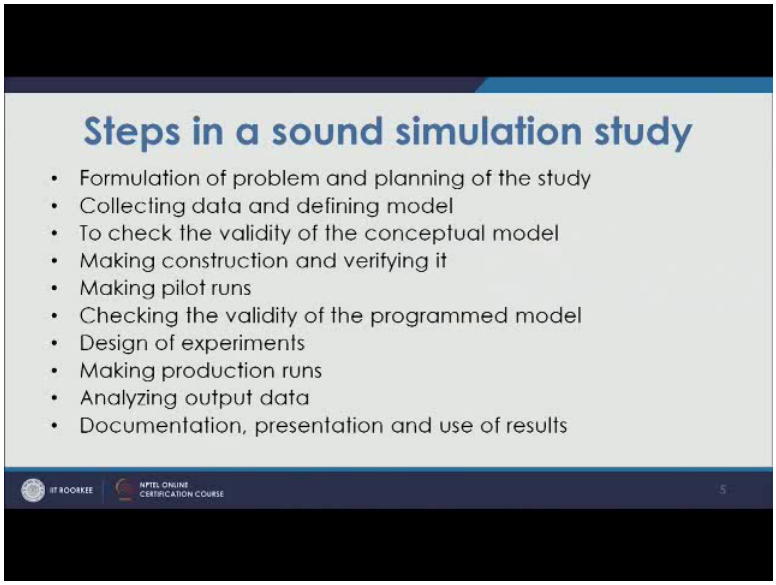


Now, after that once you have come up to this state then after all processing has been completed, a check is made to determine if the simulation should now be terminated. So, once you have come here and you have got the statistical counters updated, you have the time of occurrence of future events are generated, you have got everything updated here then you will check whether the simulation is over. So, you will check whether simulation is over. So, here you will be asking again to the main program, I mean in connection with the main program whether you should terminate here the program. If the terminating condition is satisfied, then you are going to so if it is yes you are going to make reports, generate the output performance measures list, you will make report and then it you will go on end.

But if it is no, then the control is going back to the main program. So, if it is no, then it goes in this direction. So, as it is there if yes the report generator is invoked. So, this is the report generator. So, this is invoked and invoked from the main program to compute estimates or the desired measures of performance and produce a report. So, you will find all the estimates of the measures of performance, and you will make a report and that will be ending of the program, but then if it is not in that case it will be going back to this place.

So, if not control is past back to the main program and then again the timing routine event routine all that comes so the main program and main program timing routine, main program event routine and termination check style all that is to be followed. So, this loop will go on it will again have the next event then it will come back to the event routine time is there, then event type is there and then further it will have the condition of simulation over. And then if a simulation goes on till this condition is satisfied. Once it is satisfied, it will come and make the report. So, this is how this program is made and there is logical you know organization of all these subroutines and they are you know connection with the main program to have a proper computer program to have a good simulation results.

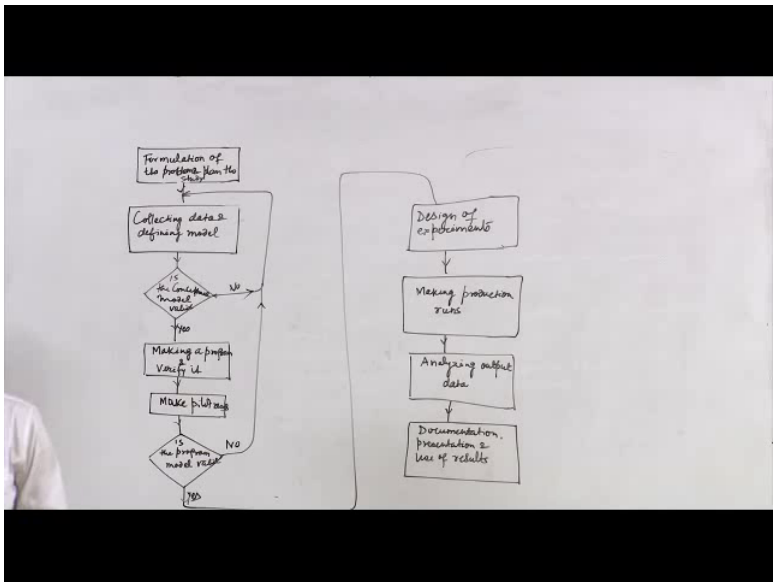
(Refer Slide Time: 12:45)



Next we will discuss is about the steps in a sound simulation study. Next is the steps in a sound simulation study. So, as we do the studies of simulation as we have seen that there

is proper logical connections between the difference subroutines to make a program, but then how to ensure that the steps which you are making it is giving you a good simulation results. So, there are certain steps which you must follow to see that your simulation is sound.

(Refer Slide Time: 13:33)



So, for that first of all you have formulation of the problem and planning of the study. So, what is written is this is your formulation of the problem and plan the study. So, for that you need to be sitting with the business experts, the person who has the problem and the subject matter experts and you will have to find what you want to achieve, so that must be in your mind. And this way you they will help you in formulating the problem. Now, once you are able to identify that what are your objective, what you want to achieve, what will be the domain, then you try to go and go to second point that is collecting data and defining model.

So, after that you will move to collecting data and defining model. Now, once you have identified the problem, once you have planned what you want to achieve, once you have formulated the problem, then you will have to collect the different data. Suppose, you want to analyze a system like a queuing system then in that case you will have to collect the behavior of you know data or the pattern of data which you are going to use as the arrival or the departure of the customers. So, for that you will have to collect the data at different times. So, if you want to model for a particular day or for a particular time in a

day then for that time you will have to find the different kind of data when customer is coming, when he is departing, all that or the service every service time of the you know server who is sitting there. So all that data collection will be going on. And data collection is only possible when you have formulated the problem you know what kind of data you need. So, once the first part is over once you have planned what you have to study there you are going to collect the data.

And then you are defining a model. So, model means how you define a model. Now, you are defining a model by making certain assumptions. As we discussed that when we are having the mathematical tools with the requisite assumptions or approximations then we make a model mathematical model or so. So, similarly in this case also in when we are simulating any real world process or any event or so activity in that case you have to have certain assumptions, you have to have certain approximations all these up after these all these approximations, you are making a model for that certainly you need to have expertise in certain areas. Certainly only subject matter experts can give you more input about how you have to make a good model. So, the collecting data and once you collect the data, you define a model.

Now, once you make the model then you have to check the validity of the conceptual model. So, here it is there is a checking condition, you have made a conceptual model, this model is based on certain assumptions or approximations and on some mathematical tools are there or certain expressions are there. So, you have to check how valid it is, how valid your conceptual model is, what you have thought of what has been your frame of thought based on that what kind of model you have made, and how much it is valid.

So, this is a checking condition. So, you are going to check the model validity. So, is the conceptual model valid again for that you need to have experts who will say that depending upon the objectives of your study, whatever model you have made, whether that will give you the result you want, so that will be checked. If it is yes, then you will move further; and if it is no, you have to go back to this place. If they say that no, this concept on which you have made the model the data collection is not appropriate is not going to give you what you want, what measures of performance you are interested in that cannot be achieved by this model formulation. So, that conceptual model if it is no it will go back to here, and then it will further move downwards. So, you must have to be ensure that the conceptual model is valid.

And then you will go and make the and construction making construction making the program basically it is only return, making the program and verifying it. So, what you are doing is you are making a program and verify it. So, what it does is you are so once you have come to this place, you are going to ensure yourself that your conceptual model is valid. So, you are going to make the program. So, program will be made with the help of many you know experts who are making in who are expert in making programs. And then once the program is made, then you are verifying this program whether whatever program you have made this is ok, because there is debugging of the program, there will be round table analysis of the program that is verification of the program and that is made by the same the subject matter experts in the program making.

So, once they say that yes the program has been the aim with which the program has to be made that seems then you are going to make the pilot runs. So, you are going to make pilot runs. So, now with this program, you are making certain pilot runs, you are getting some pilot results. Now, this result again is to be validated. So, checking the validity of the program to model, so again you are checking is the program model valid. So, once you are having these programmed model, you will certainly try to see how much it is valid, you will have certain results, simulation results, and you can compare them against the experimental results or previously computed results. And you will see that what is the error percentage or how much it is close to the real results.

If you see that the results are ok, if it is acceptable to you, then you will move forward. If not in that case you will have to go back and you will have to see again you will move to this defining the model, coming to again validity of the conceptual model making a program make pilot runs and so. So, this way you have to make this program model valid; unless it is valid program model you cannot rely the results of your programmed model.

Once you ensure that your model is valid, programmed model is valid, then you go for design of experiments. So, if it is no, in this way. And if it is yes, then what you do is you go further design of experiments. Now, in this case, you have to design how many runs you want to have how much will be the time for which the run has to be made, what are the kinds of measures and how much you need to run, how much time you have to go for the simulation, what are your output performance measures. So, this way you will have to design the experiment, the runs and that runs basically so after that you will make the

production runs. So, in this case you are going to have the estimates of the time how much time it is going to run or so then you are making the final production run, so that is making production runs.

Now, once the production one is over, you are getting many data, and this data is to be analyzed. So, you are analyzing the output data. So, this is goes like this. So, once the production one is completed, you have got all the results, you have to analyze the output data, what are the measures of performance, how you have got with time, what are the results you have to analyze. And you may have to conclude based on that that what are the factors which are important, which are the important factors which have a say in the system. And then after that you have the documentation, presentation and use of results.

So, these are the different steps for a sound simulation studies. What we see here is that whenever we do the simulation studies, it is not only that you write a program and get the results. You will have to check its validity, you will have to verify the program which you have written, whether the program is written correctly or not. You will have to check the validity of the model that can be done only by comparing it with certain results which is established, so that is why this verification and validity both are very important in the case of this simulation studies.

Then why we have discussed about all that initial stage is very important where you have to define the problem. And for that what you need to get what is your final out output performance measure for that what are the parameters for which you have to calculate, these are important and that is achieved only when you have the expert persons of that particular area. So, you need to have the data which is very much pertinent or which is useful for that particular area. And once you get that you may have many a times the data which you get that may have some you know useful part, but many of its part are of no use. So, the person must be good in deciding that which part of data is useful for him which can give him the good results, because ultimately that data if the data is erroneous the he cannot get a good simulation result. So, he will have to have a good group of persons who are experts in that particular area the business heads or so or the analysts and then they have to make the model would conceptual model, because for that also they need expert persons.

Because when you are making the model what kind of assumptions are to be taken, which kind of assumptions are to be left, these are important. Because many a times making the model simulation model of real system is very difficult; it is very, very complex. So, you will have to have the assumptions and these assumptions can better be given by those persons who have a good exposure by working in that area. So, what will be the proper assumption. So, many a times we take certain assumptions which basically undermine the importance of the problem itself. So, you will have not to take certain assumptions only with an aim to make the program more simpler, so that may give you the results in a less time, but that may not be the real representation of what you want or the that may not give you the main result what you need.

So, basically this assumptions are important, approximations are important, so that you have a proper program. Then you have a team - core team of round on the round table they will be sitting and they will be doing the debugging of this program, they will be looking at the connections of the main program with the different routines, how they are invoking the different subroutines. And in that case they have to ensure that the program main program works properly. And then after that the pilot run is taken, the results are validated, and once you are ensured that yes the program works fine then you go for getting the final runs and get the results. So, in that case, the credibility of the program is more; the simulation results which you get will be more realistic to the real outcomes, more close to the real outcomes, and you can say that you have a credible you have a good simulation program which is sound.

Thank you.