Scheduling Techniques in Projects
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Lecture - 09
Dependency Structure Matrix-II

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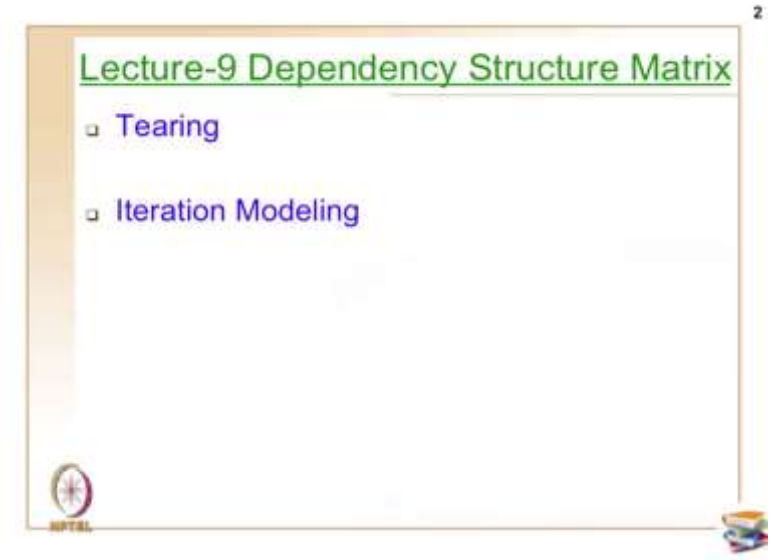

Title is Dependency Structure Matrix again and we are actually continuing with the last class. So, last class we have seen the two basic operations; predominantly the formation of a DSM and the partitioning process. In this class you will learn about tearing process and the iteration modeling which is a third and the fourth operation ok.

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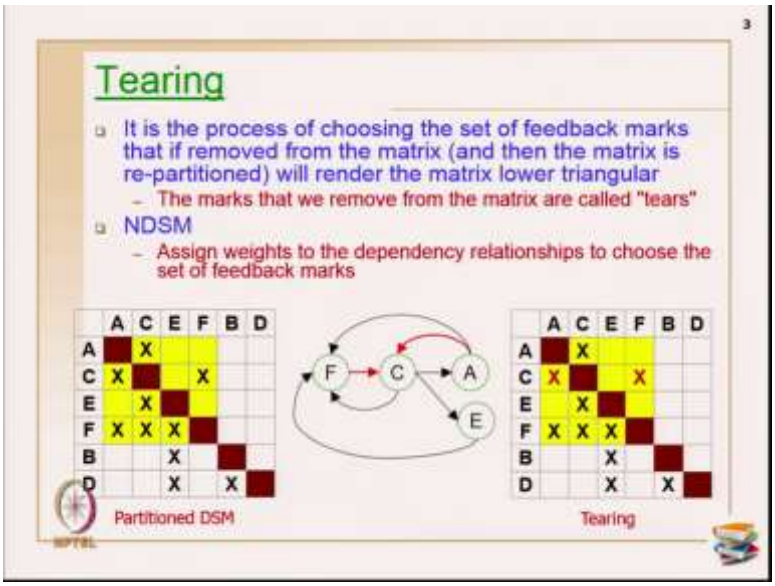

So, what is tearing process, so let us see. So, it is a process of choosing a set of feedback marks. So, primarily feedback is the name given to X marks which are above the diagonal and feed forward marks are the name given to X marks which are below the diagonal. So, in a way if I take this example so all these X's are primarily the feed forward and these two are primarily called as a feedback marks. So, you have to choose a set of few marks, if you start choosing all X marks then you may have to repeat everything every now and then.

So, you have make the number of tear marks as less as possible ok, as minimal as possible. So, it is a process of choosing the set of feedback marks that if removed from the matrix and then the matrix is re-partitioned which will make it as a lower triangular. So, the marks that we remove or generally are called tear marks. So, in this partitioning example I have this example in graphical form also and these are the feedback marks which I am choosing to remove and how do we do; one way is to analyze the network like how I will show in the next slide is to analyze and network and choose a set of marks. Even then it is better that we have NDSM.

NDSM is nothing, but Numerical Dependency Structure Matrix. While I was explaining you with the various representation on DSM. I little gave an introduction on numerical dependency structural matrix. So, this number can be any variable which can range from 0 to 1. The number replacing the X marks can be 0 to 1 and it can mean to anything

whatever you want to keep. It can be strength of dependency, it can be sensitivity on information, it can be information what does it called dependencies, or it can be even reverb probability, it can be anything that you wanted to keep between these two activities ok. So, primarily use them in order to choose the marks for tearing process based on the type of project.

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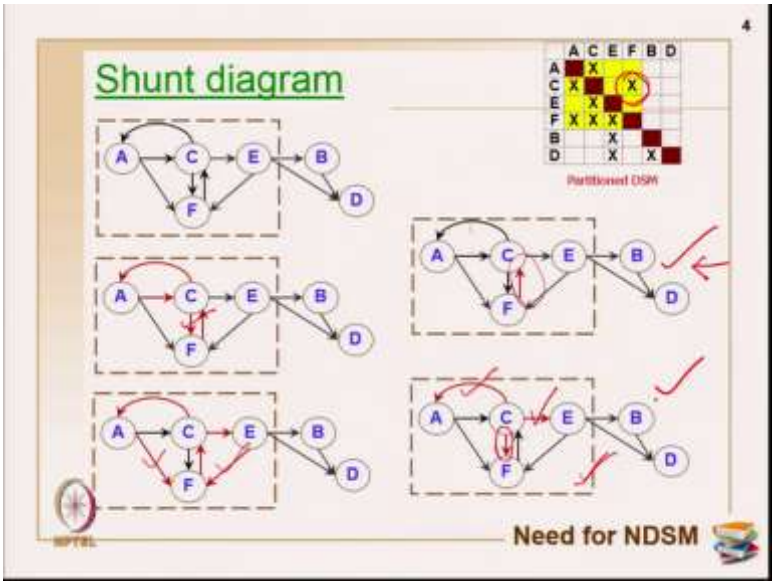

Now, let us see a little more on the analyzing the network. The age-old technique which people used for analyzing the network, primarily the cycles or loops is called as a Shunt diagram. So, let us see that little more and then we will go on into NDSM for choosing the set of feedback marks ok. So, I am having a partition DSM. The same example which I brought it up in the earlier classes, I am using the same example so that you can easily follow till the end and the same graphical representation I have arranged it here for this sequence like A C E F and B D.

So, this is my block representation and then I have to do my B and my activity D. So, that is what is the real case ok. If I analyze this properly what I can see, I can see two cycles of cycle length 2 ok. There are two number of cycles A C to C A and C F to F C. So, predominantly there are two different cycles and cycle length is primarily 2, which implies two activities are involved in the cycle of the loop. That is a meaning of the same. Now if I little more analyze the network carefully, I have two cycles of length 3 also.

So, CA to F to C so, this is the link. C to A to F to C this is one cycle and the other one is C to E to F to C this is another cycle. So, I have two different cycles again of cycle length 3. So, within a block of four activities how many cycles I have? I have four cycles; two cycles of length 2 and two cycles of cycle length 3. So, I have 4 cycles in total if you see carefully. So, what you should do a common thing is choose any set of feedback mark by attacking that feedback I am actually you know removing all of my cycles or many of my cycles.

So, if I choose this X mark which is from F to C ok, if I choose is X mark which is from F to C which is this so, what happens which is what I have shown here. So, what happens is I have removed my C to F cycle. So, I have broken down this cycle ok. So, I have also broken down this cycle which is a C E F cycle that is also has broken up and I have also broken down the A C F cycle also ok. Three cycles I have broken down so, all three cycles are gone.

If I have to choose one more tear mark in any of the two, then with to 2 tear marks I am actually I have broken down all my cycles. So, I will have a sequential or a parallel activities only right now to start with. Then repeat wherever you made assumptions to check and then based on that you will get the duration for the entire processes ok. Now if I have chosen another mark for example, I have chosen exactly a difference set of feedback mark, so this cycle is broken.

Now what about this loop is still remaining so, I have to choose one cycle for here and here also I have to choose one more, because there are two cycles here. One cycle of length 2 and one more cycle of length 3 is here. Again, if I have to choose this, I have to choose one more so, I have I have chosen this as a common cycle ok. So, minimal tools 2 tear marks you have to do or it can be 3 or even more ok that is what you have to do.

Now which is the best option is it this or this how will you tell? With number of assumptions made; obviously, this stands out to be the best, but you do not know that without checking out what is the duration of all these activities, what is the relationship between those activities ok. Is it a really sensitive project or is it like very uncertain a project every time changes are happening and so on.

Then there is no harm in redoing something and then as information starts flowing in you can still repeat and go ahead. Then this situation may be better if your durations are all

smaller and so on. So, you do not know that without analyzing your NDSM. So, the need for NDSM is really essentially in order to choose a set of feedback marks for breaking up the cycle and a place to start for your partitioning activities ok.

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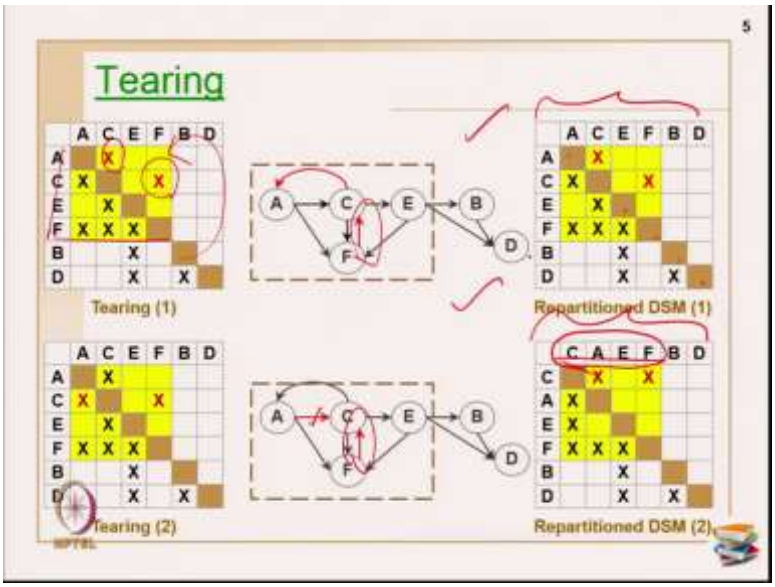

Now, what happens as I told you earlier, every time you choose a set of feedback mark so, I have chosen the common one as from the earlier case I have chosen the common so, which actually breaks down three of my cycles. So, among these two's I have chosen two options. So, one option also I will show you, the other option also I will show you and you have to again do the re-partitioning process. In this case the block remains as same the sequence for the block is still ACEF and then BD.

Suppose if I change the set of feedback mark and I have chosen this, but this is still the same, because three cycles are already gone. So, I am going to choose this as my set of feedback marks, then in that case what happens is, meanwhile re-partitioning the DSM, the sequence within the block is changing now to CAEF ok. So, this is what you have to do with the help of re-partitioning.

Now I am just wrapping up from the start till the end in formation of the DSM. In formation of DSM again you had two steps; WBS in order to get the list of entities for example, list of activities and you used multiplication of two DMM's in order to get an activity DSM just to get the X marks. Still you have to verify with the experts and go ahead and getting up refined your processes and then you are going into partitioning. In

partitioning it identifies all your sequential an independent activities which implies a dependent and independent activities and all your blocks are all identified ok.

Now within the block, the sequence of the block you will not know in a partitioning step. So, you have to do tearing. Tearing is nothing but identify in a sequence within the blocks by choosing the set of feedback marks. So, I have chosen few places for tearing, primarily for making assumptions. So, I have made an assumption here, I have made an assumption here and then this is my flow. Once this is fully done then I have to repeat the steps again and again in order to finish up for the assumptions made in order to compensate for the assumptions made ok. So, then you are actually getting out the sequence within the blog.

So, as a result what has happened you are a from the partitioning and tearing process, you actually got the sequence of the entire project execution ok. You got the data formation, partitioning, you got the overall stretch or a sequence of the whole project along with block identification. Tearing you are actually finding out the sequence within the block, you have done tearing process. Now the next question that comes is: is this a better sequence or is that any other sequence which is really really good ok.

To answer that question then you have to really do iteration modeling, which is implies identifying the duration of this particular blog. So, go through this, plot your durations along the diagonals ok. Add values along this primarily the rework probability, what is the percentage of rework or what is the probability for any change in activity A whether it affects activity C or something that you may have to redo it. And, then see what is the duration for this entire project or what is the duration if I go through this particular sequence of a project execution.

You have to really check that cross check and then you choose the tear marks and then go ahead ok. If you are not happy in doing iteration you can still go ahead with values here and then doing it. Suppose if you want to really evaluate whether it takes 16 days, this takes 20 days or this and other sequence take 18 days. So, what is it how much of rework is happening in the activities, individual activities and so on then you should really do the iteration modeling.

So, this dependency structure matrix. It is a little tricky concept and complex concept. So, I thought I will introduce you with one more set of examples, so that you can understand this better.

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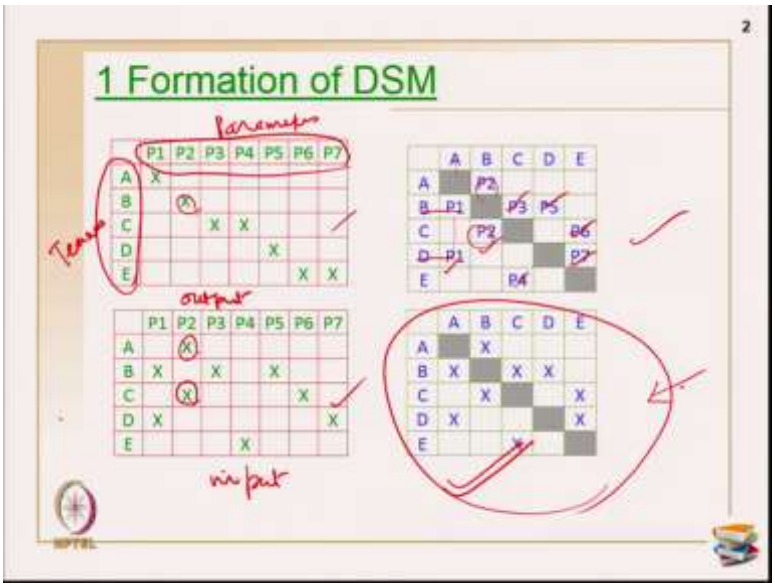

So, this is a hypothetical example. So, this first table is primarily a DMM on output parameters ok. So, A, B, C, D, E maybe this can be teams or components. This can be parameters or deliverable. So, whatever you want you can keep ok. And this table is primarily on input items which implies. Let us assume if these are my teams or deliverables. And these are my parameters. Then this is and DMM on teams and parameters on output parameters. This is on teams and my input parameters. So, now, how do you read this? So, primarily team A gives one parameter P1 team B is responsible for releasing one parameter P2. Team C for releasing two parameters P3 and P4 like that you may have to read.

Same way for the input I need P2 for completing my 5 team activities, I need P1 and P3 for completing my team activity B and P5 also. I need P2 and P6 for completing my team C. I need P1 and P7 for completing my team D and so on. So, this is how you read on the input parameters ok. Now, let us see how this is merged as a team DSM.

So, first you give A, B, C, D, E; A, B, C, D, E. So, this is primarily the list of teams I have ok. So, A releases P1 which is required by B and D; so, A releases P1 which is required by B which is required by D. Now, B releases P 2 which is required by A and C

ok. So, here if you see this is how it is. So, B releases P2 which is required by A and C like this you may have to do P3, P4, P6 and P7 ok.

Once you cross check whether there are any omissions in the list of teams or parameters and so on. Then once you have very fully comfortable with the flow. The flow you can easily look at like this and then read giving and gives information to. Once this is completely settled and satisfied, then you can go to merging it as a conventional activity DSM by replacing all the variables that you have given here into X marks.

This is how the team DSM is formed. Suppose if you are very comfortable in the list of activities relationships and you think you have done several projects earlier and you are very experienced and comfortable. Then you can go in doing this directly in the first go itself ok. Again I am repeating you can ignore. You can ignore the 1, 2 and 3.

You can ignore these 1, 2 and 3 steps and you can directly doing this formation of DSM on one go itself. Suppose if you are very comfortable in understanding on the whole project ok. This is primarily on formation of DSM. So, the basic operations in DSM, number 1 is formation, number 2 is partitioning.

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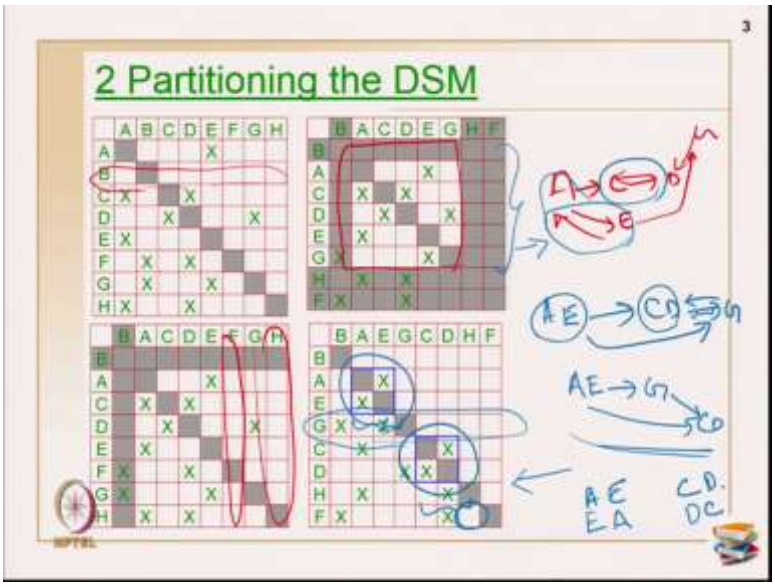

So, we will see the partitioning in the second step. And this is a generic example I have taken. So, I have done the formation using any of the method I am comfortable as discussed in the earlier slide. So, this is my original DSM. Now, I have to know what a

sequence of executing this particular example is. That is the main concept in partitioning. Again I am just making you recollect: partitioning is resequencing the rows and columns in such a way that, you can identify the independent and dependent activities and also the block formations that is the main objective of partitioning DSM ok. Now, if you see here to do this primarily you have to identify the independent and the dependent steps in the first go. So, how do you do? You have to literally see whether there are any empty rows and columns. First I am going to look for empty rows ok, where are the empty rows.

For example, activity D has a completely empty row here ok. So, what you have to do is, empty rows implies they are the starting activities. So, move the activity B on to the first column and to the first row and ignore the activity B from further considerations ok. Keep it as highlighted and ignore this completely ok. So, I have ignored that and I have pushed B completely.

Now check whether any more activity has an empty row apart from activity B ok. If you look here there is no other row which has an empty cell throughout, empty complete row ok. So now, the independent activity on the starting phase we have identify it is only one activity which is activity B. Now what you have to do is look for empty columns again. If you see for the empty columns, I have activity F. And I have activity H. Both are empty cells there are no X marks in both the activities.

So, what I have to do is, I am going to push H and F to the last. Any order you can keep because they both are parallel activities. So, I am going to keep H and then F and I have prevented them from any more evaluations ok. So, now, is there any other empty column again there are no empty columns no empty rows. So, primarily what I have identified is B is the start activity H and F are the finish activities that much I have identified.

And I know there is a loop along with the interior part ok. Now, how to identify the loops here. There are so, many methods for doing it and I will show you one method. Primarily the block is very simple. So, I am going to show manually, otherwise you can also use power of adjacency matrix on excel sheets and you can still get the result ok. Now I am going to show manually only.

So, primarily A to C and then A to E then C to D ok, then D to C ok, then E to A and then G to D ok, so G to D ok. So, I have identified all the activities E to G, E to G and then G to D ok. Again I am checking. So, A to C is done, A to E is also done C to D is

done then D to C is also done E to A is done ok, then E to G is also done and G to D is also done G to D is also done.

So, I have identify everything. Now if you see here I can see that there are two loops here. There is a loop of cycle length 2. C to D and A to E ok. So, what I am going to do is A and then so, primarily A to E so ok. So, this is sorry ok. So, I have two loops. So, AE is one loop and then CD is one loop and then I have activity G and A E G afterwards I have activity G.

So, primarily I have a block of cycle length 2 and then I have one more activity also ok. So, this arrow mark is actually from G to D only. So, this is primarily the merging of the blocks which we do ok. So, AE is one block, then I have C D is another block and G is an activity giving inputs to CD and after AE I have my G.

So, how do I represent and the normal sequence? So, AE to G, AE to CD and then after G, I have CD. So, easily you will find the sequence when you are evaluating in a graphical format on the inner side ok. So, accordingly what happens is. So, I have my block here. So, activity B is a first activity H and F for the last two activities. A E is one particular block as I have highlighted.

And CD is one particular block as I have highlighted. And G is primarily the activity in the middle which is giving inputs to CD, which is receiving inputs from AE and it is giving inputs to CD ok. So, with this I have identified how to execute after B, AE has to be done together. Then activity G, then CD has to be done together then H and F can be done in parallel; because I do not have any X marks in the between H and F.

So this is all about partitioning method. So, what you have to do is, first identify the top starting activities all empty columns will identify that. Once you merge one activity see whether any more empty rows are there. Start keeping on moving the process. The same way do empty columns which will identify all the last activities keep on identifying the last but before activities and finish the process.

So, in between you have some loops and you have something with the present in the loops. There maybe one or two blocks or there may be independent activities. And dependent activities coming with that also you have to identify that. There are so many

methods of doing it. Power of adjacency matrix also you can use. Or you can use primarily the path searching.

I have done path searching method what I have done is, graphical view of this complete active matrice I have taken and I have shown it up here. And then I merged all the activities which has the cycle length of 2. And then I have done topological sorting again in order to understand the sequence. And then I have replaced it in my partitioning DSM and I have shown, what is the sequence for the whole project ok. Now this is step number 2 on DSM operations number 2 ok.

Now, once we have identified or done with the partitioning process, you should know what is a sequence within the block ok. Should I do A first and then E or should I do E first and then A or should I do C first and then D or should I do D first and then C for which you may have to do tearing process.

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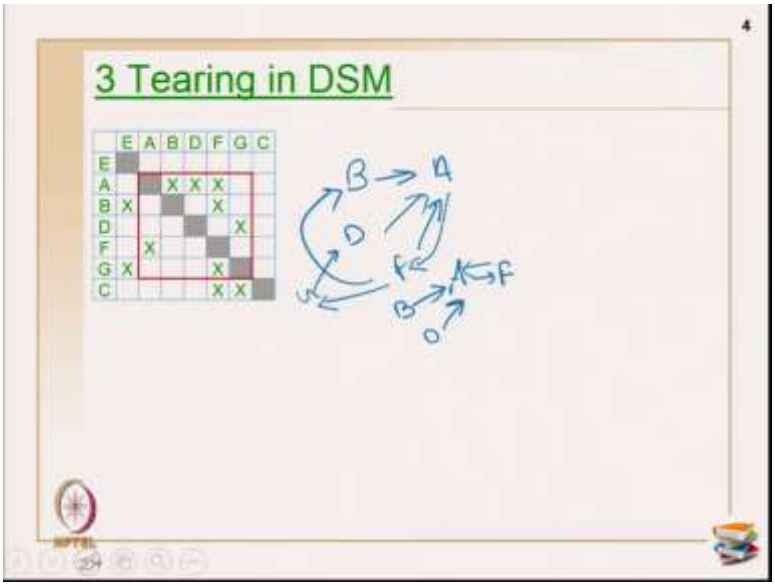

So, the next operation in DSM is primarily called tearing process. Again I have taken a DSM I have also shown as a different example. You can use all these examples for practice also. This is one example wherein I have one start activity E and one activity in the end as activity C and in between I have a complete block. That is one block which I have ok.

Now, if I start evaluating this. So, what will happen is, B gives information to A ok, then D gives information to A; then F also gives information to A ok. And then F gives information to B ok, then A gives information to F then G gives information to D and then F gives information to G ok. So, I have identified all the relationships A to F. So, this is little clumsy. So, I am going to put it in another format A to F, then B to A ok, then next is D to A ok, then F to A ok, then F to B, F to B.

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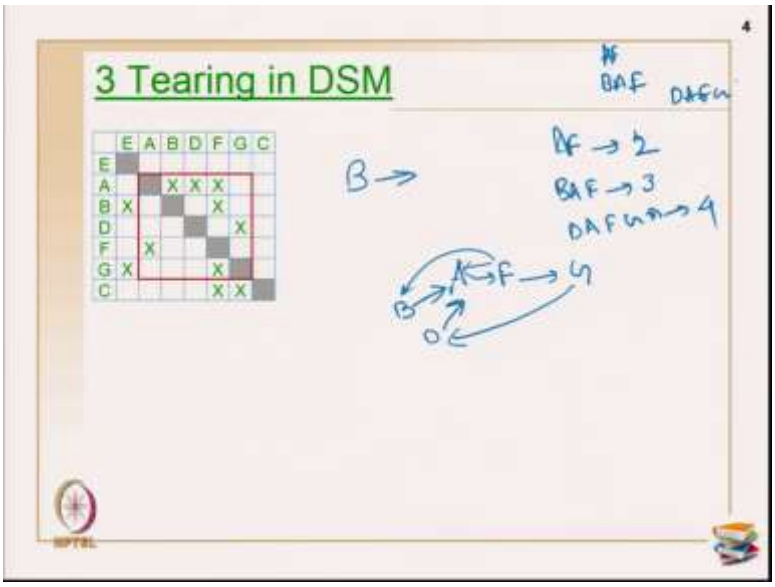

Then next is F to G then G to D ok. So, this is primarily the graphical representation of the block inside ok. If you see here what are all the loops I have. I have AF which is one loop of cycle length 2. Then I have BAF is another loop which is of cycle length 3; B to A, A to F and F to B this is a length of cycle length 3. A to F, F to A is a cycle of length two. Then I have one more cycle which is DAFGD ok. So, this is primarily a cycle of length 4.

So, I have three cycles of different size within the same block ok. So, now, what are the options I have? So, I have. So, many options now, I am going to put this here. So, that is easy for us to evaluate A F, B A F and then D A F G let me erase all these ok.

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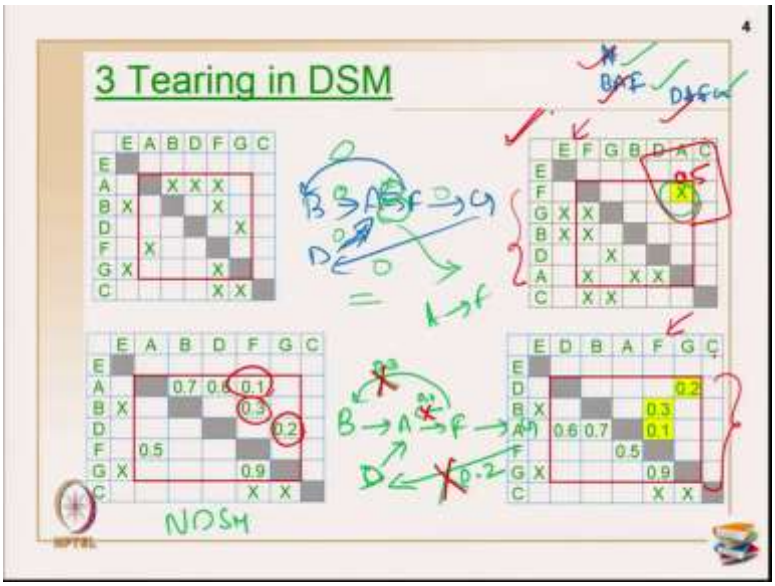

So, now what I have done is, I wanted to tear off the marks. So, what I have done. The one mark which I wanted to tear is A to F ok, then B to A, D to A, D to A then F to A then F to B then F to G and then G to D ok. So, now what I have done is I am going to tear off this mark which is A to F. So, let me use another color. So, A to F so, this one sorry this one is what I am going to tear ok.

So, now, if I have used A to F as my tear marks then my resulting sequence for execution will be F and then G then B D and A. So, this is one way of evaluation because when I have opened up the whole graphical representation, I saw this one relationship A to F is actually you know causing three loops to be existing there.

If I break this one loop from A to F automatically all the three loops are getting are getting erased away ok. So, I have chosen one with the help of my graphical evaluations. There are other methods also available for the same. Let us assume I am going to use strength of dependency. The weightage of the dependency between all these activities I have taken up. I got values from my experts and I have dumped in all my values on a scale of 0 to 1, which implies 0 means no dependency. 0.1 means is very weak dependency which can be ignored, 0.2 a very weak dependency which may be marginally ignored ok. 0.5 is like moderate dependency 0.9 or 1 is like a very strong dependency. And if you start breaking it; obviously, you are going to have so many

repetitions going on. Now, blindly I am going to go with the NDSM this is primarily call NDSM which is nothing but numerical design structure matrix ok.

Primarily I have got all the values within my blocked, because in tearing you are going to find the sequence within a particular block. So, I have got all the values within my block ok. And what I have done is, I know these are all the loops which I have. So, I am going to break the weak links ok, what I have done is I have dumped in the values of all these relationships over there.

And I am going to break the weakest link ok; let me write down again ok. So now, this F to A ok. So, this is primarily my F to A this is 0.1 and G to D, G to D this is primarily my 0.2; then F to B this is primarily my 0.3 ok. I have given only the weak dependencies ok, let us try and see whether we can break the weak dependencies.

I am going to break this relationship, this relationship and this relationship ok, 1 this is number 2 and this is number 3; because they are going to be my very weak dependencies here ok. So, when I have thought of breaking all these relationships; obviously, I have broken down all the three cycles in my loops ok.

So, this cycle, this cycle, and the third cycle. All the three cycles are broken down. So, now, my resulting matrix will have a different sequential together. But I have to make three assumptions. Now what is the variation between option number 1 and option number 2? In option number 2, let us see here A to F. So, this is primarily a dependency of value 0.5 and these are all very weak dependencies 0.1, 0.3, 0.2.

But I am going to make three assumptions and I am going to break all my weak dependencies. Or I am breaking one medium dependency and I am going to use this as my sequence or breaking three dependencies and they are going to use this as my sequence. So, now, which is the better sequence among the two? That you will not be able to see just with the tearing process because, you have to evaluate with the help of an impact.

The measure of performance for us is primarily on time scale. Primarily you have to see what is the duration for this sequence and what is the duration for this sequence; based on the repetition that you have got all these values. How much time the activity is going

to repeat what is the duration and the reach repetition? And how are you going to see the whole project that you may have to consider now.

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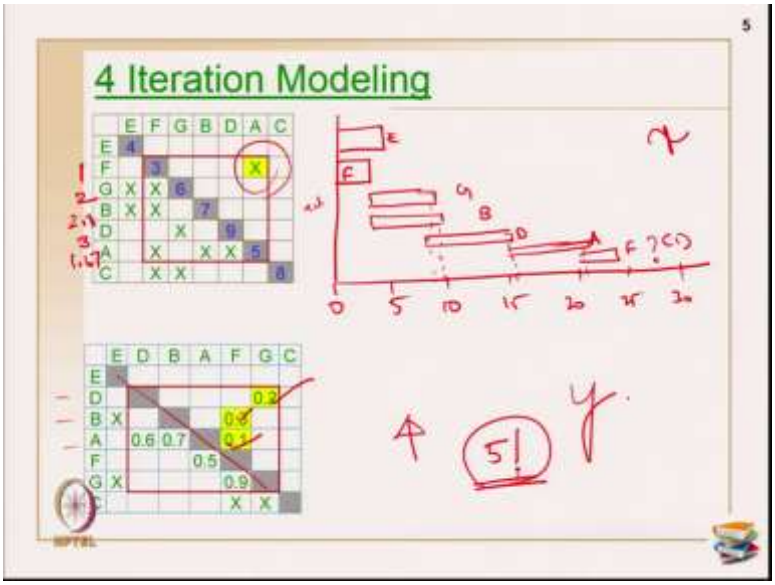

For that we have to do the iteration modeling which is the last step ok. If I am going to now take the same example which I have shown here, I have broken down a moderate dependency. The same example I have taken up here and I am going to evaluate this. So, now, what we will you do? So, I have also dumped in the duration along the diagonals, diagonals always carry duration and they do not have any other value.

E's duration is 4; F duration is 3, G is duration as 6, B is 7, D is 9, A is 5 and C is 8 ok. Now, if I going to plot this on a bar chart. So, I am going to use a bar chart now ok, 0, 5 this is 10 this is 15 this is 20 this is 25 this is 30 and these are my list of activities. If I keep it in that order, now this is the sequence that you have already identify. So, activity E is taking a duration of 4.

So, this is E and F is actually a parallel activity to E; because I do not have a relationship with E. So, I can start F even before here. So, this takes a duration of 3. So, after F, I have to do my G and activity B and both are actually dependent on F only and they are both parallel activities. So, I am going to do my activity G and my activity B ok.

So, primarily 3 plus 6 is 9. So, 3 plus 6 is somewhere 9 and the 3 plus 7 is somewhere close to 10. Now so, these two a parallel activities ok. The next activity B and D are

again parallel for example, activity B is dependent on. So, after activity B, I have to do my activity D. So, now, activity D, I am getting inputs for activity D only from G. So, after G, I can start my activity D and it takes 9 days of duration ok. So, 9 plus 7 is somewhere around 16. So, this is primarily my activity D which is stopping at 16 ok. Now what about activity A? Activity A needs input till D. So, I have to start after activity D and this is 16 plus 5 will be somewhere close to 21 ok.

So, now activity C can start anywhere before that. It is primarily supposed to start after G after activity F and G are done I can start my activity C; but what about the iterations in the sense what about the result of this assumption that you have made. So, once you have done with all these activities. So, primarily after activity A is also done, then you may have to repeat activity F ok; now without knowing the duration of activity F you cannot do.

Now, let us make some rough assumptions. Every time the repetition is happening, one third of earlier duration is taken for all those activities. So, what will happen here. F will be done for 1 day in the repetition cycle. This will be done for 1 day this will be done for 2 days this will be done for 2.3 something this will be done for 3 days. This will be done for 1.67 days like that it starts repeating ok.

And maybe if you want to stop the repetitions in the next round and so on, then primarily that will be after one round of F G B D A F D till A. And then activity C you will get the duration of the complete project. So, that is primarily how you evaluate. May be you will get a duration as something as X. Now for this sequence we got an alternate sequence by doing three assumptions here. There are three assumptions here.

Now, again you may have to evaluate this maybe similar kind of assumptions as to duration of the activities are actually half of the earlier duration put it in that way. And then repeat the activities may be one round or something as planned you earlier. So, take up the duration maybe you are getting a duration as y ok.

So, primarily what happens is. You can do this combination for if you are doing literally the iteration modeling, you can also skip the tearing process. And you can do this iteration modeling immediately after your partitioned DSM is done that is also an option of doing it ok. You can evaluate all your how many activities are there? 5 activities are there.

So, 5 factorial combinations you will get ok. So, all this five factorial combinations with the different sequences you can evaluate. And you will still get the minimum duration as your preferred sequence ok. That is also one way of doing up your scheduling on information modeling.

So, now, let me recap again whatever I have told you. There are 4 operations in DSM formation of DSM, partitioning process, tearing process, an iteration modeling ok. So, formation of DSM primarily there are methods for beginners, there are methods for people who have come with experience and they can easily form just like an expert can easily put up the network on CPM or PDM.

Same if we have very comfortable you can directly draw the DSM first go itself. Or I have shown you method; use entity hierarchy either as teams, components, deliverables parameters and so on. The entity hierarchy you can still use break down the whole list of your project and then stop at wherever you want. Suppose if you are at conceptual stage you can stop at teams component. Suppose if you have a detailed (Refer Time: 35:15) stopped activities parameters are deliverables and parameters. You can stop according to a comfort level and you can still form whatever type of DSM you want ok.

The next step is partitioning, partitioning is primarily because the earlier DSM that you have done. You do not know, what is a preferred sequence of execution; we have dumbed in all the data here and there.

In order to know what is a real sequence of execution, we have to reach sequence of rows and columns. So, first step in there is primarily identifying all the sequential activities: independent and dependent activities. And more them to the either of the corners then you will have a large mass of activities which have some loops ok. There can be single loop, there can be multiple loops. There can be multiple loops which are over lapping with each other and forming a bigger looped. Any combination is there, so for that simplest way to do is, evaluate them graphically like how I shown you here which we call it as a path searching method. And start identifying the loops do the sequencing here itself and dumb the result on to the matrix.

If you are working on excel sheets and you have a computer with you, then you can use matrix multiplication. So, raise it to the powers of n and whenever you are landing up in excel sheets which have rows, which are having values in the rows in the diagonal cells.

Then chose them as cycles or loops and merge them accordingly and you can proceed as per the practice.

So, path searching or power of adjacency matrix, any method will help you to identify the loops ok. Now, you know where are all the blocks and the cycles and you know you will also know what is a real sequence of execution. The next step is, what is a sequence of executing within a block for that you may have to do tearing process. And then you we primarily selected tear mark again you can evaluate graphically or you can use a numerical assessments also. Giving weightages to the relationships and you can still go ahead and evaluating ok.

But, still you do not know what is the impact of your assumptions made. For that, you can do iteration modeling. One thing is whatever options you wanted to try, only for that alone you can evaluate. Or if you want skip the tearing process from partitioning process directly jump to the iteration modeling step.

And still you can evaluate all the options available and still you can choose the preferred sequence of execution. So, both the methods are really available. And as if I have told you, what are the functions and the what is the characteristic feature of each of the steps in the DSM process.

So, accordingly you can choose one or two operations conveniently. And you can still get the scheduling of your whole project ok. So, this example will help you to understand I guess. And many problems are given for practice and assignments still, we will come back on doubts and we will clarify it later.

Thank you.