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

Professor Name - Prof. Sanjib Chowdhary

Department Name - Department of Vinod Gupta School of Management

Institute Name - IIT Kharagpur

Week – 05

Lecture - 22

Welcome to the course Project Management Planning, Technology, and Technology. In continuation with module 8 that is Scheduling Resources and Cost. In this lecture, we will be covering the Resource Constraint Project. The concepts that will be covered in this lecture are resource allocation method. Last lecture, we have seen the time constraint project. Now, we will be dealing with resource constraint project and splitting of activities and we will be solving some numerical on this.

And the further in subsequent lectures, we will be covering the rest of this module. In resource constraint project, what happen here resources are limited and but time is flexible. So, here in the time constraint project, we have seen time is fixed and resources are adequate. Here is the other way.

So here, what we find that inadequate resources are limited means it may turn out to be inadequate. So, it will what will happen? It will extend the project; it will delay the project. We have shown you in the last lecture, if that how the marriage reception, how the with limited manpower, limited resources, how the project has extended, it is also the same way. The activities so here what we do? The activities are scheduled using heuristics, you know there are many heuristics are there and the we use these heuristics. The heuristics are the rules of thumb.

So, I will just tell you two heuristics how it is being done. So, some heuristics what you do? you select first the minimum slack. Minimum slacks are which are those are the critical activities. When there are many critical activities vying for this, you take in one heuristic the least duration that is the smallest duration. Then followed by lowest activity identification number that means activities which are at the beginning, they have low identification number.

As you go to the right side, the following activities have not followed the successor activities will have more or a larger identification number. So, there may be other heuristic like precedent activity you arrange the activities in an ascending order, then you put the maximum resources to those activities which are having the maximum durations

and all. So, there are different heuristics are there. We will be solving some problem that will clarify your insights. So now, before going that another thing I wanted to discuss is about splitting.

Actually sometime it may require you know your resources are constrained, your resources are limited and companies who have multi projects in multi project situation resources are shared. Suppose a design engineer he is engaged in 3 or 4 projects. So, he is doing a one project design. Now when he shifts to the next day he goes to another project, but what happens he is mind his mindset is already glued to that. It takes time to transfer it to a new project because human is not robot that they will start at the same efficiency at the same space for another project.

Your mind requires some time to go over to the new project and all. So, these are the activity duration without splitting. So, now if you split the activity suppose your material or equipment required for in other projects and all. So, what you do? You can split activity here it is shown activity 3 splitting A B C. So, here you stop the work and send your say design engineer to some other project or your equipment or material to some other project.

So, here it is your shut down then again when the design engineer or equipment come come back then you have to start up again. So, this time is splitting is lost this shut down and start up time. So, you see if it is split 2 times then you see your project activity has that project duration has increased and that is why it is found the delay in the project durations one of the reasons is that splitting because of sharing the same resources with different projects that, but the the splitting is to be avoided that is the expert view. So, in order to complete the project in time you avoid the splitting, but it may not be always possible because your resources are are in limited. So, it always extends the splitting always extends project duration, but you have you can do this when your shut down and start up cost is very low and it is relatively easy and simple to start.

So, in that cases you if you required you can do the splitting. Now say there are some limiting assumptions for the resource allocation. what are these assumptions? in assumptions are splitting activities is not allowed once an activity starts you try to follow that it is to be completed first. Then level of resource used for an activity cannot be changed as I told you in the last lecture you have seen it you have to take one crew size 6 or 4 or 5 and that cannot be changed in between or until the task has been finished. So, this is also another limiting assumption and there are some risk assumptions.

what are these risk assumptions? Activities with the most slack pose the least risk yeah that is That is a sensible assumption if you know the activities that have huge slack that

can be completed at any time during those periods. So, it has the least risk then reduction of flexibility does not increase the risk or the nature of activity the does not increase risk the whether it is a complex project or easy task or project it does not increase your risk. These are the risk assumptions. Now we will be solving this problem. this is the resource loading we will see how the resource constraint will increase the project duration just go through this problem then we will be solving it.

It says given the network plan that follows compute the early late and slack times ok what is this network? this has been given we have to find out the early late and slack times. what is the project duration? we have to find out the project duration. Using any approach, you use trial and error develop a loading chart with only one of each resource exist given your resource module compute the early late and slack times for your project which activities are now critical What is the project duration? how could something like this be happen in project. So, let us solve this problem. all of you know this legend know this is early start, early finish, late start, late finish and these two are slacks, and this is the duration of the activity and this is the identification number activity number and middle are the resource.

If a here it is one mechanical engineer one electrical engineer you are ah having it ah mechanical develop a loading chart for only one each resource exist that is mechanical one electrical. So, let us do it. So, in order to do that what we will be requiring say let us finish it we know this 0 it starts it is 2 oks. So, let us start 0 2 this is an early start, an early finish should be 3 and this is 3 and plus 1, this is 4 plus 6 is 10. This is 0 plus 4 is 4 plus.

this 0 plus 3 is 3 plus 4 is 7. 0 plus 2 is 2. this is 2 plus 1 is 3. this is 3 plus 6 is 9. So, the critical path we can find out is 1 4 5.

and duration is 9 days. Now we have to develop a loading chart for each activity because you have this is the 9th you have to fill it up. Now let us go to the Excel sheet and try to do this same problem the loading schedule for each resource we u we have to do that hm ah we have to do that. So, we will be doing that. So, how do you do that? So, you have so, so we have found the critical chart 1 4 5 it will take 9 days.

So, let us do it electrical engineer will be required in that chart we have found electrical engineers is required activity 1. So, activity 1 is the 2 days. So, here I cannot use the pen. So, let us so, here what we will be doing we will be here activity 1 will require 2 days 2 days ok. Then the activity activity 4 I then it is the activity 4 that is 1 electrical engineer activity 4 is also electrical engineer.

Then activity 2 activity 2 is for how many days that require 1 electrical engineer for 4 days. So, 1 2 3 4 days now there is also if you see it there is mechanical engineer requires from the first 3 days. here activity 3 will require mechanical engineer for the first 3 days. this is a mechanical engineer. then mechanical engineer be an engineer will be requiring in activity 5 and activity 6 activity 5 is how many days 6 days.

Here mechanical engineer activity 5 and the durations of this activity is 6 days see here. Now what happens then Your electrical engineers will be requiring activity 7. you will be requiring ah requiring electrical engineer for how many days It is 4 days. It is 4 days. So, the 4 days you will be requiring this is the 4 days.

Then the activity what is the activity is remaining is mechanical engineer that is that will be requiring that ah activity 6 will require mechanical engineer for 2 days say your loading has been completed. So, electrical engineers will do Activity 1 2 days, then Activity 4 1-day Activity 2 these 4 days 7 7 days then a mechanical engineer activity 3 3 days activity 5 6 days then the activity 6 2 days. Now you see the since you had resource constraint your project critical path was 9 days. Now due to resource constraint it has extended to 11 days. So, see this is the you have the resource constraint.

So, your projects get delayed., So, otherwise with unconstrained it was your critical path was 1 2 1 4 5 and it is to take 9 days. Now it is gone 11 days. So, you're when the it has become 11 days your critical path has changed it is no longer the 9 days. So, you have to fill it up this electrical engineer early start late start early finish late finish and slack. So, how to do that if you look at this loading? you can do it suppose if there is loading activity 1 is the early start.

what the early start of activity 1 is 0 days. Early start is 0 early finish is how many days it is 2 days early finish is 2 early finish 2. Similarly, if you go to backward, this is the forward computation also you will find it is a late finish also there is no slack late start is also 0. So, slack is 0. So, it has no slack this activity 1 activity 4 if you see then this is also electrical it can start at early start is 1 2 3 day 3 is early start.

So, what is the early finish 2. This is for the 2 early start is 3 activity 2 early start is 3 early finish is 7. So, early finish is 7 we are talking about the activity 2 early finish and it has no slack. So, late start is also 3 late finish is also 7. So, slack is 0 then 3 activity 3 activity 3 is mechanical activity 3 starts at 0 and finishes at 3. So, early start is 0 and early finish is 3 it has no slack.

So, late start and late finish are also 3 and 0. So, slack is 0. So, for 3 then it is the 4 is the electrical engineer. Activity 4 it starts at 2 no activity 4 1 day starts at 2 finishes at 2.

at the early finish is at 3 and it has no slack one day.

So, it is also a late finish is 3 late start is is 2. So, what is the slack? Slack is 0. Now similarly for activity 5. what is the early start is 3 early finish is 9.

and it has no slack. So, late finish will also be 9 and late start will be 3. So, there is no slack 0. Now 6 is is early start is 9 early finish is 11 and there is no slack. So, early start is 9 early finish is 11 and also here it is 9 and 11 because there is no slack.

So, it is slack is 0. Now last is the 7 7 early start is 7 early finish is 11. So, this is 7 and 11 and it also has no slack late late finish is also 7 ah 11 and late start is 7. So, this also is 7 11. So, it is slack is 0. So, you have done it that you resource activity schedule is also done.

So, this is the loading schedule for each resource and this. So, we have done this problem what was given to. So, this was the problem we have done the loading chart loading chart and also the the resource activity schedule has been done. So, now let us go for one more problem.

So, this has been done. So, this is a network activities and resource leavening. So, see how the we are seeing that that limited resources are inadequate resources will extend the project duration. So, here also this go through this problem network activities of a sports tournament are shown in the table below we with activity duration. This is the activity descriptions these are the network node immediate predecessors and durations for each activity. So, draw the network go through the problem compute early start early finish late start late finish and slack of each activity ok.

Then compute the critical path and project duration draw a Gantt chart if one person is required for each activity prepare a resource level schedule. If only two persons are available per day what would be the project completion duration with resource leveling. So, we have to solve this problem you just go through it the problem once more then we will be solving the problem together. Let us proceed.

So, network first you have to draw the network. So, for positive of time. So, I have drawn the network say A 2, 2 is the duration as C3 D2 G4 this I3 this is gone. Now, you have to find out the early start early finish and all very quickly we will be going through it all of you know are aware of it all of you have done it. So, what is the critical path we have to we have to find it out.

So, this is this is. So, let me go for ok. So, this is 0 start. So, A2 is 0,2 then 2 5 that 2

plus 3, 5 then 5 plus 2,7 then this is 7 plus 4 11. Now, you have to do for each. So, this one will e becomes 5 this is 5, 5 plus e is 10 is 15,15 then g will become 15 and 11 it will be 15 plus oh, this is g this is i.

I will be 15 e 15 plus 3 that will be 18. 18 this will become how much. So, we will do this also this will be 0 8 this will be 8 plus 4 12 then this will be how much is this 15? this is also 15. So, this will be 15 plus 1 is 16 and this will be 18, and plus 2 is 20. So, now, we have to go to the backwards 20 18 slack is 0 then this will be 18 1 is the 17.

So, slack is 2. You know 16 slack is 1 sorry slack is1 this will be 17 this is 13 slack is how much slack is 5 this will be 13 this is minus 8 5 slack is how much slack is 5. what is left? this is the left. So, this will be 18.15 slack will be 0 this will be 15 15 5 slack is 0 ok this is what 15 this is 11. So, slack is 4 this is how much 1, this is 11 minus 2 it is how much 9 slack is how much 4 this will be 9 you know this will be 2 5 5 7 9, but this.

So, this will be 2 5 is 5 because here this is the minimum of this is 9 and 5 is 5 and this is 2. So, what is the slack? slack is 0 and here it is 2 0 slack is 0. So, your critical path is C this A2-C-E then e i 0 then i is 0. So, your critical path is a c e i j and duration are 18 not 20 days ok we have found it.

So, we have found the critical path. now the problem says go for the resource labeling. So, so these are the critical path what we have done it here here now we are going for the now you see the these are the critical activities say bold lines are the critical activities and the light lines are the non critical activities. Now you can see the problem says that each activity has to be done by if you see this problem what does we have done that network we have done EACS slack compute the critical path duration draws the Gantt chart we have shown you if one person is required for each activity prepare a resource level schedule for then from if only two persons are available per day. what would be the project completion duration with resource-leveling.

now we are doing that. So, this is the if one person is required for each activity this is the total requirement personal requirement 2 2 2 here it is 3 3 3 because 3 activities are falling then 2 1 1 2 1 1. So, these are the 20 days a now you have it is say saying you have only two persons per day then what happens you have to level the resources. So, here where are the three say these are the activities three. So, this activity is a non-critical activity you then shift it.

shift these activities to this side. So, these activities are for three. these activities can be shifted to these activities should be shifted here. So, that it goes here that way it becomes 2. So, then again these are the three activities. So, you have to shift either this activity

has to be shifted by how many days you have to see this up to is 3.

So, these activities have to be shifted. here it has to come start from here hm. So, similarly here also you see this way you go. So, say we have the next slide you can see we have shifted these activities and it has been labelled. it has now come 2 2 2 because we have shifted these non-critical activities here to become 2 2 2 even then here you can find these activities is 3 days 3 manpower required because three activities are there. So, what you will be doing you have to shift this activity by one day here.

So, these goes here now there also becomes 3 then these becomes 3. So, you have to this non critical activity you have to shift here then it becomes 2. Now, if you see this non critical activity is shifting here and this non critical activity h cannot that final j is the final activity it cannot start up until h is completed. So, h is getting completed here now then j if you see the 3 here that j cannot start unless h is completed. So, h has shifted one day then the j also has to shift one day that is been shown here that j cannot start unless h is complete h has shifted here one day this has become this has become 3 2 2.

So, one day it will become 2. So, then this will shift one day. So, if it shifts one day the project will spill over to the 21 days. So, you can see that for resource ah inadequacy your project has gone over 21 days. So, this has gone to 21 days. So, this is the resource level schedule of this of this problem. So, to sum it up what we have done further to the previous lecture in this session we discussed the resource constraint scheduling.

The duration of the project may be increased by delaying the late start of some of the activities we have done the shifted the late start. If resources are not adequate to meet the peak demands we have this also shown the concept of splitting which at times become necessary due to resource crunch it is suggested to avoid splitting as it delays the completion of the project. In general, it is used when the starting and stopping cost is low and is relatively simple and easy to do that. So, these are the few reference books that you must go through and make your ah concepts clear. Thank you very much for attending today's lecture.