

Project Management

Prof. A. Ramesh

Department of Management Studies

Indian Institute of Technology Roorkee

Week: 6

Lecture 26 - Resource Levelling

Dear students, in this lecture I am going to discuss about resource management. In the previous class I have explained about resource loading that is allocating resources into the project. Now, when you allocate the resources there will be smooth allocation of the resources. So, that smoothing of the resource is done by how to I will explain how to smoothen the resources in this lecture that is called resource leveling. So, the agenda for this lecture is what is the resource leveling and what is the need for resource leveling, then resource leveling versus crashing, then I am going to explain a heuristic procedure for resource leveling with the help of an example. So, in project management resource leveling is defined by guide to the project management body of knowledge as a technique in which start and finish dates are adjusted based on resource limitation with the goal of balancing demand for resources with the available supply.

Part-II

Project Planning

Traditional project activity planning
Agile project planning
Coordination through integration management
Project feasibility analysis
Estimating project budgets
Project risk management
Quantitative risk assessment methodologies
Critical path method (CPM)
Programme evaluation and review technique (PERT)
Risk analysis with simulation for scheduling
Gantt Chart & Scheduling with scrum
Crashing a project
Resource loading
Resource levelling
Goldratt's critical chain

Agenda

- Resource leveling
- Need for Resource levelling
- Resource levelling vs Crashing
- Heuristic Procedure for Resource Levelling
- Resource Levelling -Example

Resource Levelling

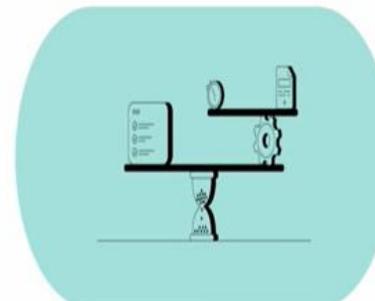
- In project management, resource leveling is defined by Guide to the Project Management Body of Knowledge (PMBOK Guide) as "A technique in which start and finish dates are adjusted based on resource limitation with the goal of balancing demand for resources with the available supply."



So, we are going to match demand and supply of the resources. So, resource leveling problem could be formulated as a optimization problem. The problem could be solved by different optimization algorithm such as exact algorithm or metaheuristic algorithm. Need for resource leveling, networks are not simple sequence of events, activities can performed only when resources that is manpower, machines, materials and so forth are allocated to them.

Resource Levelling

- Resource leveling problem could be formulated as an optimization problem.
- The problem could be solved by different optimization algorithms such as exact algorithms or meta-heuristic methods



Need for Resource levelling

Networks are not simple sequences of events: activities can be performed only when resources, that is, manpower, machines, materials and so forth are allocated to them.

Of course we cannot assume unlimited availability of the resources.



Of course, we cannot assume unlimited availability of the resources. Therefore, whatever resources are available, they must be utilized to the maximum extent. For a given project, we can determine the earliest and the latest possible starting times for all the activities and all the slacks. So, the starting time for an activity may be adjusted to achieve objectives other than just completing the project early. One such objective is the leveling of the resources to the total project because we have the slack for certain activities.

Need for Resource levelling

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Need for Resource levelling

The starting times for activities may be adjusted to achieve objectives other than just completing the project early.

One such objective is the levelling of the resources to the total project.



Need for Resource levelling

Often the managements want to keep the total amount of resources in use during the project performance as nearly constant as possible through time and avoid major shifts in manpower and other resources.

And if constant amounts of resources are given, managerial planning decisions might aim at their maximum utilisation, in terms of the least idle time and, as far as possible, allowing for the smallest variation.



So, the earliest starting time can be adjusted so that there will be a match between demand and supply of the resources. Often the management wants to keep the total amount of resources in use during the project performance as nearly constant as possible through time and avoid major shift in manpower and other resources. And if constant amount of resources are given, managerial planning decision might aim at their maximum utilization in terms of the least idle time and as far as possible allowing for the smallest variation. That is why the leveling is required. The management may wish to level resources to maintain steady progress, expenditure pattern and cash flows.

Need for Resource levelling

The management may wish to level resources to maintain steady progress, expenditure pattern and cash flows.

This analysis, aiming at constancy of the resource usage is called resource levelling.



Resource levelling vs Crashing

- In **resource levelling**, then, the aim is to reduce the peak resource requirements and smooth out period-to-period assignments within a constraint on the project duration.
- It may be recalled that like resource levelling, the crashing also involves reallocation of resources.



So, this analysis aiming at constancy of the resource usage is called resource leveling. In resource leveling, the aim is to reduce the peak resources requirement and smooth out the period to period assignment with a constraint on the project duration. It may be recalled that like resource leveling, the crashing also involves reallocated of resources. But whereas in crashing, shortening of the project time is the objective, in resource leveling, smoothing of the resource usage rate without changing the project duration is the objective. So, in crashing our aim is to reduce the time and reduce the cost also.

Resource levelling vs Crashing

- But whereas in **crashing**, shortening of the project time is the objective, in resource levelling, smoothening of the resource usage rate without changing the project duration is the objective.



Resource levelling

- It is possible to smooth either individual key resources or all the resources employed in the project on a daily basis.
- It may easily visualised that such an analysis would very complex when activities and resources involved are numerous, and it sometimes might require revising the entire project schedule.
- However, this might worth investigating before key resources are committed.



But in crashing that the levels should be equally, constantly should be utilized, the level of the resources that is objective of this leveling. It is possible to smooth either individual key resources or all the resources employed in the project on daily basis. It may easily visualized that such an analysis would be very complex when activities and resources involved are numerous and it sometimes might require revising the entire project schedule. However, this might worth investigating before the key resources are committed. Here we discuss a heuristic method for leveling of resources in a given situation.

Heuristic Procedure for Resource Levelling

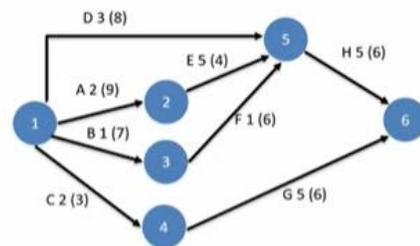
- Here we discuss a heuristic method for the levelling of resources in a given situation.
- To keep the problem simple, suppose that personnel is the only resource to be considered.
- The method is explained with the following example.



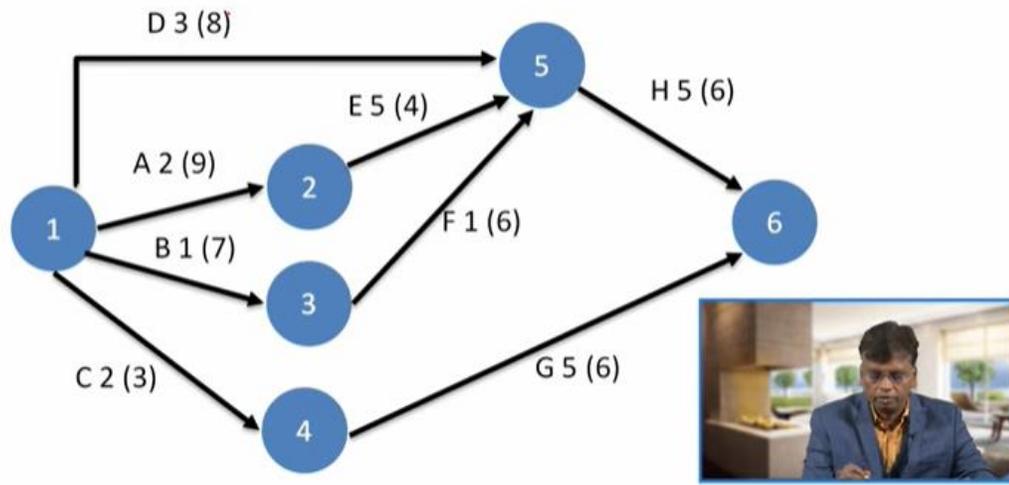
To keep the problem simple, suppose that the personnel is the only resource to be considered. The method is explained with the following example. In this leveling example, you are given a figure and corresponding network for your project. Here the project activities require manpower. So, this represents, so whatever value which are in the bracket represent the manpower required and this D represents the activity name and 3 represents the duration.

Resource Levelling -Example

- You are given in Figure the network corresponding to a project.
- The project's activities require manpower of similar type, and the requirements, in terms of the number of men, are shown in parentheses next to the activity identification and timing (in days) for each.
- The network corresponding to a project in Figure



Resource Levelling -Example

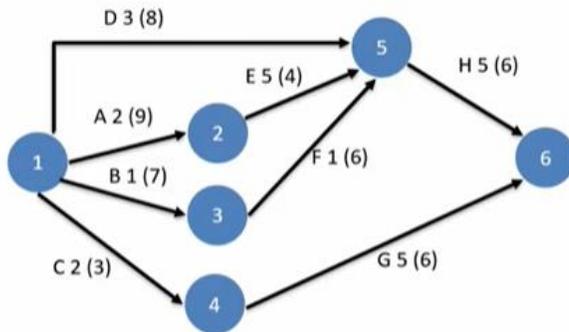


Resource Levelling -Example

- Determine how the activities of the project may be scheduled in order to have as smooth a requirement for the manpower as possible, without causing a delay in the project completion.

Now you see there are 1 to 5 activity D, duration is 3 unit of time, manpower requirement is 8. Similarly, A, B, C, E, F, G and H. Now determine how the activities of the project may be scheduled in order to have a smooth a requirement for the manpower as possible without causing a delay in the project completion. So, we have to find out the correct project schedule so that the manpower requirement is constant. There should not be any high variation in the manpower requirement.

Critical path



1-5-6 → 8 Days

1-2-5-6 → 12 days

1-3-5-6 → 7 days

1-4-6 → 7 days

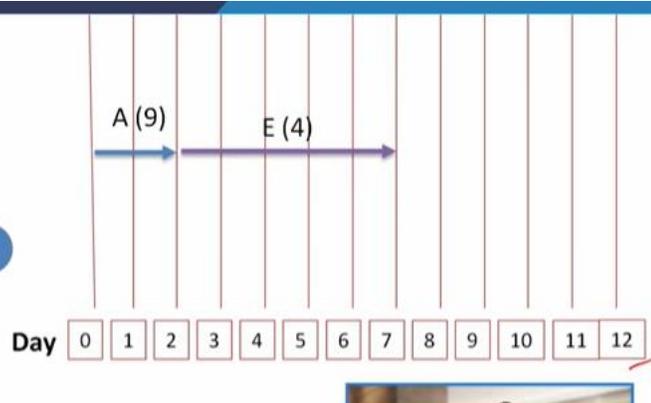
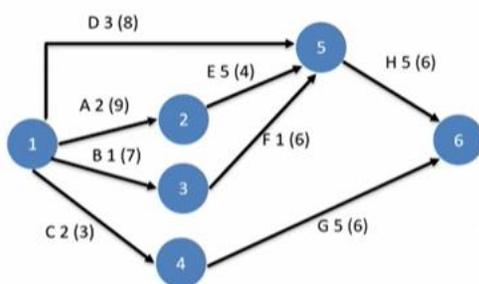


So, the first task here is we have to find out the critical path. So, what are the possible critical path and corresponding the duration? So, 1, 5, 6 is possible, this 1, 5, 6 is possible. So, the duration is 3 plus 5, 8 days. Another route is 1, 2, 5, 6. This also 1 possible.

Duration is 2 plus 5, 7 plus 5, 12. Another route is this route 1, 3, 5, 6. Here the duration is 1 plus 1, 2, 7 days. The another route is this route 1, 4, 6. Here the duration also 7 days.

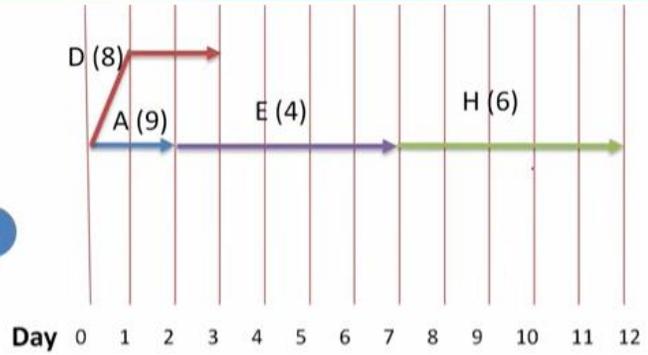
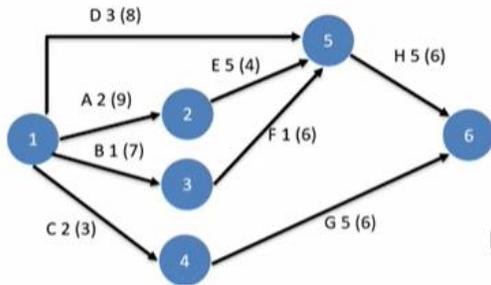
So, the critical activity is this one 1, 2, 5, 6. So, why we are finding critical activities? You cannot do any adjustment because there is no slack in that activities. So, what I have done? I have up to 12 days I have done that one. I have given a scale for up to 12 days. So, I have written all the critical activities.

Critical path

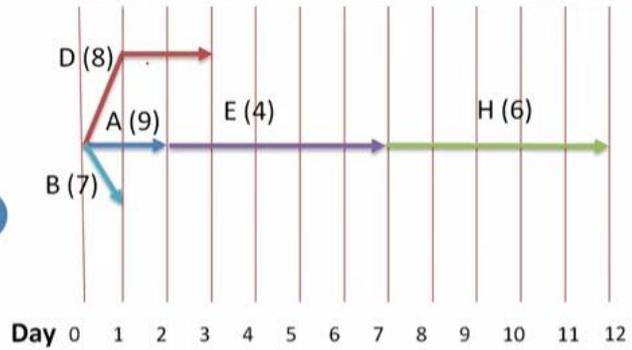
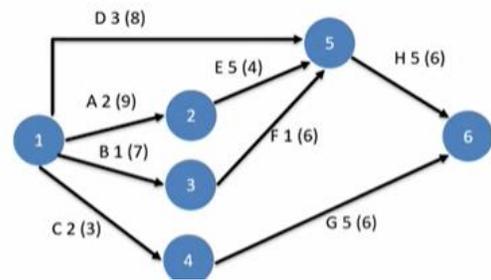


What is that critical activities? Here activity A, activity E and activity H. So, activity A is there, then activity E is there, then activity H is there. The next activity is activity D. So, activity D duration is 3 days, the manpower requirement is 8. So, whatever value which is written in the bracket is manpower requirement.

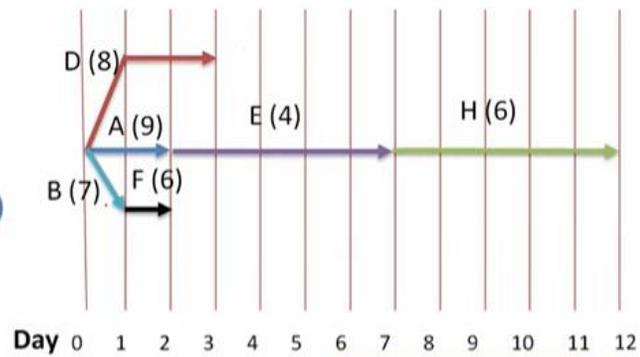
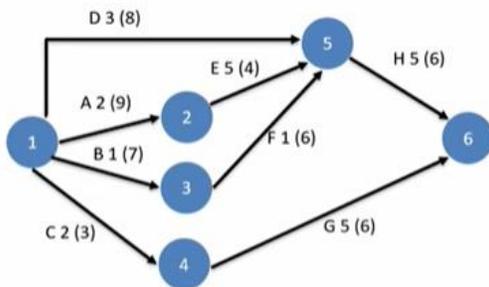
Critical path



Critical path



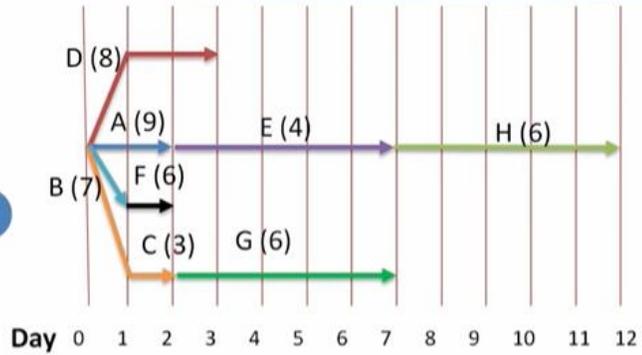
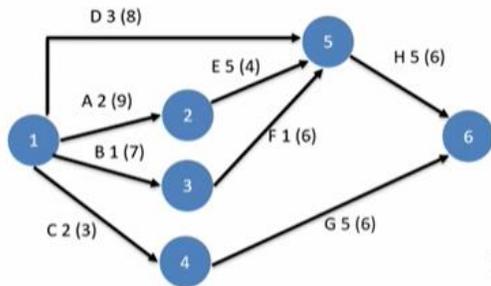
Critical path



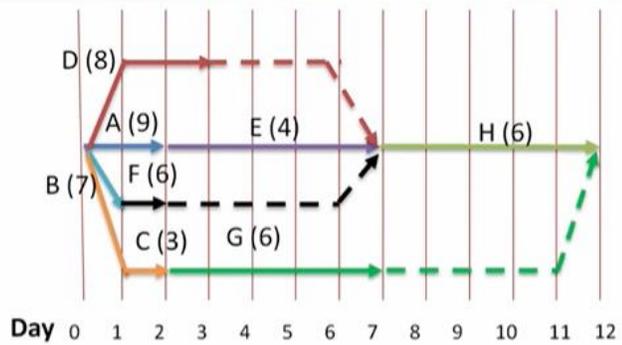
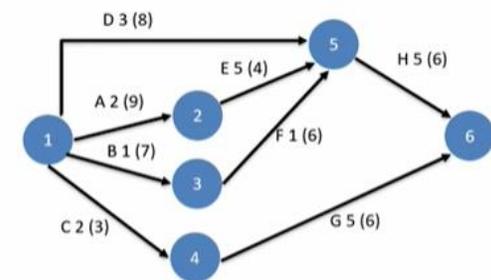
So, activity D I have written. The next activity is B. So, manpower requirement is 7, but the duration is 1 day. The next activity is F. The F duration is 1, but the manpower requirement is 6.

Next activity is C. The duration is 2 day, but the manpower requirement is 3. The next activity is G. Duration is 5 days, 1, 2, 3, 4, 5 days. The manpower requirement is 6. So, now I have completed all the activities.

Critical path



Critical path

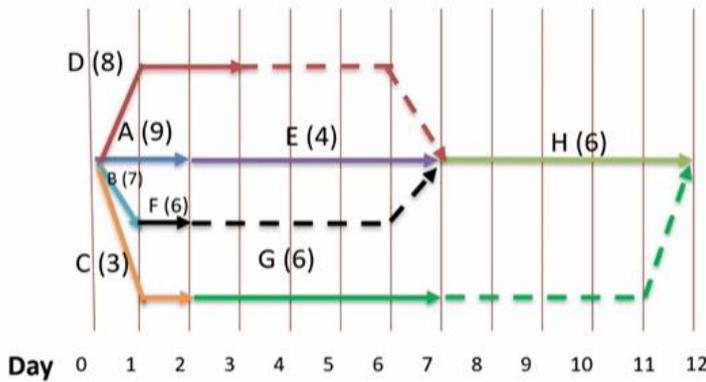


So, what it says that A, E, H is the critical activity. For example, activity D duration is 3 days, but it is finishing with the E. So, that is why I have written in the dotted line. So, activity B duration is 1 day and after that activity F. So, activity F is finishing with activity E.

That is why I have completed with the dotted line. Similarly, for activity C, activity G. So, activity G finishing with activity H, that is why I have written in the dotted line. So, how I got the 12 because 12 is the maximum duration. Now what we have to do? Now here we have to do the concept of smoothing, leveling.

So, what I am going to do? For each day, I am going to find out what is the manpower requirement. Now I have drawn the project network. Now I am going to find out the manpower required for each day. For example, day 1, so we need here 8, 8 plus 9, 17, 17 plus 7, 24, 24 plus 3 is 27. Similarly, for day 2, 8 plus 9, 17, 17, 6, 17 plus 6, 23.

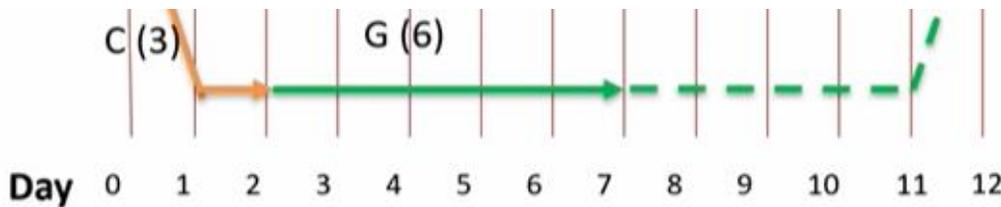
Critical path



Men Required

27	26	18	10	10	10	10	6	6	6	6	6
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So 23 plus 3 is 26. Day 3, 8 plus 4, 12, 12 plus 6, 18. Day 4, 4 plus 6, 10. Even day 5, 10, 6, 10, 7, 10. See on the 8th day, we have 6, 6, 6, 6, 6. So when you plot it in x axis, it is the day.



Men Required

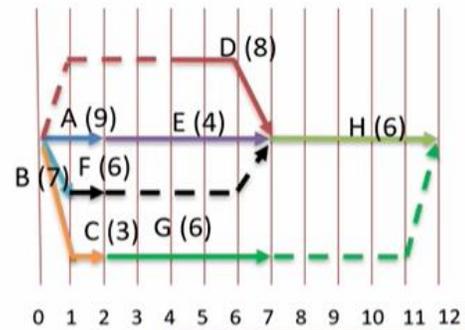
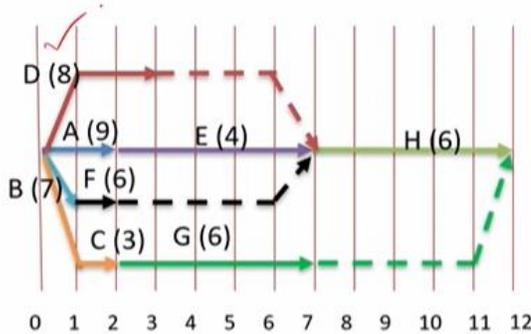
27	26	18	10	10	10	10	6	6	6	6	6
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$8 + 9 + 7 + 3$

In y axis is manpower. So what is happening? The first two days, there is a lot of fluctuation. So here up to 9th day onwards, manpower requirement is only 6. So 4th to 7 manpower requirement is only 10. But the initial days, there are more variation is there. So now what I am going to do? I am going to reallocate these activities within the available limits, so that the manpower is leveled, smoothed.



Action

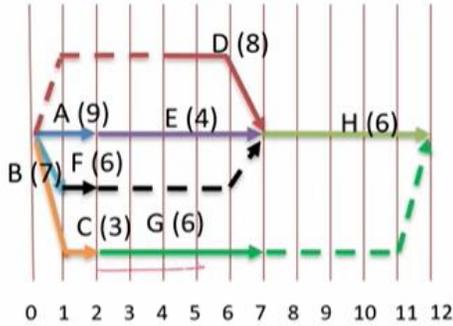


Postpone D to the beginning of 5 day

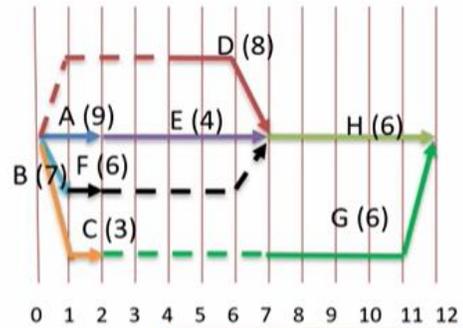


So what I am going to do? So postpone activity D, so this activity D to the beginning of the 5th day. So what I have done? You look at from the left hand side to right hand side. So instead of 0th day, so I am starting on the 4th day, that is the beginning of the 5th day. Because the duration is 1, 2, 3, that is the first action. The second one what I am going to do, postpone G to the beginning of 8th day.

Action

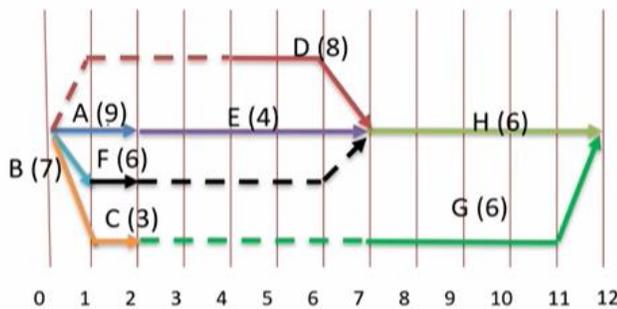


Postpone G to the beginning of the 8th Day



What is the G? This is G is there currently. Now I am going to push it on the beginning of 8th day, that means the 7th day onwards. So after readjusting, now I am going to find out what is the manpower requirement. Now you see, day 1, the requirement is 9 plus 9 plus 7, 16 plus 3 it is 19.

Day 2, 9 plus 6, 15 plus 3, 18. In day 1, 2, 3, in day 3 it is 4. Day 5 also it is 4. Now you see here, here the manpower requirement is 12, because this 8 plus 4, 12. So here also 8 plus 4, 12.



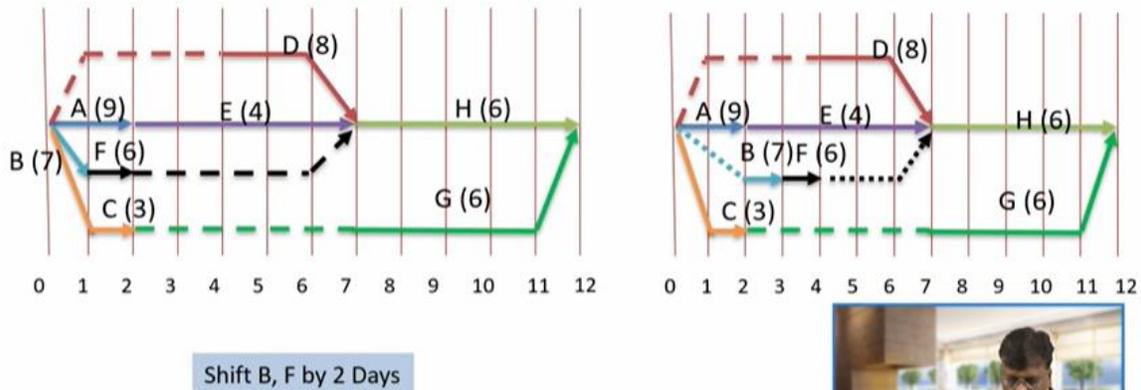
Men Required	19	18	4	4	12	12	12	12	12	12	12
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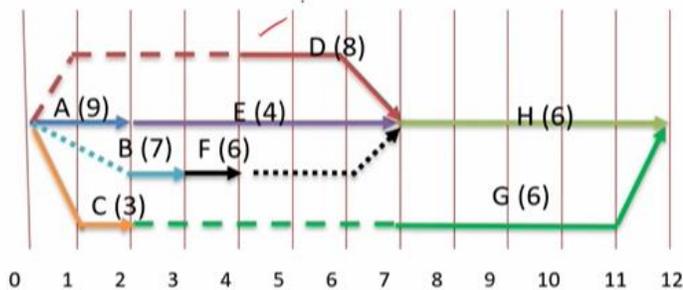
Here also 8 plus 4, 12. After that 6 plus 6, 12, 12, 12, 12, 12. So after doing that readjusting, what I have done? I have done some changes in activity D and activity G. Then now when I plot that meant required versus time, so after 5th day, it is manpower requirement is 12. But still on the first 2 days and 3 and 4th day, there is a more variations. Now I am going to do further some adjustment, then I am going to see what is the

manpower

requirement.



So what I am going to do? I am going to shift activity B and F. So this is my activity B and F to 2 days. So instead of starting on 0th day, after 2 days if I start it, then this will be my new network. Now for this new network, I am going to find out what is the manpower requirement. So what modification I have done? D I have shifted, G I have shifted and B and F together I have shifted.



Men Required	12	12	11	10	12	12	12	12	12	12	12
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Now what is the manpower requirement? 9 plus 3, 12. Here 9 plus 3, 12 and 3rd day 7 plus 4, 11 and 4th day 6 plus 4, 10 and 5th day 8 plus 4, 12, 12, 12, 12, 12, 12, there is no problem. So now finally what has happened that when I plot this manpower requirement and the versus time see the company can run with 12 manpower for 12 days, there will be slight variation on 3rd and 4th day. So how I am able to achieve this? After doing a small modification within the slack of each activities, then I am able to level the workload requirement. So this is possible and one important point here, you cannot do any adjustment on the critical path because their flow to 0 you cannot do any adjustment, but only for non-critical activities you can adjust your early start time so that it is not violating

the overall project duration and the precedence diagram.

So when you adjust it what has happened that the manpower requirement is equally leveled. And one more thing this is a trial and error method, there is a heuristic method. See if the problem is very big, if there are so many activities, so manually doing this adjustment is not possible. So you have to go for some optimization techniques softwares. Obviously this heuristic procedure become quite complicated when many activities with many combinations are required to be considered.

Resource Levelling -Example

- Obviously, this heuristic procedure becomes quite complicated when many activities, with many combinations are required to be considered.
- In such situations it may be necessary and useful to employ a computer for the purpose.

In such situation it may be necessary and useful to employ a computer for this purpose. So in this lecture I have explained what is the resource leveling, then I discussed about need for resource leveling, then I have compared the resource leveling versus crashing, then with the help of a numerical example by using a heuristic procedure I have explained how to do the leveling. Thank you.