**Scheduling Techniques in Projects**
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**Lecture – 11**
**Beeline Diagramming Method**

Topic of today's lecture is, Beeline Diagramming Method. So, what is Beeline Diagramming Method? This is a very simple lecture compared to any other any other topic we have seen so far. Now what is this topic primarily about? So, let us introduce little on the background side first.

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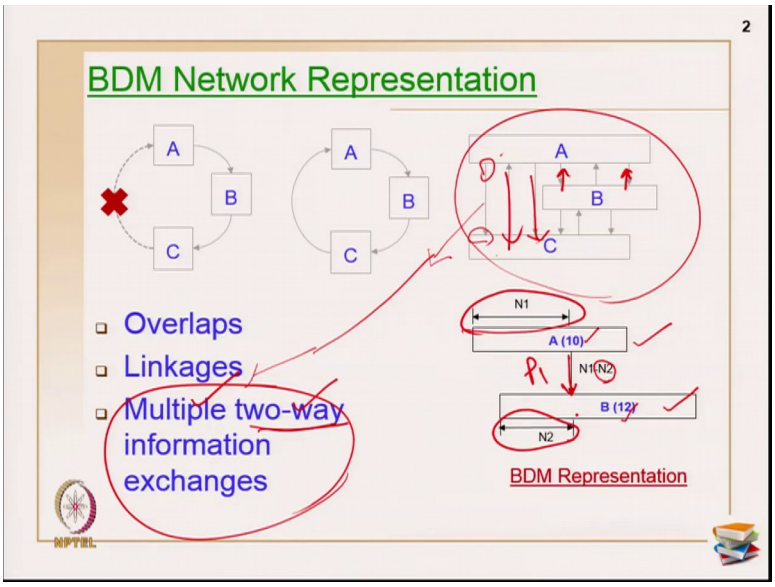


So far in information management, we have seen DSM.

DSM I have shown you as to, how to represent information; but primarily it was like only one relationship between any two activities or any two deliverables and so on. You would have seen only one relationship. And DSM can also be very powerfully used for representing construction phase also, for representing the workflows in construction projects as well you can still use that also, I have shown you how to do and so on ok.

Now, what is this BDM representation? As I given the hint right now. So, when you are having multiple information flows between any two teams or any two components and so on; then you should look at a technique like BDM, for representing and for analysis. So,

what happened? So, have we not dealt all these earlier, have we not come across multiple information sharing earlier and so on, yes we did so.

Suppose for example, if you want to see the history with which we have come across, this I have also shown when we were discussing on DSM, the introduction to DSM. Earlier we were very comfortable in making assumptions, all the assumptions varying the schedulers mind only; and the activities were represented and the people were very happy to go with sequential and parallel relationships alone. Then came in techniques like simulation, DSM, and so on, wherein people could easily define the sequence, do schedule analysis with multiple options, constraints and etc. So, the cyclic representations in a way, we call it a cycles or interdependencies they were we could easily represent, this happened maybe since 2000 and so on.

So, BDM is a very recent concept, which has come only in 2012, 13 and so on. So, the person who developed this BDM was Kim. So, BDM the abbreviation is Beeline Diagramming Method and these lines are primarily called as Bee lines.

So, if you are having a problem which you have to represent like this in multiple information relationships; then you have to really go for BDM only ok. Now what are these? There are other terminologies also for representing this concept; one is called overlaps you can see here A B C are primarily overlapping with each other. So in a way we can call it as an overlap, but the real overlap as you see in BDM that is not the case. So, this is like, I would not say an advanced overlap, but it is too much of information relationships and typically you are doing an overlap.

And in the last class, in the previous 1 or 2 classes earlier I have introduced what is called linkages. Linkages are nothing but links. They primarily need not follow the conventional Finish-Start relationship. So, these are all called linkages, I can start anywhere from my predecessor and I can stop anywhere at my successor.

So, for this particular linkage so A is predecessor and C is a successor; and like I can start anywhere in the flow and I can stop anywhere. So, it is not following in the conventional Finish-Start, nor it is following like PDM representations wherein you are able to show Start-Start, Finish-Finish, Start-Finish and so on.

So, you can actually directly connects the predecessor and successor under relevant points. So, links are primarily the shortest travel distance or shortest distance between any two activities or any two deliverables or any two teams and so on. So, they are primarily called linkages. So, this Beelines are the linkages ok, they are also called Beelines and they are also called linkages.

If you want to give a proper definition for the linkages, then this is a proper definition we have come across. So, one is multiple you can represent so many relationships or information exchanges among any two activities. Then it also is a two-way, it is not like I am only having all relationships only in one direction; I could actually represent all the relationships between any two activities.

I am not having only one side of communication flows; I am actually having two-way communication flows. A can also give information to B, B can also give information to A. So, it is multiple, it is also two-way information exchanges. So, that's where we are actually in BDM ok. This technique as I told is a very recent origin and we have developed and we found that it is a very useful technique for representing an information flows in design phase.

And what is a BDM representation right now, having known that I can represent multiple information flows and so on and it is a technique for scheduling in design phase; then primarily you should know how are you representing the time phase of all the relationships, because information is driving your schedules here.

So, let us assume I have two activities; activity A, activity B and the duration for A is given as 10, duration for B is given as 12. So, I have these two activities and there are three ways of representation as given by Kim; but we are only going to show only one representation which is the N1-N2 ok.

N1 is primarily the time it takes to show my time from the predecessor what time the information can be released. And N2 actually represents the time at which the information is received by the successor; that is how the information is represented as a linkage.

So, N1, N2 is a linkage and it shows the time at which. So, N1 from the start of A activity what is the time it takes to release that linkage maybe I can call this linkage as

P1 ok, this gets a parameter. So, this is the time it takes for the parameter P1 to be released from A N1 and the same parameter P1 is required by B at the time called N2 ok.

That's how the BDM representation goes.

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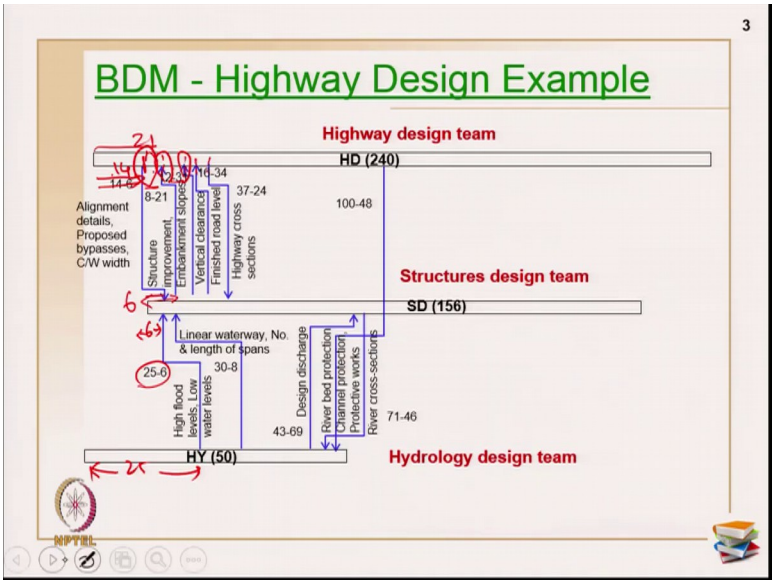


Now, how can I get information directly from the site for this? For the first project; obviously, it is very difficult for you to get an appropriate information. I would still say you will get information on different parameters or different deliverables and so on you can still get it.

But if you want to really work, maybe on abstract level like components or teams, then you can still draw a BDM ok. I may have so many teams, I may have different deliverables coming in out of those teams; still I can form a BDM and I can still go ahead with that. So, this example is primarily teams and parameters, I have shown you teams and parameters. If you want to get information like this and work out with the parameter level on the teams or components; then you should have done at least 1 or 2 projects earlier ok, then only with that domain expertise that you have, you will be able to say what time what parameters can be released and so on.

Because N1, N2 you would not be able to define unless you have done 1 or 2 projects here earlier. Especially when you are working in the lowest level of your WBS; abstract levels of WBS yes, you can still do it for the first projects.

So, I am taking a highway design case ok; there are three teams here. This is a truncated example it is not a complete example only to showcase the relationships that travels across the three teams. Three teams are there. Duration for the three teams; this is taken from the time the three teams were on the whole project; 240 days highway design team was in the whole project, 156 day structures design team has spent the time in the whole project, hydrology design team has spent almost like 50 days in the whole project.

Now, so first link 14-6, so this implies, this is my predecessor, so this time is primarily 14 and the time with which it is reaching the structures design team is 6. So, what is the information that is traveled: alignment details, proposed by-passes and the cross section width, ok; so these are the information which has reached the structures design team ok.

Now let us stay see, from hydrology to structures design team at the time 25-6. So, this is primarily 25 and this is my 6. At the same time, structures design team is actually receiving two inputs; one from highway design team and one from hydrology design team. From the hydrology design team, high flood levels, low water levels and so on are received from here ok. Now let us see, what other information are travelled. Once this information is received by the structures team, the structures team starts working on their design calculations and it can actually send structure improvement, embankment slopes details to highway design team. So, time frame is 8 and this is now 21.

Now that is how you have to understand that, at the same time high hydrology design team is releasing information; linear waterway and number and length of the spans to structures design team. Then after some time structures design team is releasing vertical clearance to the highway design team ok, then finished road level at 16-34. Then from the highway design team, after getting all the inputs it releases highway cross sections to structures design team. Then design discharge is released from hydrology design team to structures design team. So, like this the flow continues and all other information between these teams are really exchanged. I have not shown the complete list, this is only to show what is a detail ok.

In this case all these parameters which were exchanged between the three teams.

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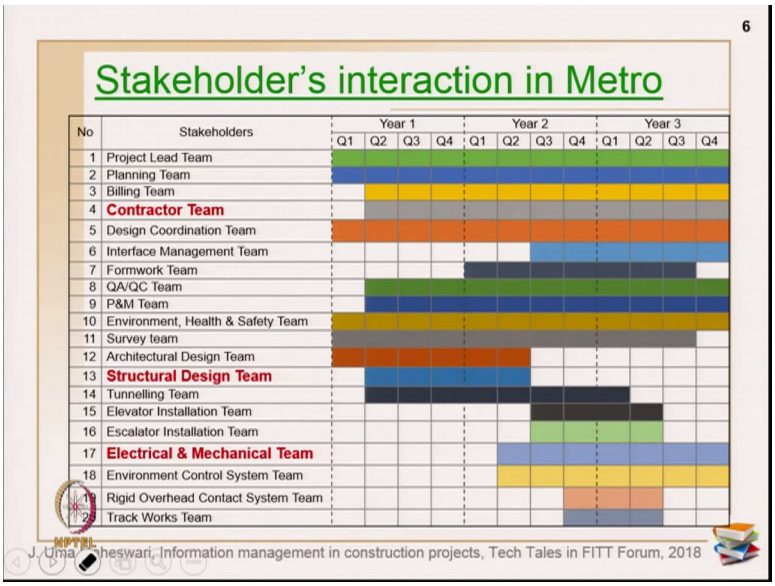


And other case ok, let us see the other case which is a metro construction example. This is a metro design example and this example I have introduced you to show the complex information exchange between different teams. And in any project you may have so many teams and there may be complex interactions between all these teams, that I have introduced you at that time.

Now, I am going to take the same example right now. So, this team this particular example 20 teams we have taken out and within a span of 3 years there was close interaction with all the teams that was there. Now the three teams which I am going to take for today's class will be, for explaining the BDM representation will be contractor team, structural design team, electrical and mechanical team ok

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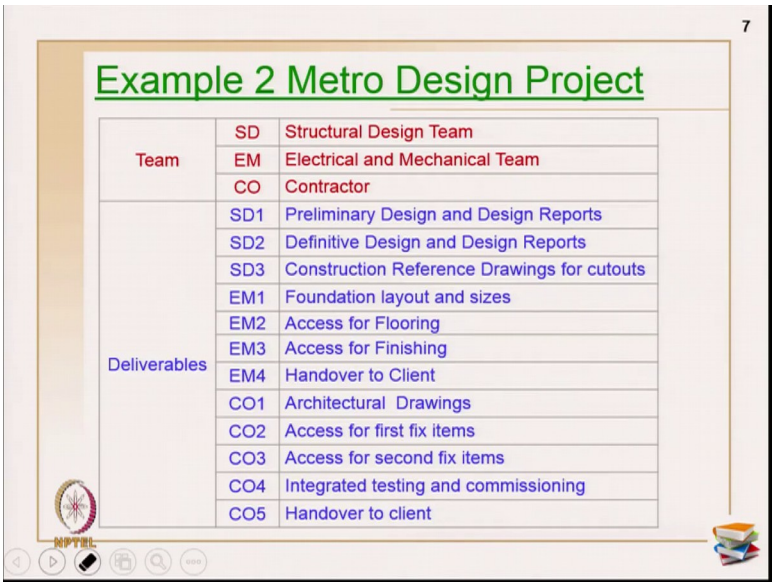


Now let us see the three teams, so I had given a short symbol for the three teams. So, structural design team, electrical and mechanical team and there is a contractor. So, there are three teams given here ok. And there are few deliverables as a part of the three teams. So, the deliverables are listed out here; preliminary design and design reports, definitive design and design reports, construction reference drawings for cutouts. These are the three deliverables from the structural design team.

And I am having four deliverables from the electrical and mechanical team which is; foundation layout and sizes, access for flooring, access for finishing, handover to client. So, there are four deliverables as a result from the electrical and mechanical team. From the contractor there are five deliverables which is what we have come across handing over to client, architectural drawings, access for first fix items, access for second fix items, integrated testing and commissioning and sorry this handing over off to client is coming from the other team as well.

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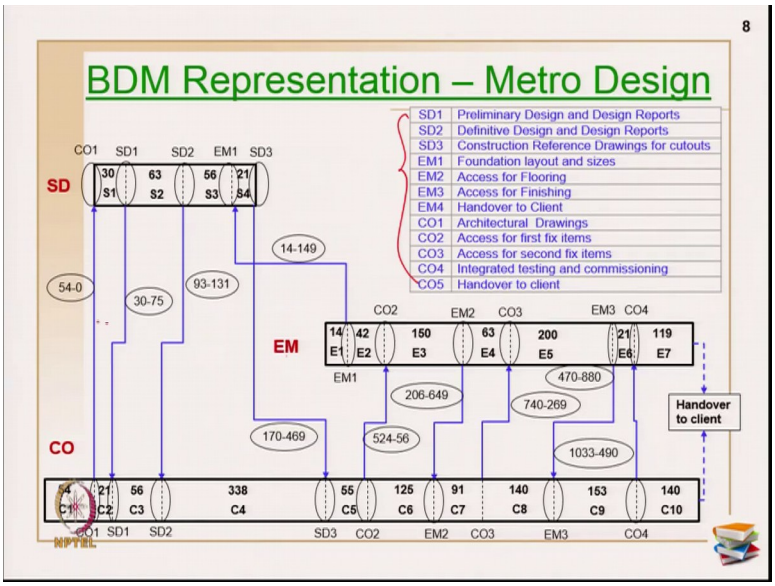


So, now, let us see the BDM representation here. So, these are the same example I have shown it, the same example I have used here, so that is easy for you to go ahead because I am using only symbols here for representing because of the too many texts written on the slide.

This is my structural design team, electrical and mechanical team and this is my contactor team, so these are the three teams I have. And all the deliverables which are all shared between the teams are all listed here and there is a short abbreviation used for all these deliverables; the time duration or linkage between these deliverables are all shown here.

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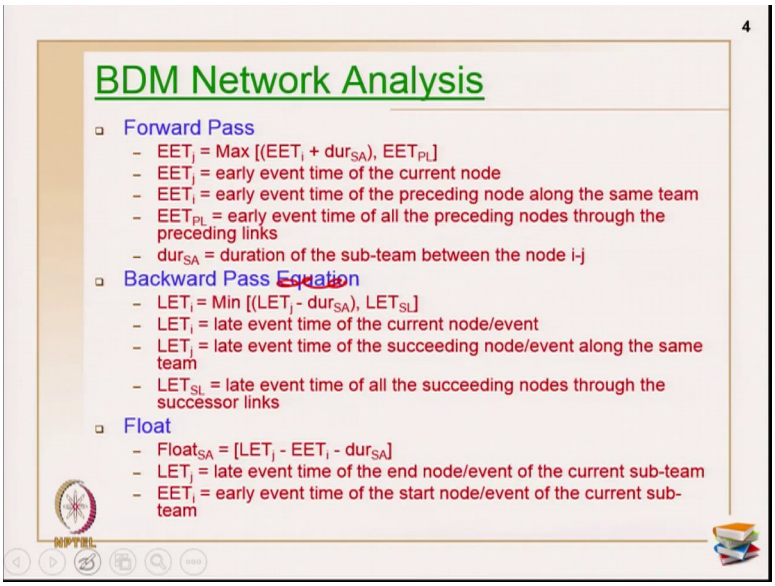


Now, let us move on into analysis, because you are more worried about how to do my scheduling with information exchanges, so let us see how to do the analysis.

Same way like your earlier network analysis; you will have forward pass, backward pass and float ok. So, in the forward pass there is a formula written and again let me also say something. So, in the BDM network analysis just like your PDM network analysis you can still do two ways of analysis; one is the activities can be interrupted and the other cases activities can be contiguous.

In the particular method where I have written all the formulas and I am going to explain you with an example we are assuming: the activities are interruptible in the middle which implies the activities can be broken down as and when the progress can happens on the critical path and accordingly calculated. Equally in other method of contiguous execution is also possible and the forward pass, backward pass calculations are accordingly different. And you will have a different formula for the same.

So, I am not going to narrate the story on how these equations have come; if you are interested you can go through to search papers and you can still see ok. So, we are only going to see the equations, explanations and how do we apply in a project ok. So, this is EET which is implies early event time. So, what we are going to do is, we are going to take a simple example and at the point of the linkages.

So, wherever there is a link, we are going to break down this the highway design in two different sub parts. And we are going to treat this as sub-activity of the highway design. So, I am having highway design sub activity 1, sub activity 2, sub activity 3, 4, 5 and so on. So, accordingly you may have to stop that.

And if you want to find the time at which these links are coming in, then I may have to treat it in terms of nodes. So, I am going to work in terms of events only, the nodes primarily to me are my events. So, I am going to work on event calculations.

So, what happens is EET j which implies early event time of a successor, which is equal to maximum of the first EET i will be 0 or it is maximum of my earlier links only. And the EET j is what you have to calculate, which will be maximum of EET i plus duration of the sub activity or the maximum of the two values and the other one is EET of my PL.

So, what are these terminology? So, EET j is early event time of the current node which is at the jth position not at the ith position. And the EET which is equal to early event time, so primarily the start of the particular event plus duration of the sub activity in the same team and or it is maximum of the other value; the other value is primary the early event time of all the preceding nodes through the preceding links ok

I may have too many predecessor or linkages coming in at that point. So, you have to see the early event time of all the preceding links. So, with that maximum of all these values you will take that value as my EET j.

In the backward pass again, it is called late event time of i; because late event LET j is primarily the maximum value you are getting with the, you are getting at the end for the last portion you will take the maximum of your EET j. And for the previous activities or events you will take the minimum of the values or which has come from the preceding links.

So, accordingly what you will do you will do minimum of LET j, which is from the last node you are traveling minus duration of the particular sub activity you have taken into consideration or LET of my successor links. So, I may have too many succeeding nodes coming out from the same late event, you may have to see that and you may have to see whichever is minimum that you may have to take it for my a late event time.

So, which is minimum of LET j? So, the LET j is late event time or the succeeding node or event along the same team minus duration of the sub team between the node i and j. And the LET SL is late event time of all succeeding nodes through the successor links. This may look complicated with an example I think you will understand much better. The next is float; float calculation formula is very clearly given, late event time of the successor link minus the early event time on the predecessor link minus duration of the activity; following similar to your PDM analysis.

So, LET j is late event time of the end node or event of the current sub-team and EET i is early event time of the start node or event of the current sub team.

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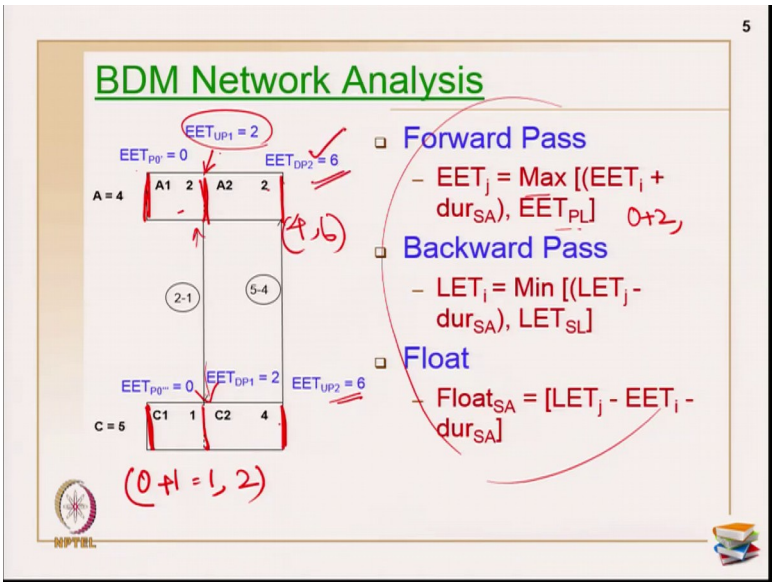


Now, let us move on here I have taken a simple hypothetical example; all these formulas I have written in one side for you to cross check and then go ahead with the calculations.

A's duration is 4, C's duration is 5. So, now, we are starting with the links; the first link is coming from A to C. And the linkage value is given as 2 to 1, which implies A1, the sub activity A1 takes 2 days of time and then it is releasing this and the sub activity C1 it is taking 1 day of time to release my to receive my link from A.

Then there is a next link from here. So, this is actually a truncated portion. So, now, my next links from here. So, at the time of 5-4 which implies; from the starting point, the duration of this is 5 and from the starting point, the duration of this is 4. That is how the

notation reads. So, which implies, now what is the duration of my sub portions. So, C2 is a sub activity here, duration of the sub activity is 4; A2 is a sub activity with the A and the duration of the sub activity is now 2 ok.

Now, let us move on with calculating my forward pass and backward pass ok. Now let me erase this, so that otherwise it will look, it will be overwritten. Now, so the further, let me start with A and early event time I have given some notations here only for understanding, only for me to note put it in a tabular form; otherwise there is no purpose here, you can directly put the values here.

So, this EET for this particular node. For this particular node the EET value is 0; EET for this particular node is given as, this is 0 plus duration of this activity is 2 ok, I am going to use this formula here. So, this is 0 plus 2, any predecessor link is coming into this, there is no predecessor link coming in here. So, this is 0 plus 2 only and that is why I have written EET for this particular places 2 ok.

Now, I am going to start from activity C, because the links are coming from opposite side. So, EET for this particular place is 0 and for this particular link my value is 0 plus 1. So, which is equal to 1 and I have another segment here EET of the predecessor link; there is a link which is coming in to me and EET value for that link is 2 ok.

So, now what is written here maximum of these two values, so 1, 2 maximum value is 2. So, my EET at this particular place I have, I am getting an EET value of 2 at this linkage. Let us move on into the next link so; obviously, this is a successor for me and this is my predecessor. So, I have to start working out from here. So, now, what about this value, what about this early event time. So, early event time is, this value is 2, 2 plus 4 is 6 there is no predecessor. So, this value I am getting it as 6.

Now what about my early event time for this particular node. So, I am having 2 here, 2 plus 2 is 4; with the help of my predecessor link the value is 6, maximum of these 2 values is 6 for me ok. So, I am getting a value called 6. Now let us erase this, so that it is easy to show the late event times.

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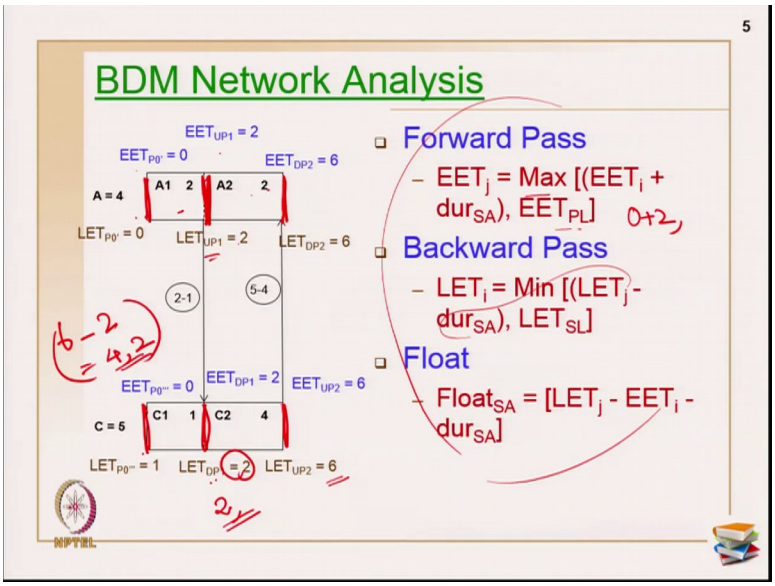


Now let us see the backward pass. Backward pass we have stopped at this particular point. So, this will be my starting node with which you have to start the backward pass.

So, late event time for this particular event will be 6. Now next will be this particular event, because the link is traveling from this side. Now what will happen here is, minimum of late event time minus duration, there is no successor activity here. So, you cannot take this. So, this becomes nullified here and what about the late event time of the successor link, I am having a value called 6; that is why you got a value called 6 here.

Now moving backwards, so this particular event. So, late event time is, either I should do 6 minus duration 4 which is equal to 2 or any successor links which I am having. There are no successor links here, so this value will be noted down as 2. Now let me move this way, because the link is travelling here.

Now what about this particular place, so I am at this particular place? So, the value is late event time 6, 6 minus duration of this particular activity is 2 which is equal to 4; and the late event time of a successor link ok, because I am having a 2 here, so 2. So, what I should do, minimum of these two values 6, 6 minus 2 is 4 here and because of this link I am having a late event time of 2. So, among these minimum value is 2. So, this value is now taken up as 2.

Now I can do this or this, anything is fine ok. So, I am going to do this first; late event time of this particular node is 2 minus 2 is 0, late event time of this particular node is 2 minus 1 is 1. So now, forward pass is done, backward pass is also done.

Now, let me erase. Let us see the float calculations now, float calculation is very simple. Let us go through that.

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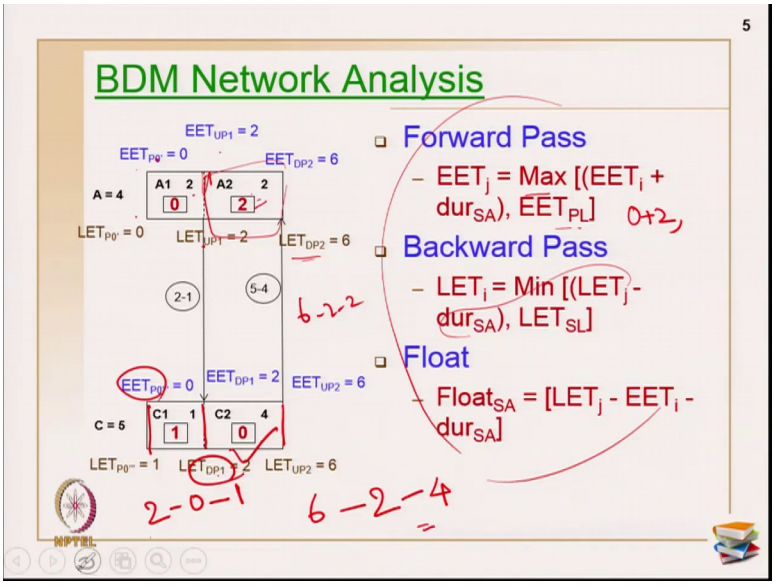


Float calculation, so it is late event time of 2 minus early event time is 0, so minus duration of this is 2. So, this value is now 2 ok. So, this is 2 minus 0 minus 2 which is equal to 2 ok, for this particular segment.

Now let us take this particular segment, float of this particular portion. So, float of the sub activity is what I have written, I am going to take the float of sub activities. So, late event time is of the jth side is 6 minus the early event time of the same segment is 2 minus duration of this is 2. So, I will have 6 minus 2 minus 2, so that will be equal to 2 here.

Now what about this particular segment? So, this is my sub portion here, late event time is 6 minus early event time is 2 minus duration of this activity sub activity is 4, so 6 minus 2 minus 4. So, this becomes 0 here. Now let us look at this particular portion. So, the late event time is 2 here ok, the early given time is 0 minus duration of this particular activity is 1. So, this is now will be 1 here ok, that is how the calculations are done.

Now, so far we have seen forward pass, backward pass and also we have seen the float calculations also. Now we have finished up the entire network analysis ok. As per the analysis now what happens? So, this particular activity is taking 0 float, this particular sub activity is taking a float of 2, this particular sub activity is taking a 0 float, this particular sub activity is taking a float of 1 ok.

So, now what are my critical paths and how do I show my critical path? My critical path here is A1 with the link and C2 is critical path here; because of the 0 floats I have on this particular network ok that is how you have to complete the analysis. So, network schedules, how to represent the BDM representation itself you have understood, only for one linkage we have seen; one type of linkage which is a N1 to N2.

And using the three formulas primarily on forward pass, backward pass and float, we can also show the individual segments, where the path is critical.

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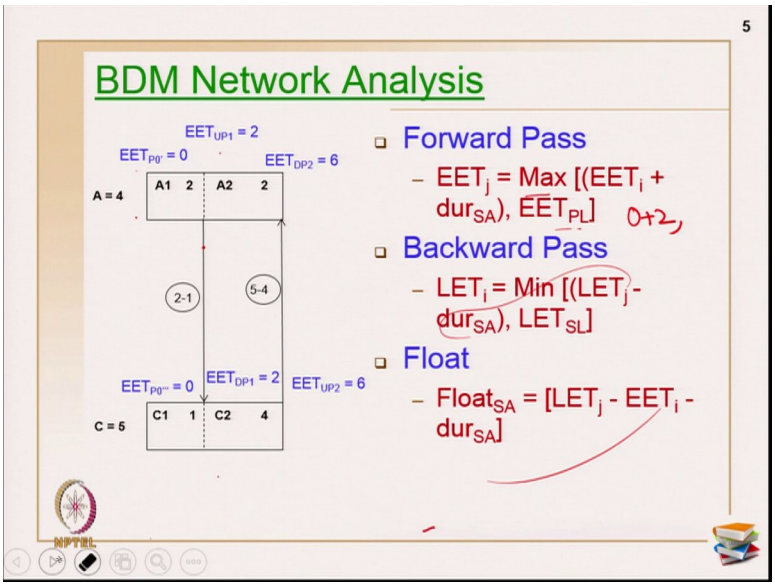


So, you should not have the impression that, every time I should be taking up only the teams and parameters. So, far in this example we have seen multiple information links travelling between parties, it can be any link between any two issues. For example, first example I have shown, parameters travelling with the teams and in this example deliverables traveling with the teams; say it can be any link, the link can be anything just like in types of DSM. Here also it can be between teams and components, it can be between teams and parameters, teams and deliverables, or components and deliverables,

components and parameters. So, based on whatever you want you can accordingly develop different DSM's of your choice.

Now whenever I make this information relationships, you can this is more like a bar chart. When we went to the experts and ask them for opinion and inputs on this BDM example, they were very happy to receive this BDM network ok, under so many issues behind. One is this BDM really looks like a bar chart, but with lot of information stored in. So, it is not like a basic bar chart, but it has so much of information contained within the bars ok. So, they were very happy to visualize the entire network, by travelling like this ok. After this, this deliverable, then after this deliverable, so they were able to see and visualize the entire network, more than the network schedules on CPM or PDM and so on.

So, they overwhelmed and receive this network with enthusiasm ok; but there are some problems in implementing in the industry, because of the manual method with which we are still working out in calculations ok. Still now, there are no software which can help us to do all the calculations automatically, as you can see I also have done mistakes while showing the calculations.

So, same thing can happen because of the large values you have with the information flows and sometimes it may be even in hours and some values may be in when you are converting in days to hours you may get large values like this thousand and so on. It is really difficult for somebody to go through with the calculations that you have to keep in mind; that is the only one drawback we have in BDM.

So, far we have finished DSM and BDM. So, information management, information driven schedules; two schedules we have seen, one primarily in iterations, this I can see it is partial and interdependent only, it cannot support iterations ok. It can only support interdependencies, but interdependence is multiple information exchanges in two ways. So, two different technique which, one can support till iteration and one can support interdependence in multiple links. So, I have shown this.

Thanks bye.