Course Name -Project Management: Planning, Execution, Evaluation and Control

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Lecture - 13

Welcome to the course Project Management Planning, Execution, Evolution and Control. I am Professor Sanjeev Choudhary from Indian Institute of Technology Kharagpur. Continuing with the module 6 that is Developing Project Plan. In this lecture we will be discussing about construction of network and network computation process. So, the concepts that will be covered in this lecture are network computation process that is forward pass and backward pass computation, then these two and the rest we will be talking about in the subsequent lectures. So, to come to this what are the practical considerations for building a project network? The we must discuss it the in practical considerations we have in the last lecture we have talked about the basic rules and the basic steps of developing a project network.

So, we must look at that there should not be any network logic error. What is this logic error? Logic error is looping. Looping we have talked about in the previous lecture that looping is not allowed. Say this is the looping or the network logic error.

Suppose A, B A is B starts after A is completed. When B is completed then only C can start, but C cannot go to A because it is because this has already been completed. So, these are called illogical loops. So, these are not allowed for network development. Then activity numbering I have told in the in the previous lecture the identification number that I each activity because a project is a huge project say thousands of activities, then you must have to give some identifications number those are the WBS codes.

As I mentioned in the previous lecture it may be numeric, alphabetic or alphanumeric whatever is convenient for that project. So, activity numbers will also go from in ascending order like the successors or the succession succeeding activity will have a larger number than the predecessors' activities. And it is customary to have some gap between the numbers like the number should be say 1, 5, 10, like that like say numbering should be say 1, 5, 10, 15 because that way what happens if you for a big project and all 1000s of activities you may miss some activity while planning. So, you can come back and put a number in between so that it is captured. So, it is always better you give This

with a gap numbering should be at a gap and it will be an ascending order means from left it will keep on increasing while it is moving to the right.

Then use of computers to develop network what is that use of computers nowadays we are all big projects and all we are do use computer software and it is very handy and it is very useful because otherwise manually computing and all it is a herculean task. So, if you wanted to see say this is an illustrative say illustrative computer how do you use it this you use it suppose it is just an illustrative one these are the task names duration it looks like this, I will explain more about it later on later on I will be using more about it. Then calendar dates you have to have to fix that calendar dates like say when you are having a project plan what happens? that how many working days it will require for it gives you the output working days, but there may be holidays in between there may be 5 days a week there may be 8 hours say shift there may be 12-hour shift there may be 2 shifts there may be 3 shifts 1 shift. So, if your project duration means that calendar dates for that will increase, but the say project requires say 340 days that number of days will be remaining same actual working days, but the calendar dates will keep on increasing then multiple starts and multiple projects these are nothing, but the dangler. So, you try to avoid the dangler.

So, you give otherwise say there may be 3 4 projects can start at the same time, but it looks an open ended. So, you tie it up with a note called start similarly for the end we have discussed it that is a dangler to avoid dangler suppose in this program say these are the activities. So many activities can start at the same time. So, it is showing an open-ended thing. So, if you put a note here start and tie all these then that becomes a that is otherwise you are this is called the dangler open ended you try to put it similarly for the end.

So, these are the practical considerations for building a project network. Now, next we will be talking about steps for developing network analysis model using part and CPM. First of all, you have to do you have to identify the task that means, what you do for your project you do work breakdown structure to the elemental level that is the work package level. So, those are the task you have to first and it requires tremendous amount of expertise like the project expertise not everyone can do it. So, we talk with the experts in that project then you study you benchmark and many things are many steps are required for identifying the work package or the task.

Then to build a you require a relationship how do you draw the project network, network require relationship which activity will follow which one. So, there must be a predecessor there must be a successor that interdependencies between the activities that we have to define the relationship then only you can draw or develop a project plan. Then third step

is you estimate time that is the duration how much each activity will take more accurate your estimations of the duration it will be more accurate will be your plan. So, the project is the summations of those work packages activities and all. So, you need to estimate the time for each activity then assign resources then these activities have to be done by the man they will require material they will require equipment.

So, all these has to be assigned then only you can complete drawing a network and compute critical path otherwise in the absence of all these you cannot complete the compute the critical path nor you can draw a network analysis. So, just to show it give you a glimpse of I will show you how does it look like. Say this is a real life for illustrative purpose given you have to first list down the task and activities say these are the list and task activities are done and this is the coding that is the identifications number numerical numbers are given to identify the activities because you do not call these whole activities on the network and all you just give it with a code. So, that is the identification number then to draw a the any draw a network you need the predecessors that is the interrelationships between the activities unless you get these you cannot draw the network these predecessors are to be given then after the predecessors are given you have to find out the time estimates for each activity. So, these each activity then only you can find out the schedule then only you can find out the total project completion time then also you may need to give your resource requirement suppose this activity will take so many of manpower.

So, these resources are given. So, these are the task as I told you to as I told you to that this is the steps for developing network analysis this all these has been shown live then only you can if you have this then only you can draw this network. This network is said here you can find out these are the task name this is for a software project MS project. So, these are the task name you must have to specify first then you have to specify your predecessor these are the predecessors unless predecessors are given it cannot interlink the activities then you have to give the duration these are the durations given for each work plan work package or the activities each activity then the the computer network will be done and your you can have these work is the network plan and the project completion time. So, this is the steps for developing project network analysis model.

Now, to go further we will discuss about the notations that will be used for developing a project network. What are these notations? You must remember these notations. these will be used henceforth always to draw the project network. First thing is you will find network activity duration is denoted as t that is the expected time for each activity then early start it is es the earliest time and activity can begin if all previous activities had begun at their earliest times, then early finish this is the early start plus t duration it is the early finish earliest time and activity can be completed. Then late start the latest time and

activity can begin without delaying the project completion time.

Late finish LF that is the latest time and activity can be completed if it is started at its latest start time and total slack, slack we have already discussed is denoted by ts. it is the amount of time and activity can be delayed without delaying the completion of the project we have discussed it before. These are the symbols and the terms we will be used henceforth for developing a project plan. To know to develop a project plan what are there are two types of computation one is called forward pass computation another is called backward pass computation we will discuss that then we will be solving one or two problems for demonstrating this how to develop a project plan. What is a forward plan? Forward pass computation early start of the early start of an activity is the early finish of the predecessors activities.

So, and the early finish of the activity is what I told you early start plus t early finish of an activity early start plus t is the duration of that activity it becomes the early start of the next activity unless the activity is a merged activity in the merged activity there are more number of activities depended in that case you select the largest early finish of the preceding activities if there are three activities preceding an activity you take the largest early finish ok. This is called forward pass these will be clear when we go and compute the critical path in the next slide. Then similarly there is a backward pass backward pass is the say late finish of an activity is the late start of the successor activities successor activities suppose late start of an activity is the late finish of the successor activities minus t durations of that activity it becomes the next late start of an activity becomes the next activity is the late finish unless there is a burst activity, in the burst activity you there are many activities going you would select the smallest late finish of the preceding activities. So, this will be clear when we solve the problem this we will be revisiting again. Now, then the total slack is the late finish minus early finish or late start minus early start.

this is the total slack that is an activity that is the amount of time the amount of time a dependent activity can be delayed without delaying the project completion time we will talk about it more. Now we will go for the problem solving say now go through this problem then we will solve it what does this problem says just go through the problem we will be solving this. So, the problem says that from the following information develop an AON project network complete the forward and backward pass compute activity slack and identify the critical path how many days the will the project takes. So, here it is given that these are the activities this is the id then these are the predecessors and this is the time durations are given now we have to solve this problem. So, I will show it to you will be doing it.

So, try to so, what we have to do first We have to develop a project network which is AON network. that AON network we will be developing then we will compute the forward and backward pass and activity slack. So, next so, we go how to go to the next this one and try to solve this ok. Here we have to draw the project network. So, to for drawing the project network what we do we have what that let us draw the project network first A it is given A B A 2 means durations of A is given at 2 B 5 durations of B is 5.

So, then C duration of C is given how much 3 then there is D, D duration is given 4. So, this then is given E is duration is 3 it is given. So, this is the AON network diagram we have drawn. Now we have to find out early start early finish late start and late finish and slack for each activity then only we can compute the critical path. Now for the legend that we will be using it is like this ah sorry ah legend we will be using it are like this say for this ah this is early start this is early finish this is late start this is late finish.

So, A A we have to find out what is the early start of A A can start at 0 and its duration is 2. So, early start plus 2 is is is early finish. So, so ah early finish now B what is B B early start is unless A is complete B cannot start. So, the early start of B is 2, and the early finish is 2 plus 5 7 early finish similar for C C what is the early start is 2 early start is 2 ah early start is 2 and what is early finish 2 plus 3 5 early finishes.

Now what is early start of D. D is a merged activity mind it is a merged activity. So, what will be the merged activities that is the early finish of the maximum early finish you take maximum early finish is 7 of these 2 ahs 7 and 5 7 because unless B is completed even if your complete C at the 5th day 5, but the B is completed on 7th day unless B is completed it cannot start. So, it is the early finish is 7 then what is early finish early start is 7. So, what is early finish it is 7 plus 11 4 11 because then E E what is early start early start is the early finish of the preceding activity. Predecessors' activity is 11 plus 3 duration it is 14.

So, it is early finish is 14. So, you can so that forward pass what we have we had discussed this can be this you can come to that. So, say we have discussed about say what is the forward pass forward pass we have discussed early start equal to early finish of predecessor’s maximum on take. So, early finish early starts plus duration it is the next activity is early start unless it is a merged activity. In merged activity we have seen in D select the largest early finish of the preceding activities. So, we have done this now backward pass it will be the late finish equal to the late start of the successor you take the minimum that late finish and this we will be we will be discussing we will be going for it further as we move, we will be we will be going for this.

Now, for we are going for the late finish. So, what is the late finish backward pass we are going we have completed the forward pass. Now backward pass what is the late finish of E it is 14. So, what is the late start 14 minus 3, it is 11 is the late start. So, 14 and that you are getting the late start is this.

So, what is slack? Slack is late finish minus late start or early finish minus early start it is 0 is the slack you are getting it know. So, just look at it. So, whatever we have done explained here we are doing it and total slack is late finish minus early finish or late start minus early start we have shown it and backward pass we are going like this late start equal to late finish minus T unless there is a burst activity in burst activity you select the smallest late finish ok. So, we will be going for the late next one. So, what is this late finish? Late finish of D will be the late start of the previous one that succeeding one that is E.

So, it will be 11 then what will be the late start of D it will be 11 minus 4 it is 7. So, what will be now what will be the late finish of B it will be 7 because it is late start is 7. So, what will be what will be the slack here 11 minus 11 or 7 minus 7 is 0 slack is 0 then here 5 days duration 7 minus 5 it will be 2. So, duration slack is 0 now take the C, C what is the late finish late finish is the late start of the successor one. So, it will be 7 and what is the duration 7 minus 3 late start is 4.

So, what is the slack 7 minus 5 2 or 4 minus 2 is 2. Now what will be the late finish of A here A is the burst activity it has B and C as successor. So, you have to take this out of 2 is the late start it is 4 is the late start which one you will be taking in the burst activities you take the minimum. So, 2 and 4 minimum are 2 you take 2 then A to A duration is 2 it is 0 late start is 0.

So, this is 0 slack. So, if you see now the only C activity C has a slack other activity do not have slack and critical path has the 0 slack. So, this is the critical path A B C D E D E. So, critical path critical path is what you are getting critical path is A B D E is the critical path and how much time it is taking it is taking duration is duration is 14-time units say days or time units. So, you have done and C is a non critical activity it has a slack managers or decision makers project manager can delay these activities by 2 days without delaying the project completion time and this is critical path is the longest path or the duration during which all the activities will be completed will be completed. So, this is called this is the critical path and duration hope you have understood this.

Now we will be solving one more problem than it will be much clearer then ok. So, let us go for another problem just go through this problem the project information for the custom order project of the air control company is presented here. Draw a project

network for this project compute the early and late activity times and slack times identify the critical path. what is given it is given that you're that activities are given here is ID is given, ABCD, predecessors are given and durations of each activity is given. Now it is easier for you to first you have to do the draw the network diagram then compute the that E s E f and E p all this can be computed and find the critical path I will show you this quickly.

So first, we what we have to do first draw the network. Let us draw the network it is say A 2 then there is B C D E B is given how much is 15 hm hm B is duration is 15 C is duration is 10 D duration is 13 E duration is 18 oks. So, these are given. So, draw the network first ok then there is F duration is 15.

So, it is predecessors are C and D. these are predecessors of A then there is G G is how much 10 predecessors are F and and B yeah. In this network and all one more thing the the the the arrow arrows these lines can cross each other there is no harm in it hm you can then then there is H H duration is 5 oks. So, H dependent on D and E this is 18 oks. So, this is your we have drawn the network. Now, we have to find out the early start early finish and all this will be can quickly go through and once say A A early start is 0 it is early finish is 2 then B early start is 2 plus 15 early finish is 15.

C early start is 2 and early finish is 12. then D early start is 2 early finish is 13,15 E early start is 2 and it will take how much time E is 18. So, 20 now F early F is a merged activity of C and D. So, C and D merge. So, what is the we will take 12 or 15 we will take the for the merged activity the maximum. So, we will take 15 then 15 plus 15 30 is the early finish.

Now, G is a merged activity between F and B. So, early finish of of G which one you will take you take the maximum of these know of merged activity maximum of 15 and 30 is 30 because unless F is complete even though B is completed G cannot start. So, it is 30 plus 10 is 40 ok this 40. Now, H what is early start it is H is dependent on E and G E it is 20 it is 40. So, merged activity will take the maximum.

So, it is 45 is the duration 45 ok. Similarly, you now go for the the backward calculation it is L F minus 5 40. So, 0 is the slack this can start only at 40 minus 10 30. So, slack is 0 now this ah the the now G is having F now F is it is 30 is the late finish. So, let us start.

So, L F is 30 minus 15 15 it has 0 slack. Now, its G is the also for B B how much G is 30 know it is late finish is 30 minus 15 it is 15. So, it has a slack of how many days know this is the 30,40 this is this will be 30 15, and 2 and no this 15 plus 2 will be 17. I this is not 15 this is 17. So, how much is it 17 minus this thing 13 slack is 13 hm.

Similarly for this this is 40 this is 40. So, 40 minus 18 is how much 22 what is slack slack is 20. Now, C can start the C is what is the C is ah 15 it is 15 and minus 10 5 ah 5. So, what is the slack 3 now F this is 15 minus 13 2. So, what is the slack 0 now A A is a burst activity it is 15 C 50 B C D E.

So, early finish of this is 15 5 2 22. So, which one will take early now late finish late start late start of B C D E are 15 5 2 22. So, you will take the minimum of the late start minimum is which one is the 2. So, you will take 2, and 2 minus 2 is 0 it has a 0 slack. So, now, which has your critical path critical path will have 0 slack.

So, this A D D is 0 ok A D, D F then then F G then G H. So, these are the critical paths critical path is A D F G H and duration is duration is 45-time units or days. So, you can find a find it out this is clear now critical path has 0 slack these all are having 0 slack A D F G H all are 0. Other activities have slack 13 days here 3 days 20 days. So, managers have the discretion to they can allowed the resources of this any time. So, this is the, but now once you practice without doing this early start early finish late start and late finish you can compute by seeing the network.

First you have to draw the network now if you see say this A to B say 2 plus 15 plus 10 15 plus 10 25 plus 5 25 plus 5 is 30 this A B G H will take 30 days A C F G H A is 2 plus 10 12 12 plus 15 27 plus 10 37 plus 5,42 A C F G H will take 42 days now A D it is taking 45 days 2 plus 13 ,15 plus 15 30 plus 10 30 40 plus 5 45. So, it is the critical path then A E H is taking how much 2 plus 18, 20 plus 5 25 only 25. So, the longest path during the network is called the critical path during which all the activities in the network will be completed. So, we have done this. Now, coming to the coming to the conclusions we can say in this lecture in continuation of the last class in this lecture illustrates how to construct a project network and computations of network process.

Further is includes computation of forward paths and backward paths determining for float and slack computing critical path and sensitivity of network. Sensitivity of network is the one that if a network has a many critical paths or near critical paths activities those are sensitive network. If a network has only one critical path and the non critical activities has slacker and all then it is insensitive network. Then further all these have been demonstrated by solving numerical which will be helpful to all of you. So, these are the reference books one can go through there for further reading which will enhance your knowledge.

Now, thank you very much for attending this lecture. Thank you to all of you.