Scheduling Techniques in Projects
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Lecture - 10
Dependency Structure Matrix-III

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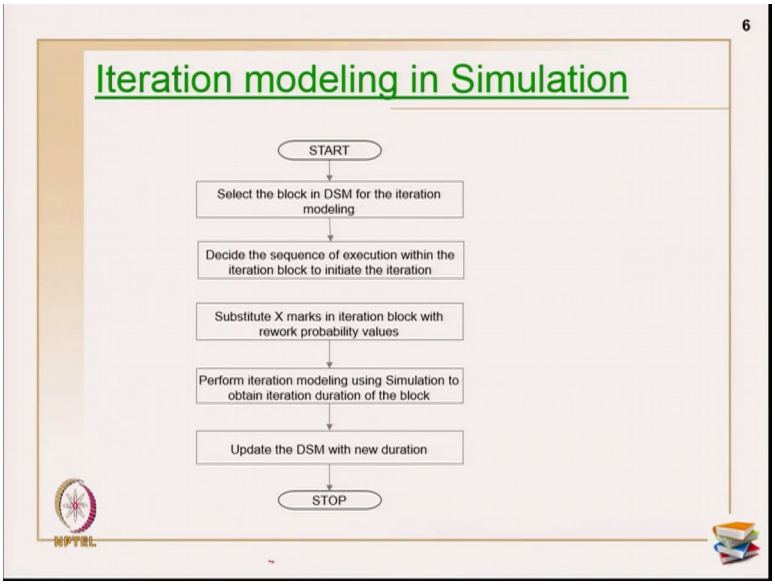

So, now coming back to phase four or the operation number four, iteration modeling in simulation; so, simple steps again our given here for simulation exercise. So, first start; select the blocking DSM for the iteration modeling ok. So, you have to really select. So, so select the block in the DSM for iteration modeling. So, I have chosen one particular block and for example, in the last example I have only one block. So, we can choose that and decide the sequence of execution within the iteration block to initiate the iteration ok.

So you should decide whether it is the ACEF, whether it is CAEF, whether it is CFAE, whatever it is, decide the sequence of execution, which implies tearing has to be done ok. Then substitute the X marks in the iteration block with the rework probability values. In the example I have shown. So, there are so many X marks there, you should know what is the probability with which for choosing an assumption and how much of rework will

happen in those activities and successor activities as well ok; that you may have to decide ok.

I may make an assumption for initiating an activity called A ok. A is actually giving information to maybe two other activities B and C. So, as a result of first you have to check by making an assumption is A repeating or not and how much is A repeating ok. And if A is repeating whether B and C are repeating or not and how much is B and C repeating ok; this B and C maybe giving information to two or three more activities. As a result of B repetition, is other activities are repeating or not? And how much is a repetition?, how many number of times it can repeat and so on. That for that you may have to get rework probability values.

This probability values you cannot do randomly you have to go to with the experts. People, the domain experts, people who have worked on a project for last three times or four times may be very comfortable in giving the rework probability values ok. For example, the same cooling tower example I can say the GA arrangement we generally takes 5-6 times. So, they can give a high rework probability for that and compared to other mechanical drawings or deliverables that they have ok. So, the only the people who worked in the projects earlier. For new projects it is very difficult to give the rework probability values ok.

For projects which we have done earlier easily you can assign the rework probability values and you can still get the values ok. Then once you have got all once you have replaced all the X marks with the rework probability values and the next step is to do the iteration modeling. Iteration modeling the best method is simulation, but that is not the only one method. You can choose any method of your own choice; Markov chain is there, Signposting is there, so many methods are available you can choose any of them.

In this exercise, I have used simulation and I have used manual way of showing with a simulation exercise. And perform iteration model using simulation to obtain the iteration duration of the block ok. Once this is done update the DSM with the new duration and then stop the whole exercise ok.

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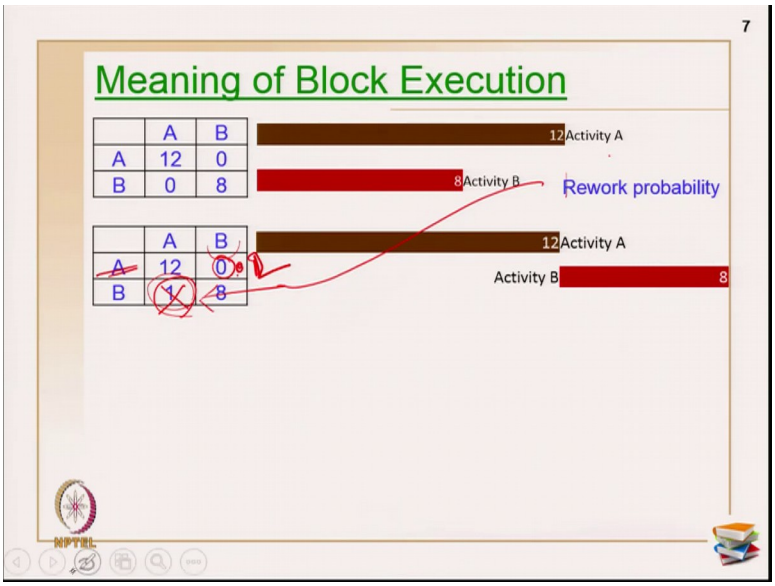

Now, what is the meaning of block execution? So, I am going to take a hypothetical example and then show you what is the real meaning of blocks? So far you have seen what is a block? You know what is tearing process. Tearing you are doing only to determine the sequence within the block ok. If you want to really evaluate the sequence suppose I have 2 by 2 activities, a 2 by 2 block, then I may have 2 sequences. Suppose I have 3 by 3 activity in a block, then I may have 6 sequences.

So, accordingly you may have to really see: what is the meaning of actually evaluating the blocks ok. So, I having a block I have taken a very hypothetical example; A B is two activities, duration for A is 12, duration of B is 8 ok. And I have used 0 as the relationship between the two activities. 0 implies there is no relationship between A and B so, I have put 0. Suppose if you if you want to have a minimal value in the duration, then you may have to put 0.1 or something if you want to show the repetition. Otherwise I have to keep it as 0, 0 implies no relationship at all ok.

So, now, what happens since there is no relationship, activity A and activity B are to be done in parallel ok. Since there is no rework also shown here so, and what is the duration for this particular block activity A, duration 12, activity B, duration 8. I have used bar chart for showing this bar chart I will explain you in the end along with the other techniques ok. So, duration for this particular block is coming out as 12 year ok. Now I will take another case.

Now I should explain you what is rework probability now, with this example I will show you what is the rework probability. Now same example I have taken, I have used a value called 1 here. So, whenever so, this X implies X originally it is X, so it implies there is a relationship from A to B. I am replacing this X value with 1 using a rework probability value of 1. So, now, what is a rework probability value? As a result of change in A there is 1 which implies 100 percent probability that B will repeat ok.

I am repeating it again as a result of any change you make in A, 100 percent of the times B will repeat which implies every time you make some change in A, B definitely will repeat because I am having a 100 percent probability value ok. Now if you look at this 0 value here, as a result of any change in B, A will never repeat, because I have given a 0 percent probability value ok. So, since I am giving 0, it implies it never repeats, 1 implies 100 percent repeats. Suppose if I have given 0.1 as my value as a result of any change in B there is a 10 percent probability that A repeats ok. Suppose if it is 0.2 as a result of change in B there is 20 percent probability that A will repeat. That is how it has to be interpreted ok.

So, now, let us go through with this ok. So, now I am having an activity A, activity B here. Now the duration for A is 12, duration for B is 8 and I have given a rework probability of 1 here and 0 here. So, how does this actually evaluate. So now since there is an X mark here so, activity A first and then activity B because there is a dependency relationship. So, only after A, B executes and now what happens there is a 0 value here. So, after B what happens A never repeats, because I have given 0. So, what happens is the duration stops. So, if giving this as a block so, this shows A and B are in dependent activities ok. So, in a way this is my parallel execution, this is my representation to show my sequential execution.

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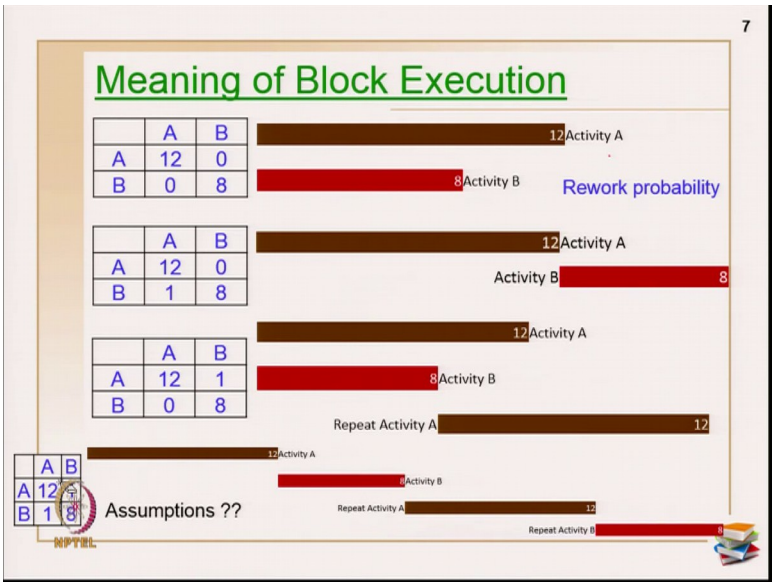

Now, I am going to change the scenario. Now what I have done is I have written 0 here and I have written 1 here. This implies A and B are parallel, because there is no relationship between the A and B and this 1 implies every time B is changing, there is a 100 percent chance that A repeats ok. If you are just executing this model what happens is every time you will get the same duration because there is no probability at all.

Here A's duration is fixed 12 deterministic value, B's duration is also deterministic given as 8 and every time B repeats, you have already told A repeats and nothing is given on information on repeat duration for A. So, what happen? So, 12 A it executes, then B also is executed in parallel. So, after B, I am executing A in parallel and duration is 12. Now what you have to really see is I am already not finished my activity A ok. So, should I repeat my activity A to the fullest extent possible or can I overlap with the activity A execution or should I wait for the activity A and then repeat my activity A.

So, all these queries that you have, with which you have to really carefully plot the values and give control statements for your activities so, that the activities will perform as per your desire ok. If you do not give any controls, default what happens this is what is the execution that will happen ok. Suppose if you think since half of the execution is already merged here ok. You need not to repeat this much of extent, then you can cut down the duration of repeat, you can do something here ok. So, those are you may have to make it in your assumptions case.

Now let us put another case ok. Now I have done 1 here and 1 here. So, what happens here, 1 is like every time A repeats, B repeats. Every time B repeats, A also repeats. So, what happened to this network? I have only showed two times it does not mean the model is chopping at two. In this case what happens the model will never even stop ok, because I am executing activity A, then activity B because it is sequential as a result of 1 here and as soon as B repeats, A also repeats, because I have told it is a it is 100 percent probability. As soon as A repeats B also repeats, because I have told 100 percent probability.

So, what happens A B keeps on repeating every now and then ok. This is also a caution you have to keep in mind; the model will not even stop. Whether you are working on simulation model it will never even stop. So, what you should do; maximum you can give 0.9 or 0.8 as a value for your rework probability values and be careful when you are keeping a value as 1. Unless you know that 1 will not no stop your model so, do not keep a value as 1 for example, in this case that may happen ok.

Now what are all the assumptions that one can make. One is duration as I told. When activities are overlapping with the repetition in generally does not happen in information flows. So, primarily the duration of the repeat activities need not be same as the initial activities and other thing is so, suppose I wanted to cut down, maybe I am just planning for half a duration is a duration for repeats ok. In the next query that can come is how long can I repeat do the repetition.

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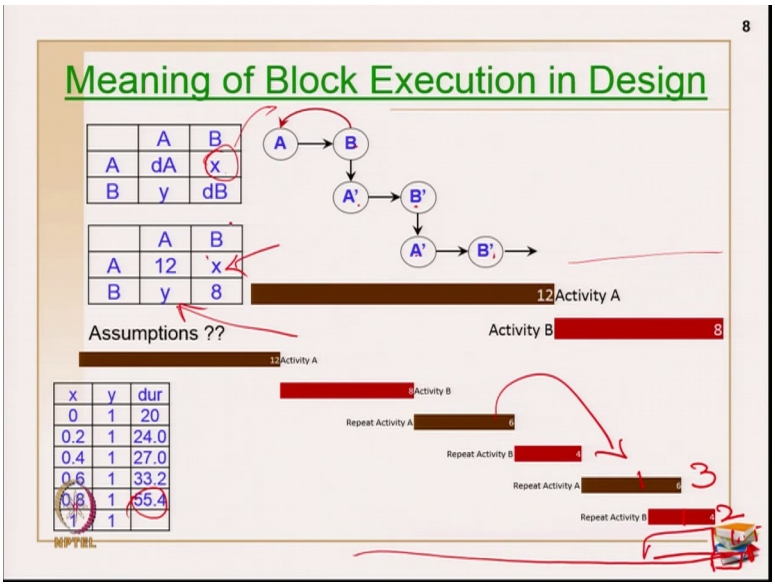

In real world practice if you will see when you are modeling on information and revisions in drawings, any sequence of drawings will not repeat like 10 times or 20 times and so on. It hardly repeats 2 or 3 times. So, you can put a control statement ok. It should not be less than maybe 1 day of duration or it should not be less than 2-3 times often, then you should the model should stop in the repetition. You can give all these control statements when you are doing your modeling ok, then only you will get the duration which is really realistic ok.

So, I am just going ahead with the same example. So, what is the meaning of the block execution in the design phase ok. We are still working on design phase so; we have to really see what is a meaning of the block? In the last example case I have shown you: what is the meaning of plotting the numbers ok. So, each number and different numbers and different places, duration is still the same. So, I have told you: what is the meaning of the same. So, what are the assumptions minimum assumptions one should keep in mind and in order to get a scheduling duration and also what are the things you should understand in the block execution ok.

And so, now I am just evaluating it with the last slide you understood that in the repetition will keep progressing till end, there is no limit ok. This is a meaning of this whole block. Now what happens, A starts because I only made this as my assumption because I have given the sequence as A and B it is understood there is an assumption

made for this link which is this link so, there is an assumption made in order to initiate my execution.

So, A is starting first, next B, and then A repetition, B repetition first time, A repetition, B repetition second time and this goes on till the end ok. That is understood. Now I am just giving the same duration for the activities and now what happens is I am just going to see what is the minimum and maximum in these cases which I have told you if there is some value in the dependency relationships rather than 0 and 1 which are the extremes. So, you will get a duration minimum as 12 and 8 because of the sequential relationship and the maximum will be so much ok.

So now, there are some assumptions to be made. So, number one assumption what I have done is: the repetitions of the activities, I have said, it takes half of the original duration only and stop or 3 rounds of the duration. If that is a case, then this will be my duration. So, this is hardly 10,10, 20 and this is 20 so, 40 is a duration of my entire block ok. If this is assumption you have given in your model and you are doing any probability value. You are giving a probability value of X from anywhere between a 0 to 0.9 or something and why also if you give from 0 to 0.9 something, what happens is your model will oscillate between the value called 20 and the maximum value as 40 ok, because I have made a control statement here ok.

So, that is why what happens is if you want to you can also put an interpolation or something and you can get the intermediate values manually if you are not comfortable in doing it on simulation ok. So, now, what are the assumptions you have to do, really if you want to do this also the second repetitions also you can say it is half of the earlier repetitions. So, in this case it can be 2 it can be 3 and 2. Next round it can be 1.5 and this can be 1 and you can say values less than 1 are not even considered. So, what happens this will stop at here, because half of 1.5 will be 0.75 and you cannot go beyond that.

So, the model will stop on that place. You can give assumptions in whatever ways you form according to the model representations ok.

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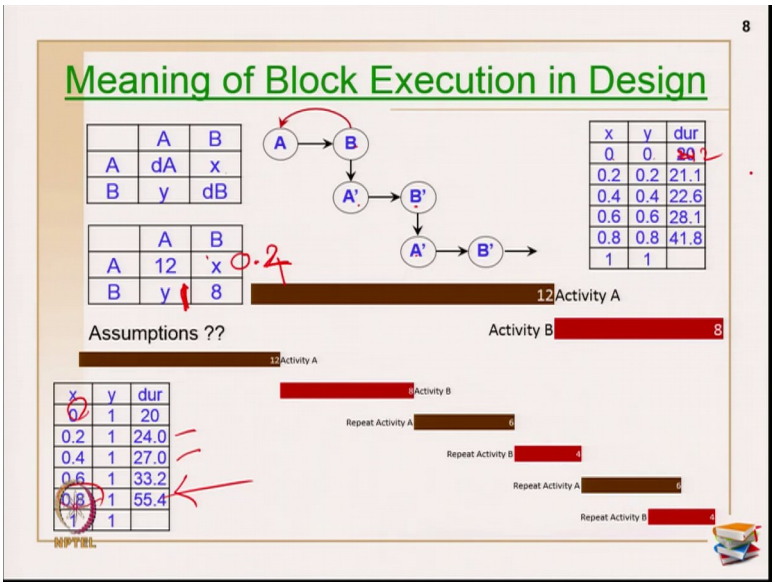

Now I have shown for different XY plots, but there is no control on duration here that is why I got values more than 55 and all. Otherwise you will get between that values only ok. In this case I have not shown anything ok. So, if the value of X is 0. So, the value of X, I am giving it as 0 and the value of Y I have constantly kept as 1, which implies that there is a strong relationship between A and B and that is where I have not removed that relationship and the B to A is actually a relationship which can be removed or ignored ok.

So, I have maintained this as 1. So, what will happen is every time A repeats and then B repeats, if the value of X is 0, then it will stop at 20 only. The value of X is 0.2, then it repeats for a few rounds ok. The meaning of that is suppose I am doing 100 runs in simulation, 20 percent of the time A will repeat and remaining 80 percent of the time 80 runs ok, in 20 runs A will repeat and duration will be a 6 or something like what you told and in the remaining 80 rounds what will happen is A will not repeat ok. That is the meaning of that.

If you are running like that, you are duration is something as 24, if you are changing this value as 0.4 it is 27; so, with the increase in probability value so, you can understand something. What is a meaning of this increasing in duration? It means actually the value, the relationship between B and A, it's strength is defined with the duration ok. You have made a very strong assumption when I am saying there is a 0.4 probability it implies

whenever there is a change in B, 40 percent of the time A will repeat which implies the strength is really greater than 0.2 or 0 and something.

So obviously, the repetitions is expected to happen ok. You should understand when I breaking a tear mark with 0.8 or something, we should understand and my durations will keep on repeat every now and then. And, I may get something close to 50 60 or something for my initial durations on 12 and 8 ok; that you have to understand and keep in mind ok; so, as far as possible try to avoid breaking up a mark which has a very high and value in the rework probability values.

Now same case I have again shown wherein both the relationships are changing equally ok. So, when X is 0, Y is 0. So, it implies the relationship is parallel. Sorry for this change. So, this will be now 12 ok, then X is 0.2 and Y is 0.2. This implies the first relationship is still there and then there is a rework probability of 0.2 and 0.2. So, this will be 21.1 then 0.4, 0.4. So, accordingly you also see here when the strength of the dependency relationships are increasing, you also get an increasing pattern ok.

Now if you see let me explain you the pattern. So this if it is this is greater like 1 or whatever it is, you will not have that much of an impact ok. This X mark relationship should be very less then you will only have little rework. Suppose if this relationship Y is more compared to X, you will get a greater duration than X less and Y more ok. That you have to understand and if you are having both the values as close to 1 or something what will happen is the model will not even stop. It keeps on running because every time both the activities will keep repeating ok. So; obviously, you have to have a control statement when you are working on information flows.

Now so, this is all about on information, again after explaining simulation I will tell you how do we run, how do we plot the simulation model as again working on computer simulation modeling and helping you with the software is not part of the course, but at least I will tell you how to do it with manually on the simulation models which I will postponed little later. Now let us see the same cycle flows, let us see how to represent in a DSM, so representing workflow in DSM.

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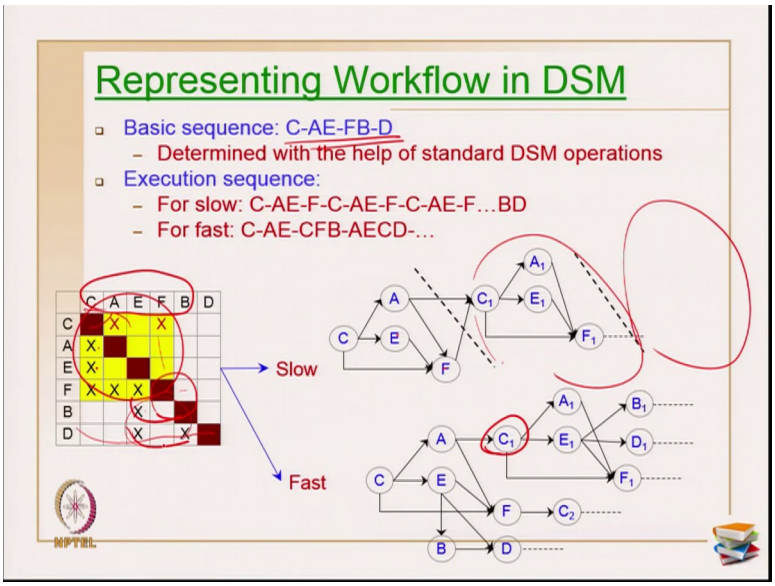

Suppose if I want to use the DSM example in a construction phase. So, what happens and what are the changes ok. So, the researchers have identified that there are two ways of executing a sequence ok. One is one is called the basic sequence and the other one is called the execution sequence ok. Now basic sequence which is nothing, but C after that A and E are in parallel. Then F activity and B activity, because this is in parallel and then activity D is executed. This is a basic sequence. This you will get from where? As soon as you are finishing a tearing process you will understand that this is the basic sequence for execution and for this entire project ok.

Now, what is called execution sequence? Execution sequence is what is the order with which I am going to first execute my CAEF and repeat my CAEF ok. That you will understand only when you are working out your execution sequences ok. There are so, many ways of doing it.

Two methods are described here; one is slow and one is fast. So, what is a slow a strategy implies? So, after C, I can start my A, but there is an option for me to repeat and check my C also. But I do not want to do because I do not want to repeat activity C too many times. I am going to wait for my activity F, information from F also let it come, let me cross check my A and F and then I will repeat C accordingly. That is also possible ok. So, what I do; I start executing my A, then executing my E in parallel, because there is no dependency relationship here then F. Once I have done, then the second time

repetition of the entire block happens, because it is a slow process of execution. Slow implies I do not want to repeat too many times every now and then as soon as new information comes I wait for all the information comes from all the activity execution then I will start my repetitions ok. Like this the repetition 1 starts, same way repetition 2 will start and so, on ok.

Now what is my fast strategy. So, as it is shown here, now once the activities are done then I do my activity B and D execution in the end. That is what is a slow. In fast what happens, I start repeating my C as soon as my activity A is done and once my activities within the block are done first time itself I start repeating my activity B D also. So, outside the block also I start repeating and as a result of each and every time of an execution what happens is I keep repeating my activities outside the block as well ok.

So, this is an information flow mechanism ok, which implies and as an information arrives, you keep executing, and also passing on the information to every other team. And then so that if they are doing those activities they can also cross check this value and then the errors are assumptions can be made minimal. In this case repetitions can be more if you are working on a design phase you may have more versions on the drawings, you may have more versions in the design mechanisms, but still you may have a shorter duration for the entire design phase.

That may also happen ok, but let me put the same concept, slow fast concept in a construction flow ok. Let us see how it works ok.

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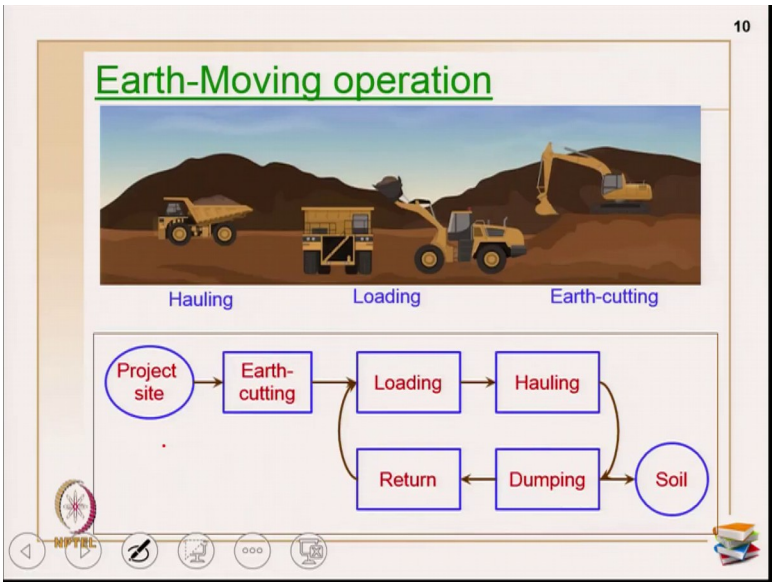

So, I am having a earth moving operation, this slide I think you remember this. This I covered in the first and second class of the lecture ok. I am having an earth moving operation. So, this is my cycle flow. So, you know what is this example all about. Now where do I have the cycle if I want to know only the activities if I am going to model only the activities here, how many activities are there loading, hauling, dumping and return. There are four activities available in this particular example and one thing you should know is all these four activities are in cycles now ok.

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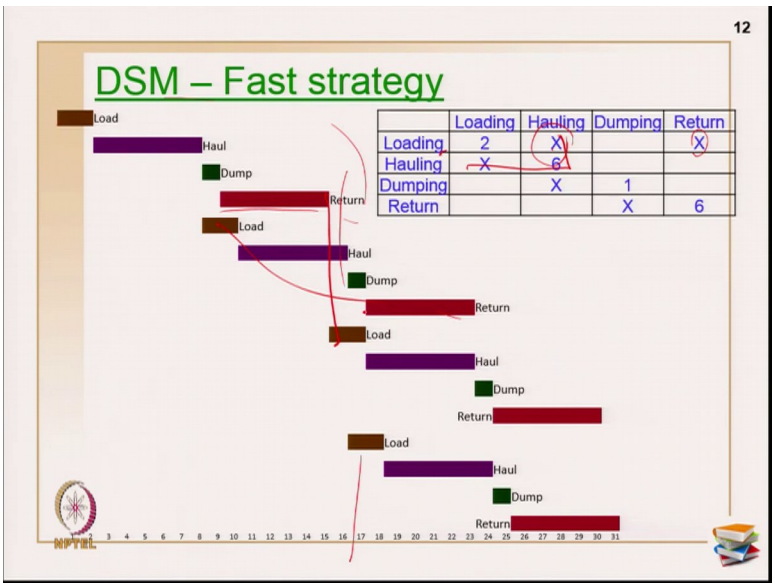

Suppose if I want to model this, what happens is loading, hauling, dumping and return; I gave some rough duration for all these based on some assumptions on data that they collected from the site. So, it takes it takes 2 hours of loading operation, 6 hours of hauling so, primarily traveling on the road, it takes 1 hour to dump the soil and it takes same 6 hours return, because I am going to travel on the same road only ok.

So, I have made the assumptions. So, 2, 6, 1, 6 and a what is a cycle flow now. After loading, I have to do my hauling operation, after hauling I have to do my dumping operation, after dumping I have to do my return process and once return I have to again go back to do the initial loading operation. Now what happens here this is a very good example slow strategy, but if you see here this looks as if I have one resource with me if I have only one dump truck with me, then I may have to do the cycling only after 1-1 full cycle is completed ok.

So, this is also a resource a pattern which is also revealed in this example ok. Slow strategy if I have only one resource in workflow this is what is the meaning of the slow strategy. So, I have to execute all the four activities in one round, then I have to repeat all the activities in the second round and so on ok. So, roughly takes 15 days to finish my one cycle, then another 15 hours sorry 15 hours to finish my second cycle.

So, hardly it takes more than a day for me to finish if we are working on 8 hours pattern, it primarily takes one full day, I would say less than a three-fourth of a day or if you want to stop and then continue on the next day after 8 hours then it takes more than 1 day for calculations ok. So, that is what is the meaning of this. Now what is a meaning of fast strategy? So, if you want to add, if you want to start your loading operation let us assume, I may have more dump trucks ok. So, what happens is I am going to you know fast track the mechanism ok. What I am going to do I have introduced one more X mark here ok.

So, this implies so, as soon as my return is done, again I do my loading as soon as my hauling is done also, I can still start my loading. So, how will this be executed. So, load to return processes is coming till here, it takes the same 15 days ok, but as soon as my hauling process is done I can still start my loading, that is also done and as soon as my return operation is done still I do my one more loading also ok.

So, after this return I can do my loading also. So, this is like multiple sources are there, you can still go ahead with your loading operations and so, on ok. But in real world situation what happens is as soon as the first dump truck is loaded up and sent, we do not wait for the hauling itself to take place ok. We start loading it up as soon as the first loading is done which is something like this ok. If you want to work something like this use the same fast track strategy and add controls on the statement so that the activities keep repeating every now and then ok. So, this is the meaning of using the DSM in construction phase ok.

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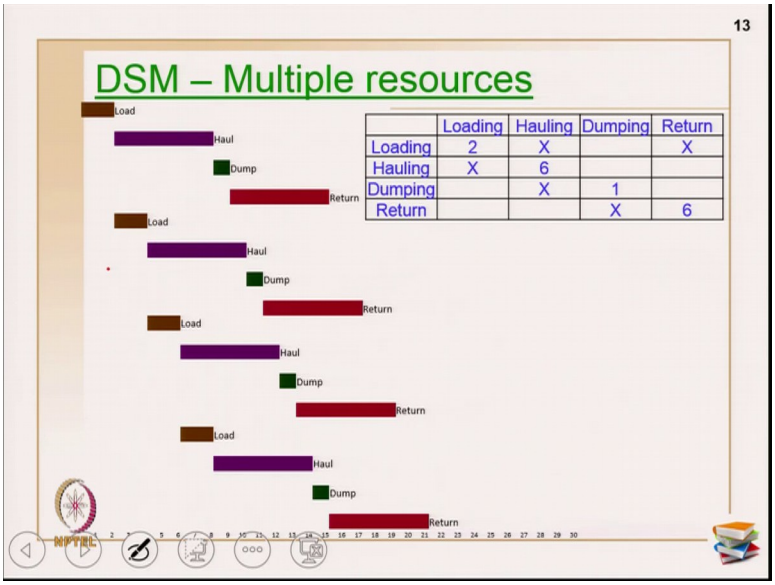

Now as I told you earlier DSM is an ideal method for information flow in design phase as well as in construction phase, but I can also use the same DSM for workflow in construction phase as well ok, which is what I showed you with this example. You can still show multiple resources and use execution strategies for showing your multiple resources. So far what we have seen is DSM, even in the same DSM when I am having a block for example, this block which I showed you this also you can use it in information flow, but I showed an application in construction because you should not have the mindset that it is only applicable for the design phase ok.

So, you can go with the slow strategy you can go with the fast strategy also, but in the AB example there is no meaning on slow or fast and both the values are same. Why, because there is nothing called waiting. The minute you have more than one X mark or

one feedback for any activity, then only the slow fast strategy generally happens. For example, in this case if I have one X mark here and one X mark here, the slow or the fast will not be applicable. Both the values will be the same for you ok.

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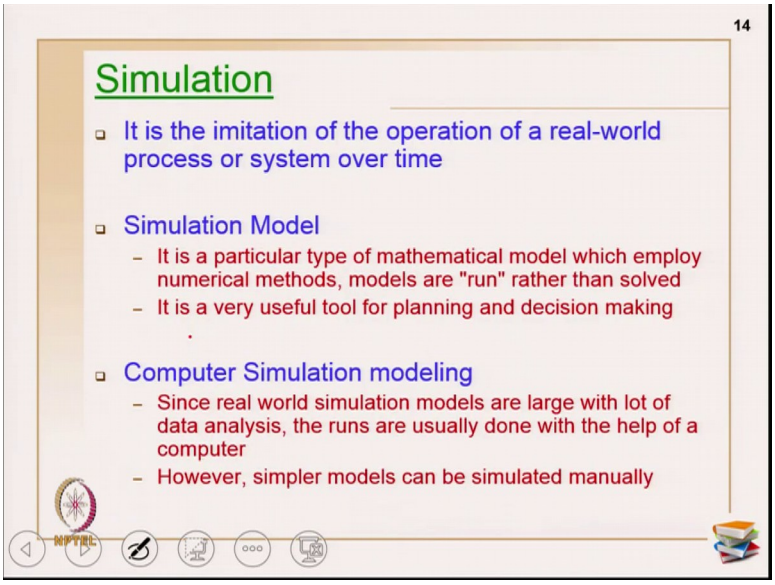

Now, let us move on into a what simulation, because I have told you so far primarily the process behind simulation. And so, far I have told you only the manual way of showing the simulation. Now if you are having a very large models in this case you did not have a very big model. So, you had only a smaller example. So, we were able to easily show the manual executions ok. Now you have to understand how to do this computer simulation modeling also. So, we will see what is the simulation process as such ok. Little glimpse on what is simulation, notations behind that, and so on we will see it right now.

What is simulation? So, this is a continuation on iteration modeling. You can still go ahead with using interpolation and you can still have a rough value on iteration modeling manual way, Simulation if you are very comfortable any of the software then you can still go ahead and simulation in getting that real simulation values ok. So, it is an imitation of the operation of a real-world process or system over time. That is a definition given by researchers on what is simulation. So, what is a simulation model? It is a particular type of a mathematical model. So, in mathematical models you have analytical type and numerical type. So, this is a numerical model where in the models are

run every time rather than solved. So, this is a very it is supposed to be a very useful tool for planning and decision making also ok.

Now whenever you say simulation model, primarily people say it is a computer simulation model and associate the word called computer with the simulation. This implies since real world simulations are very large with lot of data analysis and inputs, the runs are not possible with the help of a computer. For example, even in the previous example, you cannot do this manually ok. Suppose 20,000 meter cube of earth has to be cut and every time 10 meter cube of earth can loaded up on to your dump truck.

If you want to calculate this, then it is very difficult to do manual calculations unless you want to do some analysis like this and do ok. The best way to do is and maybe let us assume and sometimes in the peak hours of travel there may be a traffic jam so, you may have two hours of delay; non-peak hours you are actually able to come fast. So, if you want to plot all these uncertainties and durations and so on, you cannot do a manual calculation with the computer or using a calculator. So, you need a simulation modeling for the same.

So, the simulation always it goes along with the computer and we always say it is a computer simulation model ok, but still simpler models can be simulated manually. In the previous example all I showed you the manual way of explicitly representing a bar chart ok. Now what are the advantages of simulation, because I introduced you use simulation you should only little more on what is simulation.

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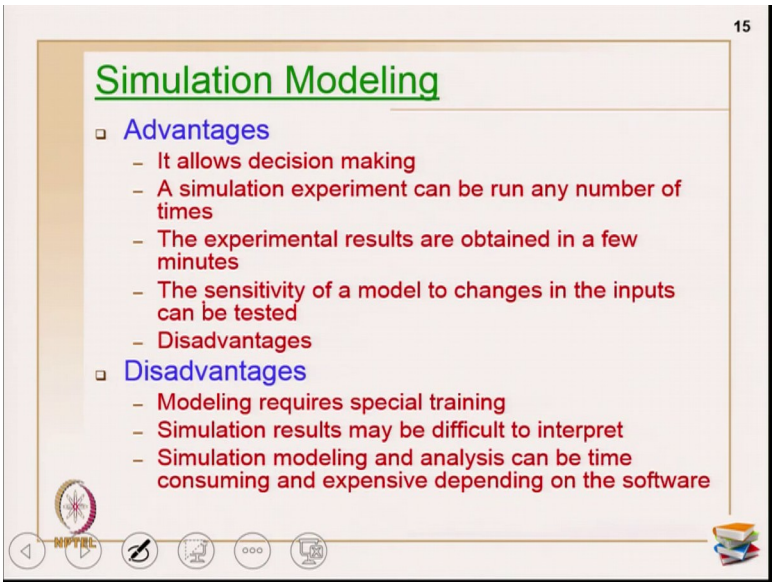

Advantages; it allows decision making. The primary advantage of going ahead with the simulation model is, as an experimental technique is, it allows decision making because you cannot really make a trucks move on the road and then calculate and do something. You have to really take decision making on how many trucks I need, how many loaders I need, how many excavators I need, those decision on how much time equipment's are waiting in the spots, how much time the resources are taking, then can I cut down the duration here and so on. Those type of decision all if you wanted to make then; obviously, you have to go in for a simulation model.

A simulation experiment can run any number of time, this is an advantage as an experiment ok. if you are not comfortable change some parameters run the model again ok. If you are still not happy with the result ok, modify all some parameters, change the network run again experiment how many of a times you want ok. The experimental results are just obtain a few minutes or seconds rather than once the model is really created, rather than you doing it manually on something ok.

The sensitivity of a model to changes in inputs also can be tested. Suppose if I want to do a breakdown along the path, 10 times the truck goes and there is no problem the eleventh time it travels on the road that is a breakdown and then 2 3 hours of delay happens for repair and so on. If you want to model or what is a sensitivity if I calculate my duration as 10 days compared to 11 days or 7 days and so on. All these also you can really test

when you are running the model ok. Sorry for the two disadvantages here it is a mistake ok.

Disadvantages; so, the modeling requires special training and as I told you each software is really different. When compared to even the software the basic representation of simulation itself we have to really understand so many control statements, constraints, loops and so on. You have to understand that properly when you wanted to do and you may have to do trace runs to see how the model is really performing, as per your plan or is it going in a different way you have to do all those. So, it needs special training.

Even representing or interpreting the simulation results, that is also really difficult and it takes so much time for interpretation. So, simulation modeling and analysis, both are really time consuming and expensive based on the software. Sometimes you may have to buy software and then ask for training, learn the software and then you may have to do ok. Lot of software are available in construction some are free for research or academic institutions and many of them are primarily commercial software ok, that you have to understand.

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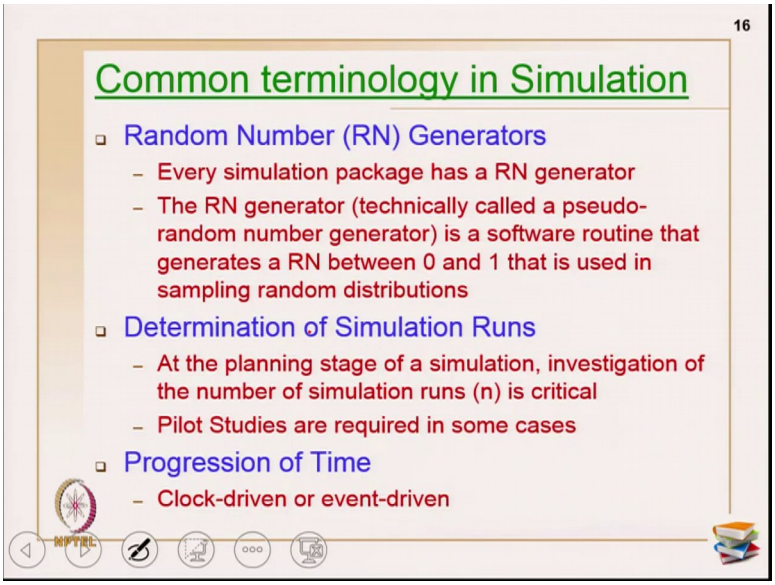

The common terminology, in simulation without which you have to understand that: number 1; random number generator. So, everywhere there is an uncertainty in a simulation then that is because of the input on random number generator ok. Every simulation package has a random number generator. In the last example on AB example

I gave values on duration as 12 8 and so on. There is no uncertainty there. Suppose if I am giving a PERT distribution or I am giving a uniform distribution or I am giving a beta distribution then; obviously, the random number generator starts playing a role there ok, and in the example last example on earth moving example I gave so much of uncertainties there.

The truck takes different time when its travelling on a peak time, non peak time it takes a different time, there may be a breakdown during its travel sometimes it happens. So, these are all randomness or uncertainty in the whole processes which is generated with the help of a random number generator ok. Every simulation package has this. The random number generator is primarily called a pseudo random number generator. It is a software routine that generates a RN between 0 and 1 that is used in sampling random distributions.

If you are very keen in doing this open excel sheet and type random and then you press it down ok, you well get a different value on the complete sets ok. You will you can do it later and check. The next thing which we were understand in simulation is determination of simulation runs ok. If you are really done the simulation only for one time then obviously, you are not going to evaluate all the parts. For example, in the AB example on probability as I said 20 percent of the time A takes repetition and 80 percent of the time A does not repeat.

If you want to really get an average of the entire runs, then you may have to do minimum 100 runs or maybe even 1000 runs in order to have a average which is close to the real number ok. If you do just 1 run or 2 run whatever is a randomness created, you will get a different value which may not be closed to the real execution ok. So, for example so that is primarily the number of simulation runs you want to carry out in the experiment and do an average of 50, 100 or 5000 runs and then you get the value on the duration for the project in this particular case ok.

Sometimes what happens is if the time the problem is really-really very big, then the time taken for 1 round itself may take maybe 2 hours or something. Suppose if I want to do 1000 runs or maybe even 100 rounds it is not practically possible ok. So, investigation itself has to be determine as to what should be the number of simulation runs and with the minimal run will I be able to get a result which I can interpret properly or not that

you have to really analyze ok. Sometimes even pilot studies are really done in some cases to really examine what is the number of simulation run one should ask use in the particular model ok. That is also some cases happens.

The next is progression of time ok. There are two clocks in most of the models. One is called the clock driven and the other one is even driven. Clock driven is like hours like 10 am 11 am 12 am and so on and the other one is event driven ok, which happens as with the case and a primarily it is like a duration takes 2 hours so, it shows first 1 hour it shows a first 0 and the 2 hours and then after 2 it jumps to 4 and so on ok, which is an event driven which happens ok. Most of the software are event driven rather than the clock driven which also you should keep in mind when you are running the models.

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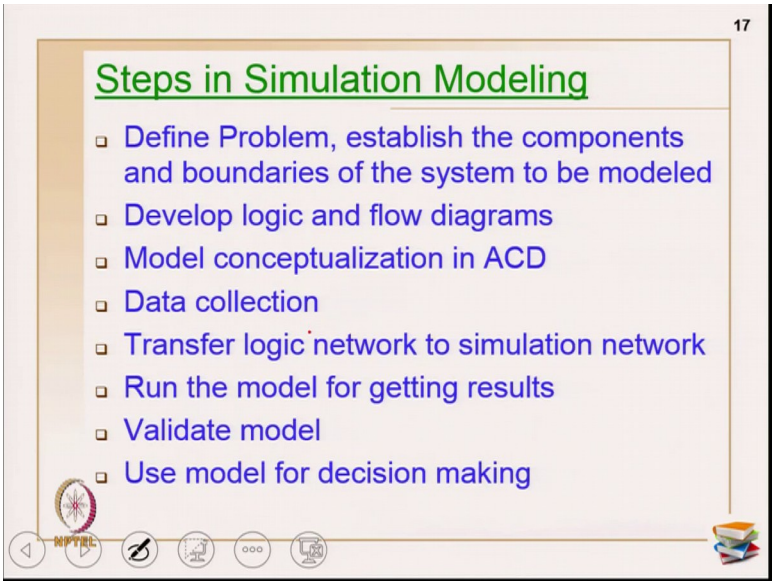

Now, a simple step by step approach when you are using a simulation model ok. Number one step; so, define the problem, establish the boundaries and the components of the system to be modeled ok. In the same last earth cutting example I am just defining the problem. The problem I wanted to know what is a cycle time it takes for excavating some large bank of sand ok. That is primarily the problem which I have defined. Suppose if you want to start from no finishing of the earth, then tamping, then finishing, clearing of the sands, if you want to expand the problem as to other components and all then you may have to properly choose your boundaries ok.

Then so, first define the problem earth cutting example. So, take only the problem and then finish up all your components. I have only four activities which I wanted to do. I am only keeping all those activities. I do not want to really see where are my trucks, when are they coming in, where are the workers, how are they coming in. So, you do not want to do other boundaries and all then you should trim your problem accordingly and choose only the problem what you wanted to model ok.

The next; develop the logic and flow diagrams. In the same earth cutting example I told do what is a logic diagram and logic diagram is primarily the pictorial representation of the model that you have to do and you may also have to show understand what is a flow process. The flow of the earth, the cycle moment of your trucks, cycle moment of your loaders, excavators everything you may have to understand in the logic and flow diagrams ok.

The next, conceptualize the model in ACD. ACD is nothing, but activity cycle diagram. This we will explain in the next slide. So, you have to now convert this logic diagram into an activity cycle diagram ok. The next step is data collection, data collection is how much time the loader takes, how much time, what is a capacity of the dump truck ok, how much time the dump truck takes to hauled, then where is the dump dumping area, how much time it takes, should there be a queue there for the dumping process, earlier dumping has not been done then you should wait or can you dump parallelly. So, all these data on the model all you have to collect it ok.

Then transfer the logic network into a simulation network. This is where your software parts comes into picture. Do you want to use software x y or z which plays a major role here. We have so, many software available in for construction simulation especially apart from genetic simulation softwares ok. Starting from your UM-Cyclone, Strobel strobe, easy strobe, we have a Symphony, we have ExtendSim, we have a analogic. So, like this so many software are out there. So, choose anyone which is comfortable for you and each one has different notations and they have different ways to the model, but common terminology all I will explained in this lecture itself ok.

Then transferred it there, run the model for getting the results, validate the model, see whether the model is giving a result properly and are you able to get the result of your of your investigation steps. If the model is giving a different result than what you are

expecting, then you have to redefine the boundary of your problem and then see whether you are getting. I am not talking about the expected result, I am talking about the performance of the results ok. That you may have to understand, then you use the model for decision making. This is a simple step which you may have to use in for simulation.

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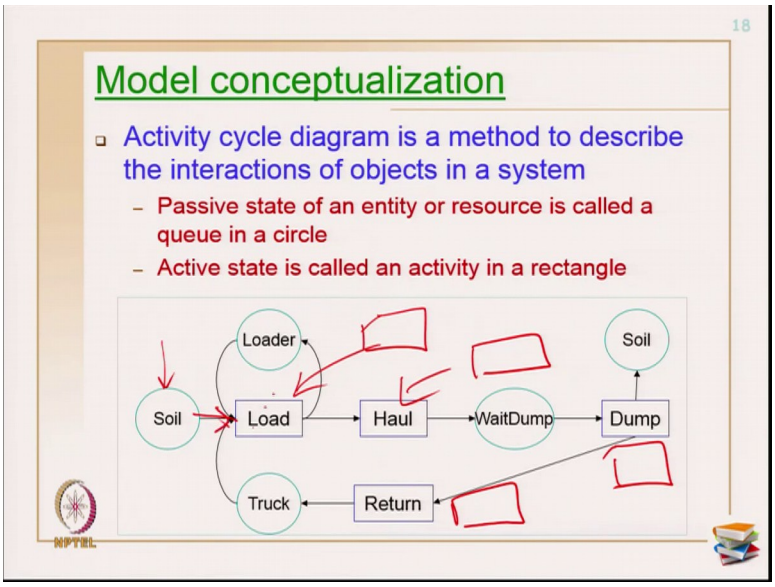

Now as I told you so, let us see what is this? This also I have shown you on ACD. This is primarily called ACD diagram ok. This you I would have explained to you while I was taking you on to earth cutting example in the first few classes. So, this is primarily I have two nodes here; one is a circular shape and the other one is circle or oval and the other one is a rectangle shape ok. So, ACD's primarily a method to describe the interactions of the objects in a system ok.

So, here primarily I need three resources; loader, soil and truck. So, accordingly I have given three different resources, then loading is my first activity to take place ok. For every loading activity I need three resources for me. So, which is primarily the passive state of an entity or you it is also called as a resource, that is primarily called the queues in the circles. So those are all represented in circle form.

The active state or the activities are primarily called active states and which is represented in a rectangle shape. So, I have only two different shapes to represent my ACD diagram. So, whenever you are defining your boundary of your problem, after defining the boundary, transfer it in ACD forms like this, then your model is very clear.

Then it is easy for you to transfer into any computer simulation software that you are very comfortable with ok.

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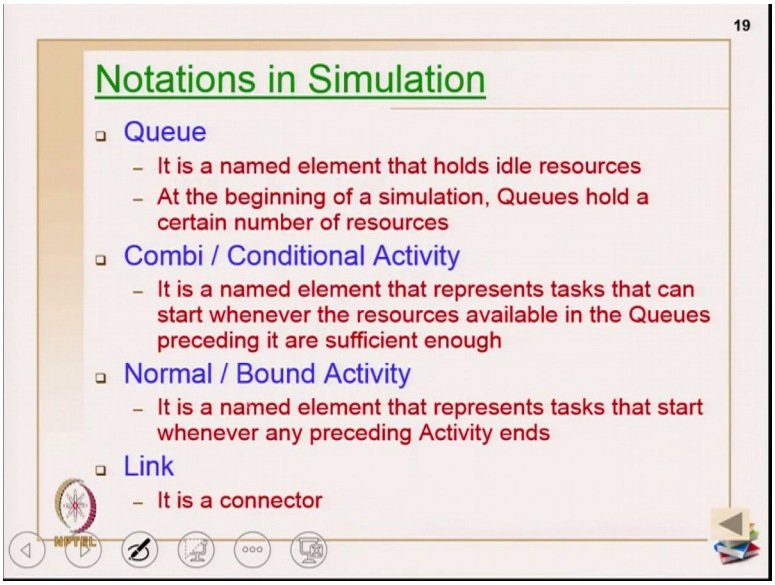

Next is notations and simulation. So, each different software uses different shapes and options for this, but I am just going to explain you the common symbols which is available in all of the software ok. Number 1 is queue. So, all these circles in the passive states are primarily represented in a queue form and these rectangles can be either a combi or a normal activity.

For example, this load I have to represent it as a combi activity, because I need resources to start the loading activity. Hauling can be a normal activities, I am going to use a general rectangle. This is also a combi activity, but this is a normal activity because there is no waiting required here and the other arrow marks are all called as the links ok. That is what I have shown here. So, queue it is a named element that holds idle resources. So, at the beginning of any simulation, queues can hold certain number of resources.

The next is combi or conditional activity. It is a named element that represents tasks that can start whenever the resources available in the queues preceding it are sufficient enough. Suppose if I need two resources in the predecessor queue, then only when the two comes in then only this activity will start otherwise it will not start.

The next is normal activity or it is also called bound activity. It is a named element that represents tasks that start whenever any preceding activity ends. So, as soon as any previous activities stops, it just follows a finish start relationship and then it starts executing the same. The next is link it is primarily a connector between all these queues normal and combi activities ok.

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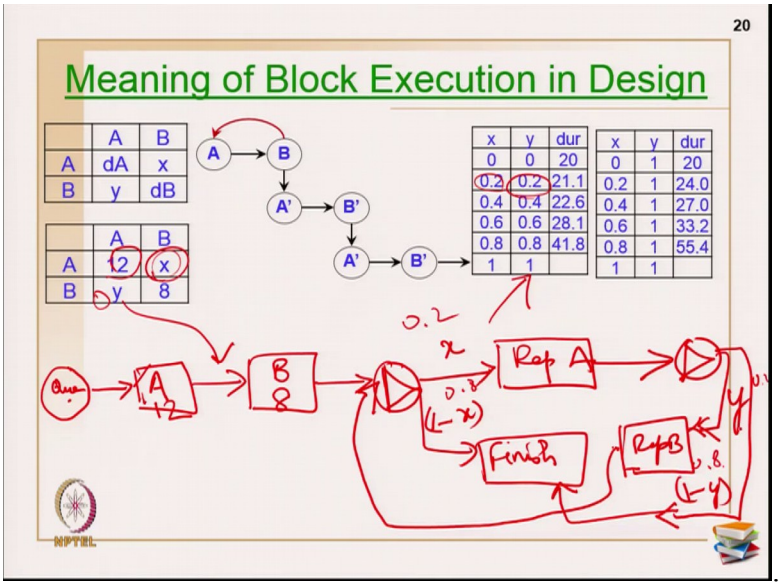

Now this example we have seen earlier ok. I told you how the durations are all varying, escalating with the varying in the combination on rework probabilities. Now, you know what is the simulation? Now if you want to represent this same activity and example on a simulation network, then how do you do ok. So, you know this is a DSM example. Boundary of the DSM is fixed. I have only two activities. Duration for the two activities are also there. Rework probability values are also given. Now, how do I represent this ok, it is very simple.

So, I am going to start with activity A. I am going to use my simulation network only here or I can also show with an ACD diagram. So, there is a queue and then I am going to start my activity A. So, this is a combi activity, queue is primarily the assumption here ok. I got the assumption as a result of executing B to A and then, I am going to start my activity A and once I am starting my activity A, I am not going to wait for anything. So, this is my activity B. Duration for A is 12 for B is 8 ok. It goes on.

Then I have to repeat so for that if you go back here what happens is, the durations and all you may have to give control statements for first second and so on ok. What I am going to do and when you are having 0's here as a Y value sometimes the B does not even execute ok. So, I do not want to take a risk now. So, I am going to take the repetitions very separately ok. So, you have to run the model and see how the model executes in order to execute the whole ok.

Now I am going to use a probability value here ok, which says whether my A repeats or not. So I have finished here. This Y is represented here, in the form of X mark and then now I am coming back to here primarily I am going to evaluate this ok. Now I am going to have two options here. So, this option will be the real X value ok, it can be 0, it can be 1, it can be 0.2 whatever it is. So, what does this say? So, according to this activity A repeats and now this probability link will be 1 minus X and here it goes to finish. So, which implies A will not repeat. When the A does not repeat, what happens? the model stops, model has to stop ok. So, I am going to take it to finish.

So, finish is a place where I am going to collect the duration. The maximum of duration that comes to finish activity, will be the duration of the particular run which I have done in the model, that is how the model works ok. Now, when the activity A is repeating then again I am going to introduce a probability here and this time what happens this probability is primarily Y. And, I am going to say it is primarily the repetition of B and again I have one more case which is 1 minus Y as to the B will not repeat sorry erase it ok, as to the B will not repeat ok.

Now what happens here is, whenever my activity A is repeating so, it just goes to B repeat ok. So now, I am having a two case. So, B can repeat, or B can go to finish ok. Now this cycle is not completed if I leave it like this. Now what I should do with this. Repeat B is there and this repeat B can also B I have to connect it with this probability. So, then the repetition goes on as per the X mark. So, that the model is tightly packed, and I have to do: duration for repetition A, duration for repetition B. I have to really see whether it is half of the earlier and so on. So, that I am having a decrease in duration based on the assumptions, sometimes my assumptions are too bad and I have to repeat it again. Leave the duration as it is and then you have to show the control statements ok.

So, I have also shown you for the same model how do I put my simulation networks representation so that I am showing the representation on a simulation network. Write the code or show it on a graphical GUI based, show control statements on repeat A, repeat B on the four clicks then you will get your model done ok. With this only we have got the data here like this for X whatever value I have shown. In this case let us assume if I have used 0.2 here, then this was 0.8 and the same case if this is 0.2 so, this was 0.2 as a link and this was 0.8 as a link ok. So, that is all on DSM dependency structure matrix. So, all the four phases we have explained in detail with an example ok.

So, next class we will see with another topic, bye.