Simulation of Business Systems
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Lecture -10
Steps in a Simulation Study

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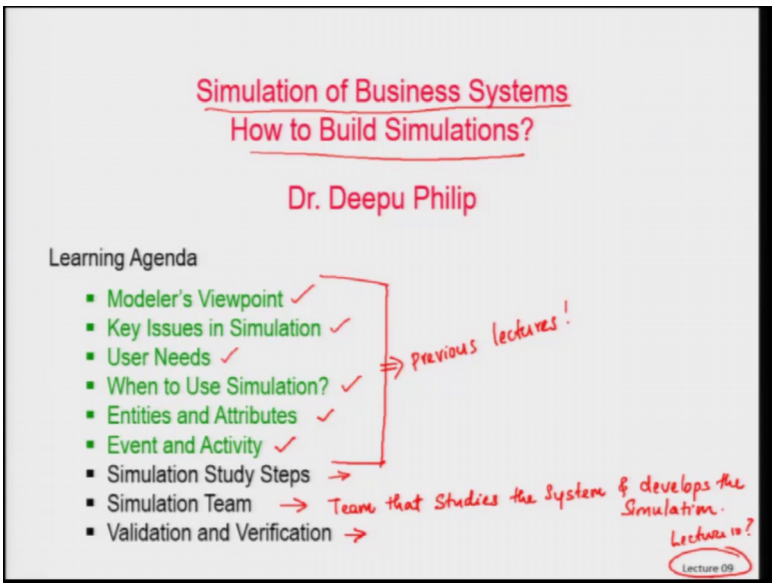

Good afternoon students, welcome to the next session of the class on Simulation of Business Systems and today we will continue with the lecture on simulation of business systems and the major topic today is; How to build simulations? In the past class you have seen that we have gone through what is the Modulus Viewpoint and what are the Key Issues related to Simulation and the how the key issues result in developing that appropriate model and what are the user needs or the typical type of user needs that associated with the simulation. And when to use simulation, when does the simulation is applicable to solve a business problem or when is it applicable to study a business system that part we seen then we also looked into different viewpoints of Entities and Attributes.

What are entities what are attributes how does entities work in a system to actually simulate the behavior of a system or the time dependent behavior of the system. And then we also studied what are events and activities, what are what are specific simulation events, what type of event that can happen in the simulation and what are activities. So,

these topics I have already been covered; these much topics have already been in the previous lectures.

I hope that all of you have studied this, understood this gone through that today we will be covering these last three topics Simulation Study Steps, how do we what are the major steps involved in conducting a simulation study, then what are the different aspects of a team simulation team, the team that.

So, this is like the team that studies the system and develops the simulation when we talk about what is validation and verification related to simulation. So, this according to me is the lecture 9, but it might be lecture 10 also so, it could be lecture 10 also I am not sure, but it is one of them. So, we are continuing with this topic.

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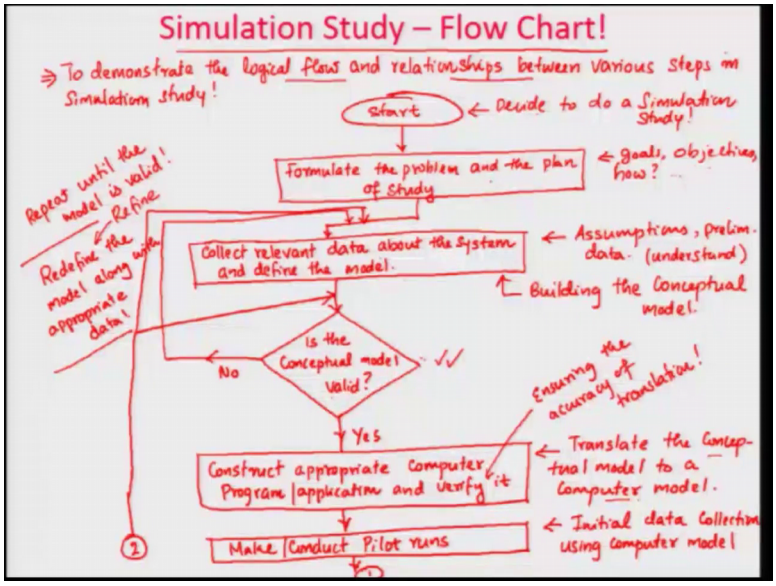

So, first let us see how the simulation study can be conducted in the logical flow. So, the reason we use a flowchart is to demonstrate the logical flow and relationships, logical flow and relationships between various steps in simulation study.

So, what we are trying to do here is to demonstrate the logical flow and relationships how various steps in the simulation study are related. So, flowchart helps us do to understand things in a better fashion. So, let us start the with the first step of the study, we are not going to do the Start, but we are or we can say the first step of a flowchart is start you decide that to go ahead. So, this is where we decide to do a simulation study so,

we decide that now we want to do the simulation study, then let us find out what are the steps. So, the first step is let us say formulate the problem and the plan of study.

The first step is formulate the problem and the plan of study. So, what we are trying to do it is here we are talking about the goals, objectives and we are deciding how to do the study or how we envision this study to happen and then I am just going to draw here. So, that I can write in this side of this one so, I will just move slightly here and the second step after this is I am just using the white space here.

Collect relevant data; collect relevant data the data that is necessary, data about the system and define the model. So, remember in model we require this is about the assumptions and preliminary data these things are required for you to know the system or you are trying to do is understand the system.

You are trying to understand what is system is all about and from there what you are trying to do is you use this relevant data to define the model. Then the second thing, third thing is the next step after this is you check, is the conceptual model; is a conceptual model valid.

The question is a model that you designed so, far is valid is it model correct or not with the data and other things, there are two things one is you can say yes, the other one you are going to say is no conceptual model is not valid then you go back in this process, you go back to the collect data and define the model. So, here is like redefine the model along with appropriate data.

So, you are defining, your redoing the process to ensure that the model and you repeat this. So, this portion repeat until the model is valid. So, you until the model is valid you keep on looping here, if the answer is yes the conceptual model is valid then we go to the next step which is you will say construct appropriate computer program or application, program or application and verify it.

So, what you are doing here is your going to construct appropriate computer program and verify it. So, this is this where you are like translate the conceptual model, translate the conceptual model to a computer model.

Why do you need a computer here? The reason you need is because it is very hard to simulate the normal system with the hand, then once this is done the next thing you do after this is make slash conduct pilot runs. So, what you doing here is you now, which is called as the initial data collection using computer model. So, here you are going to collect data and see whether the computer model is giving you the data that it is supposed to give and we put a connector here, 1 we run out of space we will take into the next page.

So, we look into this, we start with the process then formulate the problem and plan the study goals objectives and how are we going to do the study that aspect is taken care. Then we take the assumptions of preliminary data and understand the system which will give you the model and we check whether the conceptual model is correct in this particular point the answer is yes then we move into translate the conceptual model into appropriate computer model. And from this you use the conduct and do the pilot runs, to do initial data collection with the model.

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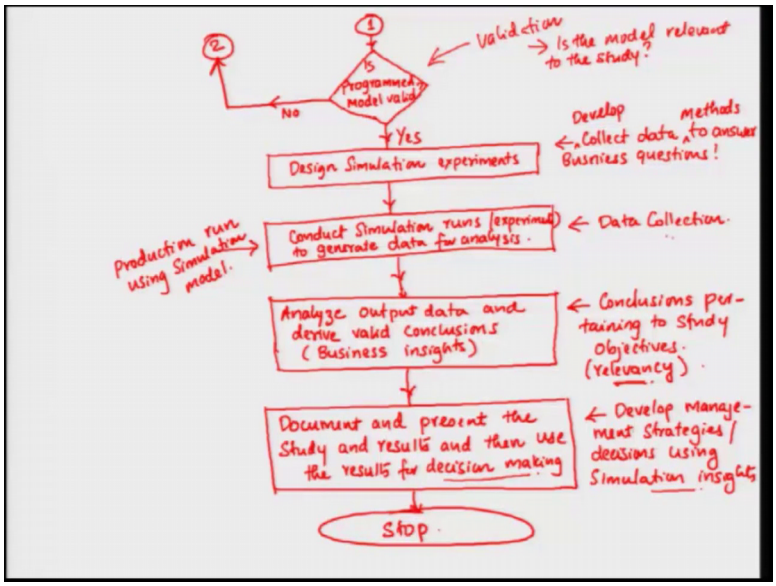

So, then from here this is our connector. So, we continue from there and what we say is then we do the next decision, this decision is programmed model valid. Now you are checking is a programmed model is valid or not, two things you can do that is yes and there is a no.

If it is no then we put an another connector and what happens is that connector goes back to so, here is our 2, it goes back to two places, can go back to first check is the conceptual model right and other check is here. So, we can see whether the conceptual model is right, if the answer is yes then there is somewhere you are done a mistake here otherwise go back to the original thing alright.

Otherwise if the answer is yes then what you do next is design simulation experiments. So, here what we are trying to do is collect data to answer business questions. So, to collect the data or you can say develop, collect data method methods to answer business questions. So, here you are designing the experiment so, that it gives you the framework of how are you going to collect the data, once this is done the next thing what you do is you do conduct simulation or runs this is called runs or another way it is the name as experiments to generate data for analysis.

So, this is where what you call as the data collection. So, here is the framework for data collection, here is the actual data collection, this is the actual data collection then once you have is the next thing you do is you analyze output data and derive valid conclusions, I rename this as business insights. So, you analyze this data to derive what we called as valid conclusions. So, here is the conclusions pertaining they are related to, not rainy random conclusions these are conclusions that are pertaining to study objectives. You are trying to analyze the data and relate develop appropriate conclusions that are pertaining or relevant.

So, this is the relevant relevancy, you are important you are trying to connect with the objectives of the study. Then finally, once this is done you have major last step is document and present the study and results and then use the results for decision making.

So, this is where you are basically saying that this is develop management strategies; develop management strategies or decisions using simulation insights. So, you gain insights from the simulation study and using that you are trying to develop strategies or make the appropriate decisions.

Then the last step is stop the simulation study. So, as I said earlier, if you look into it you, once you decide that you are going to start the simulation study from there once it is done then you do the second step is formulate the problem actually I should not do one and two because and you will get confused with the connectors.

Then you formulate the problem and plan the study accordingly the goals and objectives and how is the next major question. From there you come into the build they what you call as the relevant data about system and define the model this is where the conceptual model is getting built.

So, this step is also called as building the conceptual model, the conceptual model. So, once the conceptual model is built then from there you check whether the conceptual model is valid, if the answer is yes then you proceed below. If the answer is no you go back to the data collection step and try to refine the model.

So, this step is the redefine so or the refine the model or redefine or you can also call as refine the model. Once the model be is appropriate when you are ok with this you are saying that yes this model is right with me then you go down and convert the conceptual model into the computer model.

You translate to a computer programmer or an application and then you verify it means you ensure that the program this is where you translate then translation is this verification. You can say that ensuring the accuracy of translation this verification ensures the accuracy of the translation.

Once that it is done you do pilot runs initial data collection that is using the computer model this pilot run is again used for ensuring that you build the right model, then you check whether the programmed model is valid or not. So, this step is called as typically validation. So, remember building the right model and did we build the right model is the model right or did we do the right programming.

So, this is where you are saying so, this is where is the model relevant to the study, that question is what we are trying to do at this point, if the answer is yes then you conduct the data collection you design the simulation experiments this is data collection methodology being defined or developed. From there you run the production this is sometimes some people call this as the production run using simulation model some people call this as the production run, which is what you try to do is you that generate data which is relevant for the analysis purposes.

Then you analyze the output data whichever is collected as per the simulation experiments and then you try to derive valid business conclusions, this conclusion should be pertaining to the study objectives, though or they should be relevant conclusions.

Once that it is done you document and present the study and the results of it in such a way that they can be used for decision making or business decision making, the insights that you developed, the management insights that you developed from the simulation can be used to build appropriate strategies. Once that it is done your objective of the study is out.

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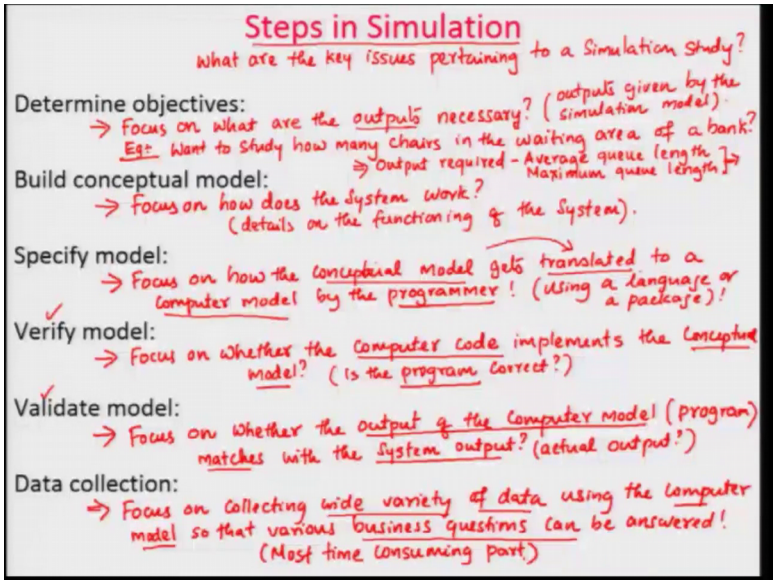

So, as I said earlier the steps in simulation and this is important because what are these steps in simulation kind of suggest, what are the key issues pertaining to a simulation study? So, we are looking into what are the key issues pertaining to the simulation study. So, the first thing is determine the objectives so, this is focus on what are the objectives, are the outputs necessary.

So, an example is if you are interested in studying for example, Want to study how many chairs in the waiting area of a bank? If that is a case want to study how many chairs in the waiting area of the bank then that translates to then output required is average queue length and maximum queue length.

So, if you have both of these things then you can decide how many number of chairs you need to purchase so, that you can put it in the waiting area of the bank. So, the objectives is also translates to what are the outputs so, this is the outputs given by the simulation model, that is what we are interested here.

Now, the second part is build the conceptual model, we talked about conceptual model this is like this translation focus on, what are we focusing here? Focus on how does the system work, The question here is how does the system work? Or the conceptually the mechanics of the system or details on the functioning of the system.

So, this question answers how does the system works or how does the system functions, then we talk about specify the model another step it is focused on how the conceptual model gets translated to a computer model by the programmer. So, here you are introducing a new person the computer programmer, the person who is responsible for translating the conceptual model into the computer model. So, this translation aspects is that is what you are trying to do in the specify the model aspect. So, whatever the conceptual model that you are built, you are trying to get it translated to a computer model.

So, the thing that was in your brain the conceptual model that was in your brain on a or a piece of paper now gets translated to a computer model, here you are using a language or a package. So, we can build the computer model using a general purpose programming language like CC plus plus or fortran or something like that or you can use a software come simulation dedicated simulation software package or simulation language like sim script, Simon, arena, stuff like that to build the specify the model, the programmer will be the person who will be trying to do this.

Now, the verification part of it is the focus on whether the computer code implements the conceptual model. So, did the programmer build the model is the computer code the computer program implements the conceptual model as such. So, is like is the program correct is the program correct is it actually implementing the concept that you are actually trying to do.

Or is the simulation model the computer model is it correct that is the thing that you are trying to do here, then the next thing is the validation of the model and validate the model is the focus on, your focusing on focus on whether the output of the computer

model, computer model or program; the computer model or the program whatever the output it is going to give.

Whether the output of the computer model or the program matches with the system output so, you are looking here is the output of the computer model is it matches with the match with the system output the actual output. Is the so did you build the right model is the model right or did you built the right model the model that fits according to what you want to do. If this two are right with the validation and the verification are done completed then what you do is then you focus on collecting wide variety of data of data using the computer model; using the computer model so, that various business questions can be answered.

So, what we are trying to say here is that you collect wide variety of data, not just the simple data, but you collect wide variety of data using the computer model. So, that various business questions can be answered, also remember this is the most time consuming part. The data collection using the simulation will be the most time consuming part of any study. So, I hope you understand the basic steps in simulation, with that what we try to do is we will also try to now talk about some real world insights.

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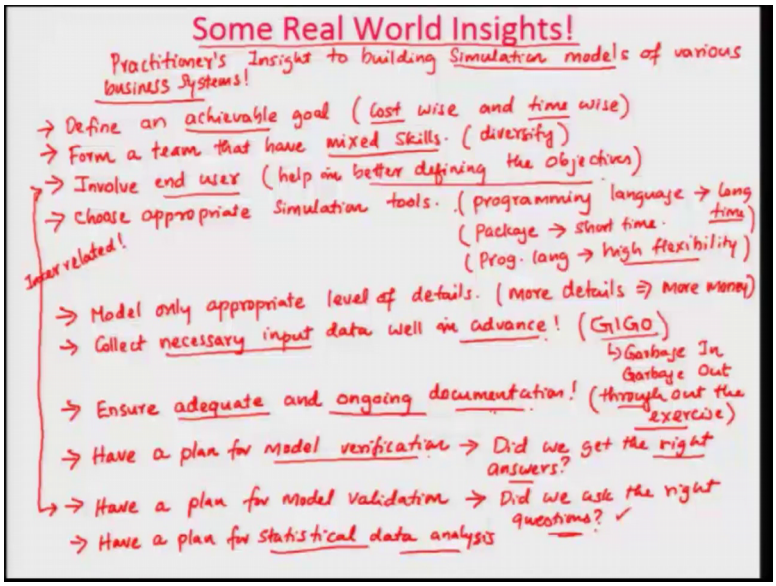

So, this is kind of like a Practitioners Insight to building simulation models of various business systems, these insights are more related to business systems if you are trying to

build simulation models of various business systems, what are some of the insights that you need to have.

So, the first one that you need to think about is define an achievable goal this is cost wise and time wise, define something that you can achieve both cost wise and time wise because in industry nobody is going to give you indefinite amount of money to do what you want to do. There should be it should be applicable it should be acceptable for an industry for cost and time.

Next thing is form a team that have mixed skills, you just cannot have so; that means, diversify do not just put statisticians alone in this team put programmers, put analyst, put people who are good at observation, data collection that kind of things. Then another one is involve end user because most of the time this is what happens is help in better defining the objectives; better defining the objectives, the end user is always the one who helps you in better defining the objectives. Then another insight is choose appropriate simulation tools.

Let us say, if you can use a package see the thing is this programming language a general purpose programming language it will means long time. It will take you a long time to build the model whereas, a package short time you can build the model in a short time.

The programming language also gives you; programming language also gives you high flexibility whereas, a package will actually give you low flexibility. So, in that thing is that the trade off is always between the time and flexibility, how customized the model you want build then depending about that you decide whether you want use a package or you want to use a programming language right.

Then model only appropriate level of details, do not model anything more than the acceptor level of details, only model the appropriate level of details if you model more than that because more details implies more money the cost will go up because simulation remember it is not a cheap exercise at all its an expensive exercise.

Then collect necessary input data well in advance, as early as possible whatever the necessary input data collect at the earliest, because otherwise this principle GIGO is very true if you collect garbage input data then you get garbage output this means garbage in garbage out in garbage out.

So, start in advance well in advance and collect necessary input data to ensure that you have the right data that you are collecting for your output, ensure adequate and ongoing documentation. So, whatever you are trying to do here is ensure that you keep adequate documentation and the documentation should be on going, continue this is a throughout the development throughout the exercise. Ensure that documentation is done throughout the exercise, many studies lack from the documentation and some point of time when you reach a point, where you are trying to find out what actually happened you find that you have no documentation to find out what actually happened.

So, this is an important point, then now we talk about have a plan for model verification, you should have a plan for model verification, did we get the right answers. So, this part that you need to ensure you have to have a mechanism to verify the model that you build, for sure. Otherwise you will be in trouble right, because if you get the wrong answers then your entire study you will be a total waste of time and money, also have a plan for model validation, which implies what we are saying here is did we ask the right question?

This part can be this issue can be sorted out if you have paid enough attention here, interrelated they are connected, interrelated. So, you have to ensure that you have asked this part is taken care of if you are involved the end user properly then finally, last one is have a plan for statistical data analysis you should know how to use statistics should have some statistical or data analysis experts in the team to decide how to analyze the data because simulation gives you a lot of data and to analyze the data and make sense out of it is not a simple task. So, you have to ensure that you have appropriate capabilities within your team to do this process.

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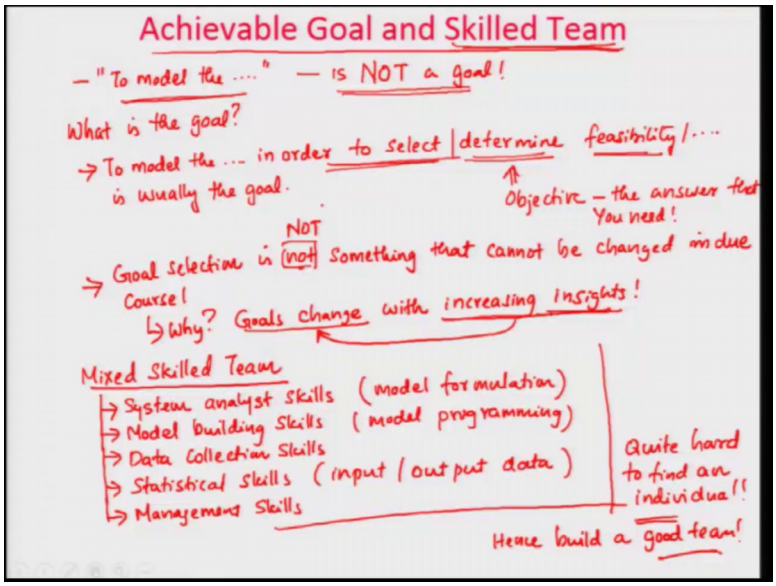

So, the thing that we need to talk about the achievable goal and the skill the team this is kind of you know something that very important to us and it is important for the success of the simulation. So, one of the things that we need to do is first remember that to model the system or whatever it is not a goal. In the business studies the simulation studies related to business to model is not a goal, this is something that you should be you should remember you are not trying to model this. What so, then what is the goal? So, then the question is what is the goal?

The goal is to model the whatever in order to select or determine feasibility slash whatever you want to call it, is usually the goal. You are never doing business simulation just to model the system you doing the model in order to do something in order to select or determine the feasibility of adding another server or building a new facility increasing the production, reducing the cost of production there is a quite a lot of ways that you can think about it. This part this determination of the feasibility and aspects this need to be clearly spelled out, because this is the objective or the answer that you need please remember that.

Also remember that goal selection is not something that cannot be changed, I will use this phrase here is NOT something, uppercase something that cannot be changed in due course changed in due course. So, what we are saying here is that it is something that cannot be it is not something that cannot be changed, you can change it as time

progresses you can do that because the question is why? Because goals change with increasing insights.

So, as you start doing the simulation study, as you start building the model, as you start collecting the data, as you start analyzing the data then you see the your insights to the system increases the minute your insight increases then your goals will change. So, say that I defined this goal and I am not going to change the goal is not a good way to do a simulation study.

Also another part you need to remember is this part called the skilled team. So, the mixed skill team; mixed skilled team is very important because you need to have you need to have various skills some other skills include system analyst skills are required, you need to analyze a system, which is also sometimes what people call as model formulation.

The conceptual modelling, then you also require model building skills this is also called as model programming translating into a computer program, some other skill that you require is the data collection skills. You also require statistical skills, this is you know then statistical skills both input and output data put data analysis, then you require management skills to that everyone to move in the same direction have the same set of study.

So, if you look into all the skills it is usually quite hard to find an individual you is very hard it is almost impossible to find an individual who has all this capabilities hence build a team, build a good team. So, then you find people who are good at with multiple of the skills and then you build a team that team will be the one who will be doing your simulation study.

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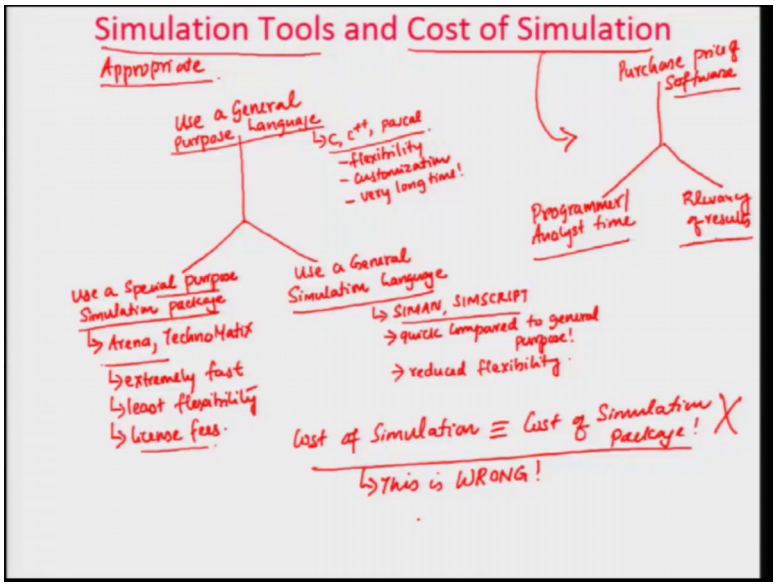

Then now we talk about the tools and the cost of simulation, what are the major simulation tools and what are the costs associated with those simulation. So, the simulation tools is what are the appropriate tools that is what we are interested in here in this one, the appropriateness of the tools.

There are three options in front of you, the three options I am going to write the three options here in the simulation tools one is using the use a general purpose language, the other option is use a general simulation language, last one is a use a special purpose simulation package. So, use a general purpose language which means use C, C plus plus, Pascal etcetera. So, what these are is these are general computer programming languages. So, the major advantages of them is that, flexibility customization, the disadvantage of this is like very long time to develop, it will take the time constraint is very high in this case because it is not designed to build a simulation.

Whereas you can use a general simulation language typically in this case this is more about Simon, simscript etcetera which are designed to build simulations. So, this is like quick compare to general purpose; compared to general purpose language, but it is also it reduced the flexibility you do not have that much of flexibility that is available with that of a general purpose language.

The flexibility is much less in this regard then the last part is that you can use a special purpose simulation package instead of a general simulation language, the special purpose simulation package is more like Arena, Technomatix etcetera these are packages.

So, these are, the main advantage of them is extremely fast compare to the other two options, but then least flexibility. So, you have these things are mostly you know then here also you have to think about something called as a license fees most of these simulation packages are expensive. So, you can think about paying good amount of money ask the license fees in this regard.

Also that is the one part then most of the time people think about us cost of simulation is equivalent to cost of simulation package. Many people think about this is wrong do not this is a wrong assumption, this is not true this cost of simulation package is a very minuscule aspect of the cost of the simulation.

So, the cost of the simulation, there are three major components in the cost of simulation the early is three the major three are the purchase price of software. So, that is only one part of it, then programmer slash analyst time; time is another aspect and the last one is relevancy of results; if the results are wrong at then the study then you have to redo everything. So, these are the three aspects that determine the cost of the simulation.

The purchase price of the software is one component of it the time spent by the programmer and the analyst in developing the model and analyzing the model is another aspect of it and the relevancy of the results, how relevant are those results with respective your simulation study is another important aspect of the stuff.

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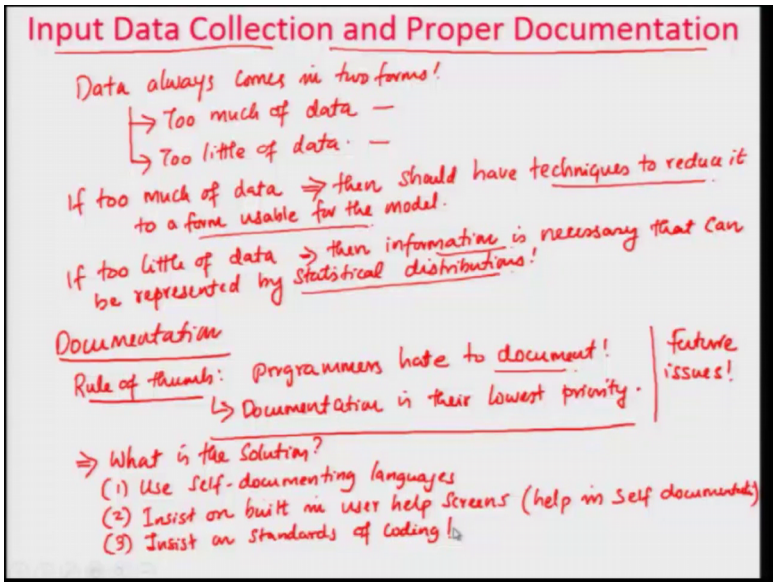

And then the last part is we talk about the input data collection and the proper documentation as one part of it. Many a times we do not do this properly, remember this data always comes in two forms with respect to in a simulation study there is only two forms as much as we are concerned.

Number 1, too much of data or other thing is too little of data. So, in a simulation study you always you have with the too much of data or you have too little of data. So, if too much of data then should have techniques to reduce it, to reduce what? Reduce the data, reduce it to a form usable for the model. So, you should have techniques to reduce it to a form, techniques to reduce it to a form that is usable by the model. If too little of data then what we need then information is necessary that can be represented by statistical distributions.

So, if you do not have too much of, if you have too little of data then you are looking at we are trying to develop create information that can be used to statistical distributions. So, if you say that you have 10 values are not sufficient, but almost all the 10 values looks like they are very similar to each other then you can say fine looks like all values are same or similar and they are looks like they are equally likely. So, then I can use a uniform distribution because you have too little of data.

So, that kind of an understanding you should be able to have then about documentation this is something what the rule of thumb programmers hate to document, or they love to program.

So, since they hate to document at the end of the time what happens is you will not be able to figure out what is actually the problem many a times or documentation is their lowest priority. So, what you can do in this regard is and if this is not done, then future issues you will not be able to figure out if there is a bug what cause the bug did the translation happened it will be all a problem to you.

So, to avoid that what can be done what is the solution, the couple things you can do one is use self documenting languages, number 2 is insist on built in user screens user help screens. So, these help screens usually help in documentation; help in self documentation.

And then insist on standards of coding, you say that your programming something ensure that the standards of coding where the logic has to be commented out is done in this regard.

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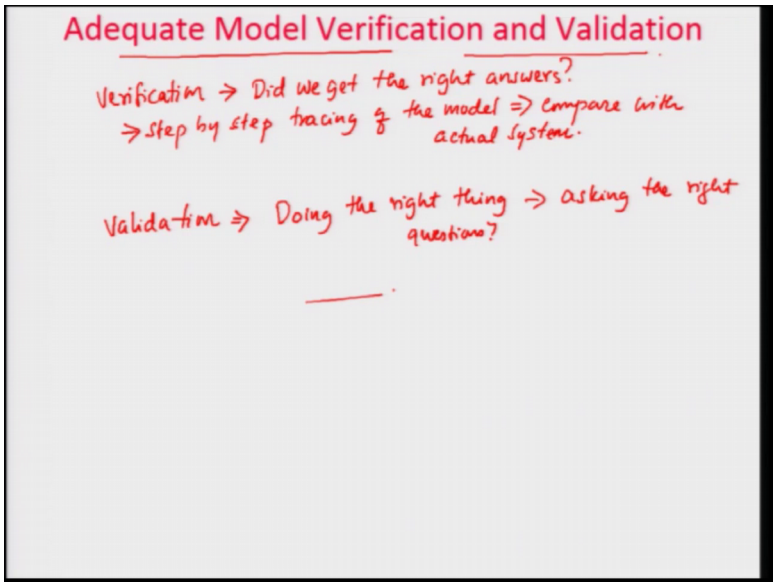

And the last part we have to do it is adequate model validation and verification. So, the model verification is what. So, verification is did we get the right answers?

So, this question you the way you do this is step by step tracing of the model, tracing of the model, which is equivalent to studying the and compare with in our workings compare with actual system. And this new see a natural way of testing this one whereas, the validation part we will get into this later down the road, but I will just give you a quick update, validation is that doing the right thing or we are asking the question asking the right questions right questions.

So, we can compare with the existing systems and do those kind of things. So, what we will do is we will kind of stop it here and we will come back in the next class and get into the details of this.

Thank you.