Project Management

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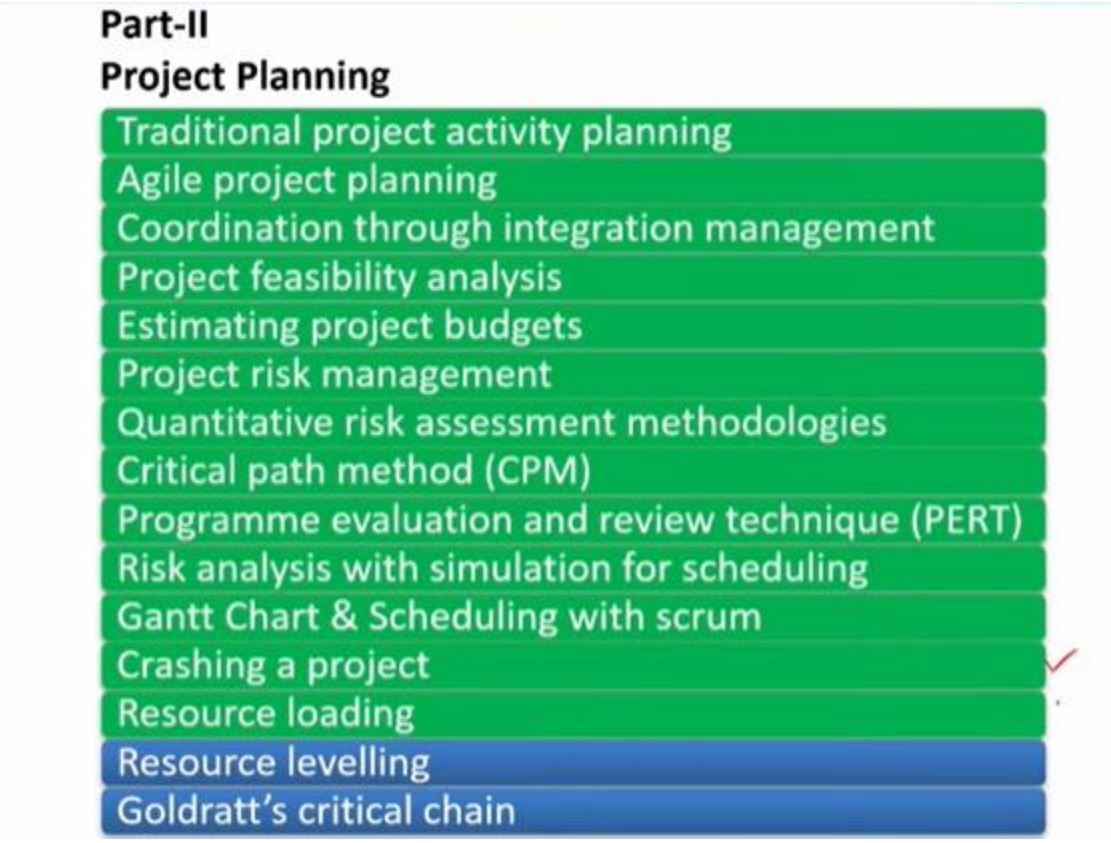
Week: 5

Lecture 25 Resource Loading

Dear students, today topic is resource loading. In the previous class, I have discussed about crashing a project. Now I am going to discuss about resource loading. The agenda for this lecture is this resource loading comes under resource allocation. I am going to talk about what is allocations, then importance of resource allocation, then with the help of a numerical example, I am going to explain how to load resources into a project network. First we will see what is the resource allocation.



Agenda

- Resource Allocation
- Importance of Resource Allocation
- Resource Loading
  - Numerical example

Resource Allocation

- A shortcoming of the scheduling is that they do not address the issues of resource utilization and availability.
- The focus is on time rather than physical resources.
- Also, it will not be sufficient to refer to resource usage simply as "costs."

A shortcoming of the scheduling is that they do not address the issue of resource utilization and availability. The focus is on time rather than resources. Also it will not be sufficient to refer the resource usage simply as a cost. So what you have done so far? So far we have done whether it is a critical path method or PERT, our important resource is only time.

Resource Allocation

- Instead, we must refer to individual types of labor, specific facilities, kinds of materials, individual pieces of equipment, and other discrete inputs that are relevant to an individual project but are limited in availability

We did not consider the other element, but in this lecture we are going to consider apart from time and cost, we are going to consider other element of resources and how to load that resources into a project network. Indeed, we must refer to individual type of labor, specific facilities, kind of materials, individual pieces of equipment and other discrete inputs that are relevant to an individual projects but are not limited in availability. So these resources also has to be considered at a time of allocating the resources to the different network or project. In addition, we commonly must consider two type of resources, those that are needed in a specific amount for an activity, for example, two machines, two machine hours, five yards of cement and twelve labor days or those that are needed to accompany the labor for as long as the labor is used such as machine. Suppose if you are allocating a resource called machine, so along with the machine you have to allocate to the labor also.

Resource Allocation

In addition, we commonly must consider two types of resources:

(1) those that are needed in a specific amount for an activity (e.g., 2 machine hours, 5 yards of cement, 12 labor days)

(2) those that are needed to accompany the labor for as long as the labor is used, such as a machine.

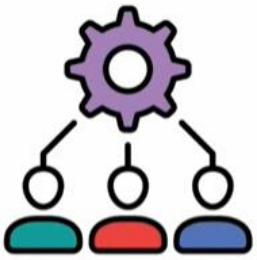
Resource Allocation

- This lecture will clarify which type of these two type of resources we are considering at the time.
- Last, we must not forget that time itself is always a critical resource in project management, one that is unique because it can neither be inventoried nor renewed.

So what we are discussing here is specific amount. So when you allocate the resources there are some accompanied resources that also need to be allocated. So in this lecture we will clarify which type of these two type resources we are considering at the time and we must not forget that the time itself is always a critical resource in project management. One that is unique because it can neither be inventoried or renewed. Already in the critical path method or PERT we consider only the time but in this lecture we are going to consider other resources apart from time like cost or when you say cost is a very common term.

Resource Allocation

- One cannot **save time—one can only spend more or less of it**.
- The relationship between progress, time, and resource availability/usage is the major focus of this lecture
- Schedules should be evaluated not merely in terms of meeting project milestones but also in terms of the timing and use of scarce resources.



So instead of cost we can say about what is the machine, manpower, scarce resources that resources also we are going to consider in this lecture. The importance of time is we cannot save the time, we can only spend more or less of it. So the relationship between progress, time and resource availability or usage is the major focus of this lecture. So what we are going to discuss when we say a project is progress, how much time it is

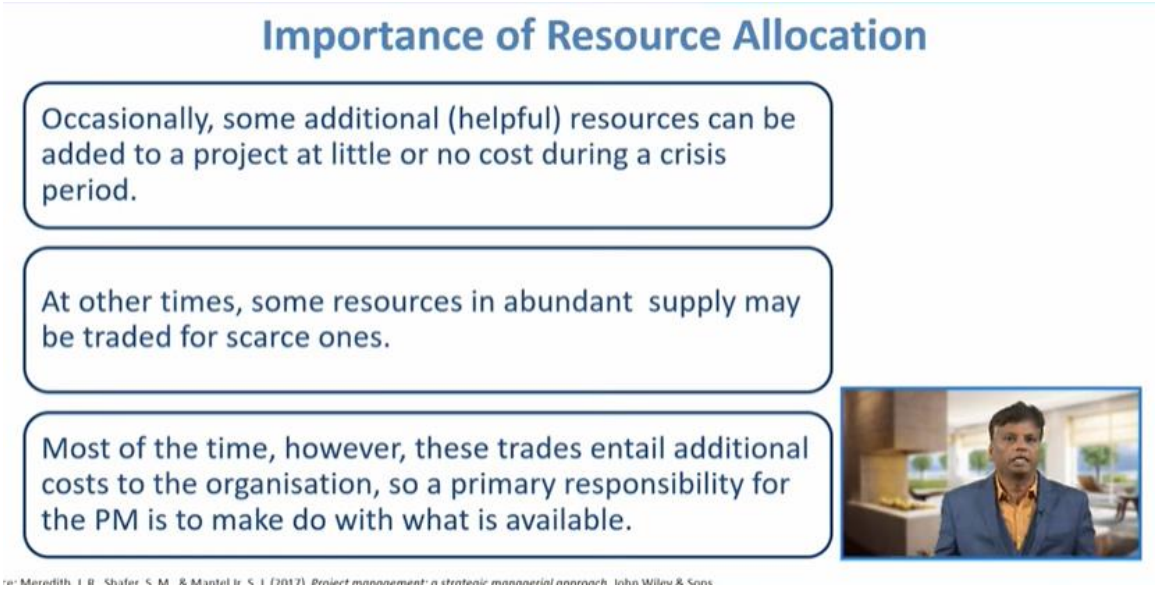
taken, how much resources it has consumed that element also important that we are going to discuss in this lecture. Schedules should be evaluated not merely in terms of meeting project milestone but also in terms of the timing and use of scarce resources.

Importance of Resource Allocation

- A fundamental measure of the PM's success in project management is the skill with which the trade-offs among scope, time, and cost are managed.
- It is a continuous process of cost–benefit analysis: "I can shorten this project by a day at a cost of $400.
- "Should I do it?"
- "If I buy 300 more hours of engineering time, I may be able to improve performance by 2 or 3 percent.
- "Should I, do it?"

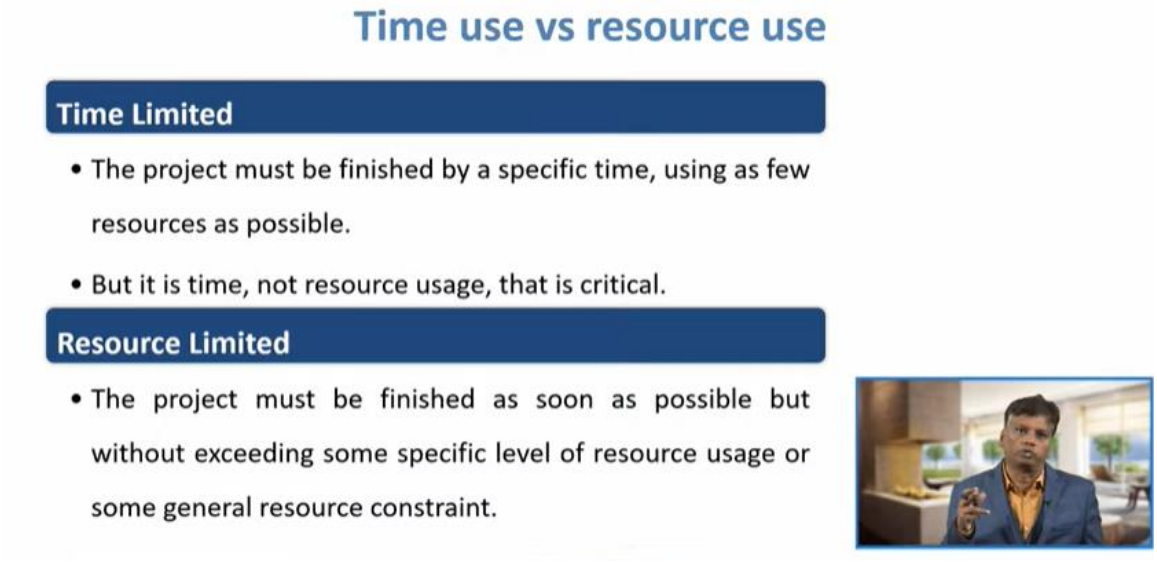
So it is not the final outcome is not more important but how effectively we have utilized the resources to reach that outcome also more important. Now we will see the importance of resource allocation. A fundamental measure of project manager success in project management is that skill with which the trade off among scope, time, cost are managed. So right from the beginning of this lecture we are discussing an important task of your project manager is trade off. Trade off among scope, time and cost.

It is a continuous process of cost benefit analysis. For example, somebody can say I can shorten this project by a day at the cost of $400. So what will happen when you reduce the time the cost is increasing. So it is the cost benefit analysis. In that situation should I do it or if I buy a 300 more labors of engineering time I am able to improve the performance by 2 or 3 percentage.



Now here also the trade off is required. So the role of project manager is should I do it. So when we add more resources what will happen? Occasionally some additional resources or helpful resources can be added to the project a little or no cost during the crisis period. At other times some resources in abundant supply may be traded as scared one. Most of the time however this trade entail additional cost to the organization.

So the primary responsibility for a project manager is to make do with what is available. So how effectively allocating resources at the right time at the right amount is more important task of a project manager. Now we discuss about the two important resources one is time versus time use versus resource use. For example, in some project time is more important element. The project must be finished by a specific time using a few resources as available.



So here the time is more important but it is time not the resource uses that is critical.

Other type of project there may be restriction on resources utilized. Here the project must be finished as soon as possible but without exceeding some specific level of resource usage or some general resource constraint. So in the first case the time is a constraint the second case the resource is constraint. Now we will talk about system constraint resources.

System constrained resources

- Some industrial processes—heat treating, for instance—are system-constrained.
- The material must be "cook" for a specified time to achieve the desired effect.
- More or less "cooking" will not help.
- When dealing with a system-constrained task or project, no tradeoffs are possible.

Some industrial process for example, heat treating is an example of system constraint because that may require a technically specific amount of time. So you cannot remove that constraint. For example, the material must be cooked for a specified time to achieve the desired effect. More or less cooking will not help. In dealing with a system constraint task or project no tradeoff are possible because that constraints are technical constraint that we cannot remove it.

Resource Loading

- Resource loading describes the amounts of individual resources an existing schedule requires during specific time periods.
- Therefore, it is irrelevant whether we are considering a single work unit or several projects
- The loads (requirements) of each resource type are simply listed as a function of time period.

So reducing the time or reducing the cost is only applicable for non-system oriented constraint. Now we will come back to the resource loading. Resource loading describes the amount of individual resources an existing schedule requires during specific time

period. Therefore it is irrelevant whether we are considering a single work unit or several projects. The load that is a requirement of each requirement of resources.

Resource Loading

- Resource loading refers to assigning and distributing resources, such as people, equipment, and materials, to specific tasks or activities within a project.
- It involves determining which resources are needed for each part of the project, how much each resource is required, and when they are needed.

So the load of each resources the load of each resource type are simply listed as a function of time period. Resource loading refers to assigning and distributing resources such as people, equipment and material to specific task or activities within your project. So the purpose of resource loading is allocating resources like people, equipment, materials to a specific task in your project. It involves determining which resources are needed for each part of the project and how much each resources required and when they are required. So these are the questions that will be answered in the resource loading problem.

Resource Loading

- It is an excellent guide for early, rough project planning.
- Obviously, it is also a first step in attempting to reduce excessive demands on certain resources, regardless of the specific technique used to reduce the demands.

It is an excellent guide that is resource loading for early rough project planning. Obviously, it is also a first step in attempting to reduce excessive demand on certain resources regardless of specific techniques used to reduce the demand. Again we caution the project manager to recognize that use of resources on a project is often non-linear. It is not that when you add more resources there will be a more outcome. So many software packages they think that when you add more resources there will be a more output.

Resource Loading

- Again, we caution the PM to recognize that the use of resources on a project is often nonlinear.
- Much of the project management software does not recognize this fact

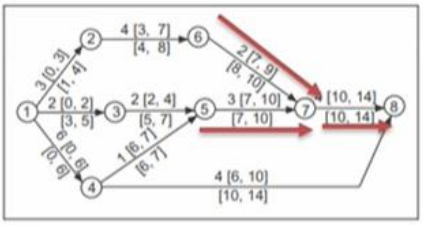
Resource Loading

- If resources of a project are increased by X percent, the output of the project usually does not increase by X percent, and the time required for the project does not decrease by X percent.
- The output and time may not change at all, or may change by an amount seemingly not related to X.
- An increase of 20 percent in the number of notes played does not necessarily improve the quality of the music.

So that is not the case. So what is happening much of the project management softwares does not recognize this fact. For example, if resources for a project are increased by X percent the output of the project usually does not increase by X percent and the time required for the project does not decrease by X percent because it is not linear. So the output on the time may not change at all or may change by an amount seemingly not related to X. An increase of 20 percentage in the number of nodes played does not necessarily improve the quality of the music.

Resource Loading – An Example

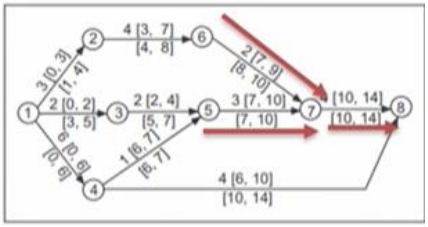
- Suppose the network shown in the Figure is given.
- It is known that each of the activities 5—7, 6—7 and 7—8 require the use of a large crane to employed.
- The crane can used on a single activity at a time and has to be employed from the start of the activity to its finish.



So the point you have to remember is just because of adding more resources you cannot reduce the project completion time or you cannot expect more performance. Now I will explain the concept of resource loading with the help of this example. Look at the figure on the right hand side. There are 8 event is there. It is known that each of the activities for example 5-7, 6-7 require the usage of large crane to be employed.

Resource Loading – An Example

- Now, if we had two cranes, then they would employ on these activities as soon as needed, and there would be no delay.
- However, if only one crane is available, then the question to answered is whether, and by how much, the project would be delayed.

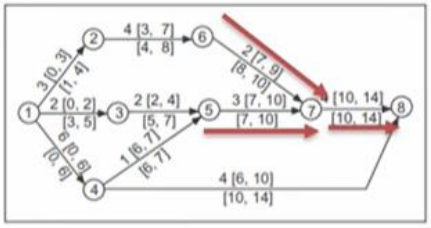


So you need a crane that need to be employed on these 3 activities which are highlighted in the color. The crane can be used on a single activity at a time and has to be employed from the start of the activity to its finish. Now if you have 2 crane then they would employ on these activities as soon as needed and there would not be any delay. However, if only 1 crane is available the question to be answered is whether by how much the project would be delayed. So if there is only 1 crane then there is a scarcity on the resources.

So the project duration will increase. But if there are more resources for example if you have a 2 crane there would not be any problem because you have additional resources that can be used to reduce the project time but the cost will increase. So from the network we observe that technologically activity 7, 8 can be performed this 7, 8 only when both 5, 7 and 6, 7 are completed. However activity 5, 7 can be performed before or after the activity 6, 7. So what happening here? 5, 7 and 6, 7 can be done in the sequential manner.

Resource Loading – An Example

- From the network, we observe that technologically, activity 7-8 can be performed only when both 5—7 and 6—7 are completed.
- However, activity 5—7 can be performed before or after the activity 6—7.
- Thus, we have to decide which of the two activities 5—7 and 6—7, should be scheduled first.
- Since both of them have the exact early start times, the choice would rest on the slack.



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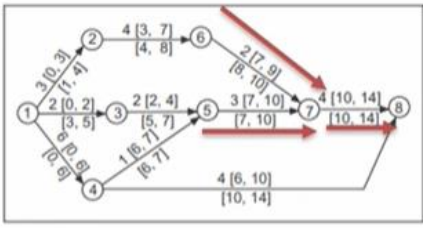
Thus we have to decide which of these 2 activities like 5, 7 or 6, 7 should be scheduled first. Since both of them have the exact early start time for example 5 to 7 also, early start time this is the your early start time 7 for 6 to 7 also 7. Since both of them have exact early start time the choice would rest on the slack. So we have to see where there is a minimum slack. For example in the 5 to 7 the slack is 0.

What is the meaning of slack here? Let us to start time when you say slack, let us to start time minus earliest start time 7 minus 7 0. So we are going to prefer activity 5 to 7. So we observe that the activity 5, 7 has no slack that is 0 slack while the activity 6, 7, 6 to 7 has a slack of 1 day. So these activities could therefore scheduled in the order of 5 to 7 and 6 to 7. So there are 2 eligible activities one is 5 to 7 and 6 to 7.

Resource Loading – An Example

- We observe that the activity 5—7 has no slack while the activity 6—7 has a slack of one day.
- These activities could therefore be scheduled in the order 5—7, 6—7.
- The ordering of the activities would affect the length of the project.



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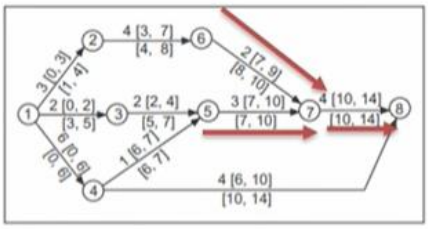
Both of them have same early start time here also 7, here also 7. But when you look at the slack so 5 to 7 has the 0 slack, 6 to 7 has 1 slack. So the first preference has to be given while allocating the resources when there is a less slack. Here it is 0 slack because it is a critical activity. So the order in which we can assign the resources is 5 to 7 then we can go for 6 to 7.

So the ordering of these activities would affect the length of the project. So when you this order of the activities for which you are going to allocate the resources will affect the project duration. Now we allocate the resources to 5 to 7. Why we have chosen 5 to 7? Even though 5 to 7 and 6 to 7 both are having same early start time.

Resource Loading – An Example

- Allocate resources 5-7
- When the crane is used on an activity for three days, the activity 6—7 cannot start before the time 10, with the result that the activity 7—8 would start only at time 12 and not at 10 as scheduled earlier



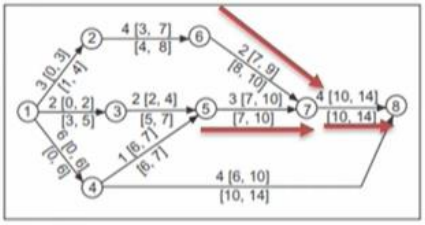
So 5 to 7 have 0 slack time. So we have to allocate, we have to give the preference to activities which are having lesser slack time. So as per this logic first we allocate our crane to 6 to 7. So when you allocate it 5 to 7 we are allocating the resources to 5 to 7.

So when you allocate to 5 to 7 and the seventh day it will start it will finish on tenth day. So what will happen to the activity 6 to 7? So activity 6 to 7 can start only on the tenth day because up to tenth day 5 to 7 is busy.

Then it can reach you can complete only on the twelfth day. So that is what I have explained here. First we are allocating resources to 5 to 7. When the crane is used on an activity for 3 days the activity 6 to 7 cannot start before time 10 with the result of that activity 7 to 8 would start only at time 12 and not at 10 as scheduled earlier. So when they start on 12 because that activity 7 to 8 will take 4 days they can finish only on the sixteenth day.

Resource Loading – An Example

- Thus, it would delay the project by two days.
- Notice that if the activities were scheduled as 6—7 followed by 5—7 instead, the project would have delayed by two days then as well.



Thus it would delay the project by 2 days. Notice that if the activities were scheduled as 6 to 7 suppose if you allocate first 6 to 7 then 5 to 7 what will happen? If you allocate to 6 to 7 it will take ninth day. So ninth day activity 5 to 7 will start so ninth day it will start 9 plus 3 only twelfth day it can finish it. So this will become 12 again it will become 16. So notice that if the activities were scheduled as 6 to 7 followed by 5 to 7 instead the project would have delayed by 2 days then as well. So whether you follow 5 to 7 or 6 to 7 the project is delayed by 2 day but the order should be first we should go to 5 to 7 then we should go to 6 to 7.

Resource Loading – A Numerical Example

- For a project consisting of several activities, the duration and required resources of carrying out each of the activities and their availabilities are given below.

Activities	Resources required		Duration (Days)
	Equipment	Operators	
1–2	X	30	4
1–3	Y	20	3
1–4	Z	20	6
2–4	X	30	4
2–5	Z	20	8
3–4	Y	20	4
3–5	Y	20	4
4–5	X	30	6

Now I have taken a numerical example for allocating the resources. So for your project consisting of several activities the duration and the required resources for carrying out each of the activities and their availabilities are given below. So here activities are given we are considering two resources one is equipment and operators. The duration of each activity also given and what are the resources availability? Number of operators is 50 we have equipment X 1 unit equipment Y 1 unit equipment Z again 1 unit. So what we need to find out draw the network identify critical path and compute the total float for each of the activities then find the project completion time under the given resource constraint.

Resource Loading – A Numerical Example

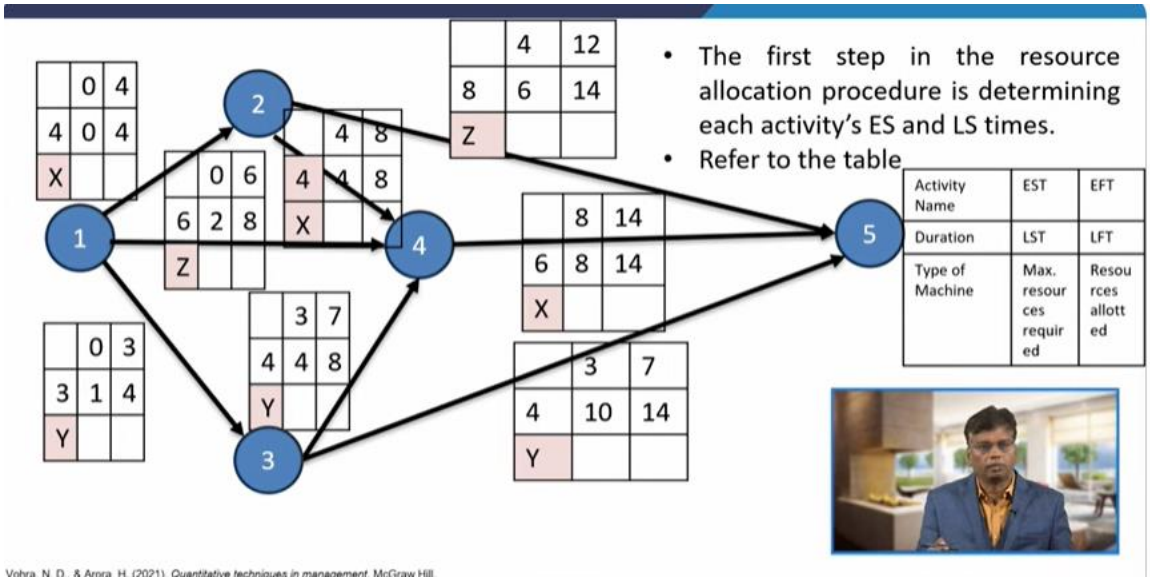
Resources Availability:

- No. of operators = 50
- Equipment X = 1
- Equipment Y = 1
- Equipment Z = 1

Activities	Resources required		Duration (Days)
	Equipment	Operators	
1–2	X	30	4
1–3	Y	20	3
1–4	Z	20	6
2–4	X	30	4
2–5	Z	20	8
3–4	Y	20	4
3–5	Y	20	4
4–5	X	30	6

(a) Draw the network, identify critical path and compute the total float for each of the activities.

(b) Find the project completion time under the given resource constraints.



Now what I have done for each activities I have found earliest starting time and earliest finishing time using forward algorithm using backward algorithm I have found the latest finish time and the latest start time. So the legend which I am using for this boxes is like this the extreme left corner is activity name for example this activity name is 1 to 2 this is 1 to 3 this is 1 to 5 this is 1 to 4 this is 2 to 4 this one is 3 to 4 this one is 3 to 5 this one is 4 to 5. So the first cell is activity time the next one is earliest start time the extreme one is earliest finishing time. So below the activity name I have written the duration then I have written latest start time, latest finish time below that the type of machine equipment required and maximum resources required for that activity and how much we are doing the allocation resources allotted what this figure says that so activity 1 to 2 earliest starting time is 0, 0 plus 4 is a 4 earliest finishing time and the X represents what type of equipment is required. In this cell what is the maximum manpower is required this cell and this cell I am going to write what we are how much manpower we are allocating.

Resource Loading – A Numerical Example

- The resources are allocated by stepping through time, scheduling the various activities as soon as their respective predecessors are scheduled and the resources required for them are available.
- For this purpose, two sets of activities are defined.

So using forward pass and backward pass I have found all these values. So the resources are allocated by stepping through time scheduling the various activities as soon as their respective predecessors are scheduled and the resources required for them are available. So for this purpose two set of activities are defined. The first set of activities

is called eligible activity set. So the first of these comprises those activities which are eligible for assignment as their predecessors have scheduled.

Eligible Activity Set (EAS)

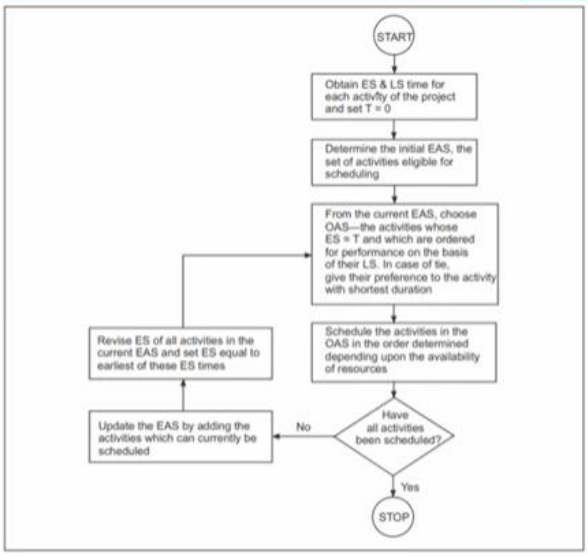
- The first of these comprises those activities which are eligible for assignment as their predecessors have scheduled.
- This may be termed as the **Eligible Activity Set (EAS).**

Ordered Activities Set (OAS)

- From the eligible activities, those activities are selected, which can start at the particular time when resources are to be allocated, and they are ordered by the criterion laid out earlier.
- These activities constitute the **Ordered Activities Set (OAS).**

This may be termed as eligible activity set. Then we are going to discuss about ordered activity set. So from the eligible activities those activities are selected which can start at the particular time when the resources are to be allocated and they are ordered by the criterion laid out earlier. So what are the criteria? One criteria is earliest start time it should be equal to whatever time we set it should be greater than the ES greater than or equal to earliest start time. Then the float should be minimum.

Resource Allocation Algorithms



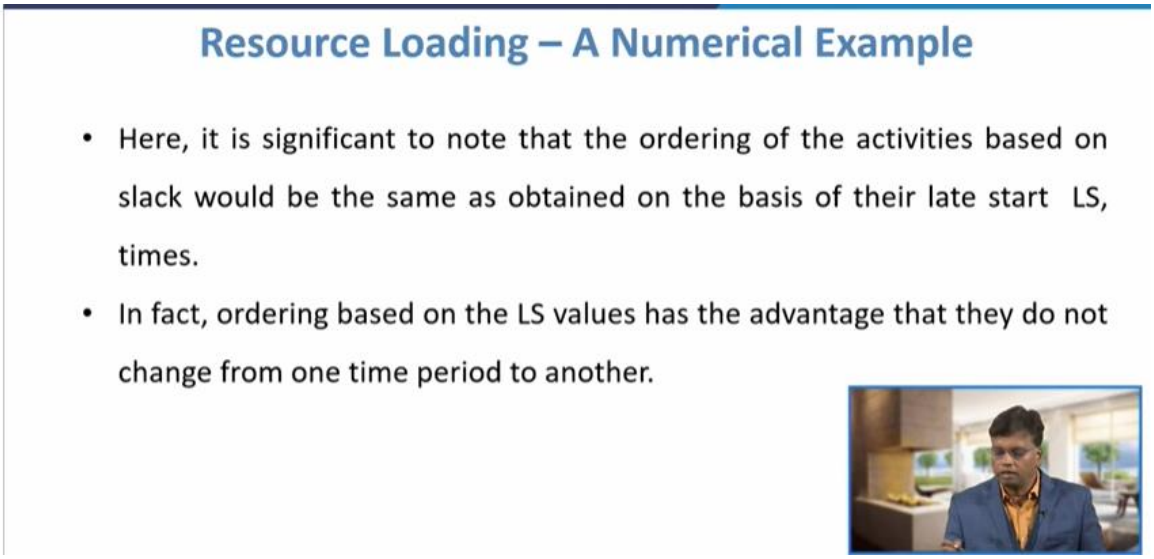
ES = Earliest start
LS = Latest Start
EAS = Eligible activity set
OAS = Ordered activity set

So these activities constitute ordered activity set. This algorithm I will explain here. So what is the algorithm says? Obtain earliest start time and latest start time for each activity of the project and set t equal to 0. So for each activity we have to find out

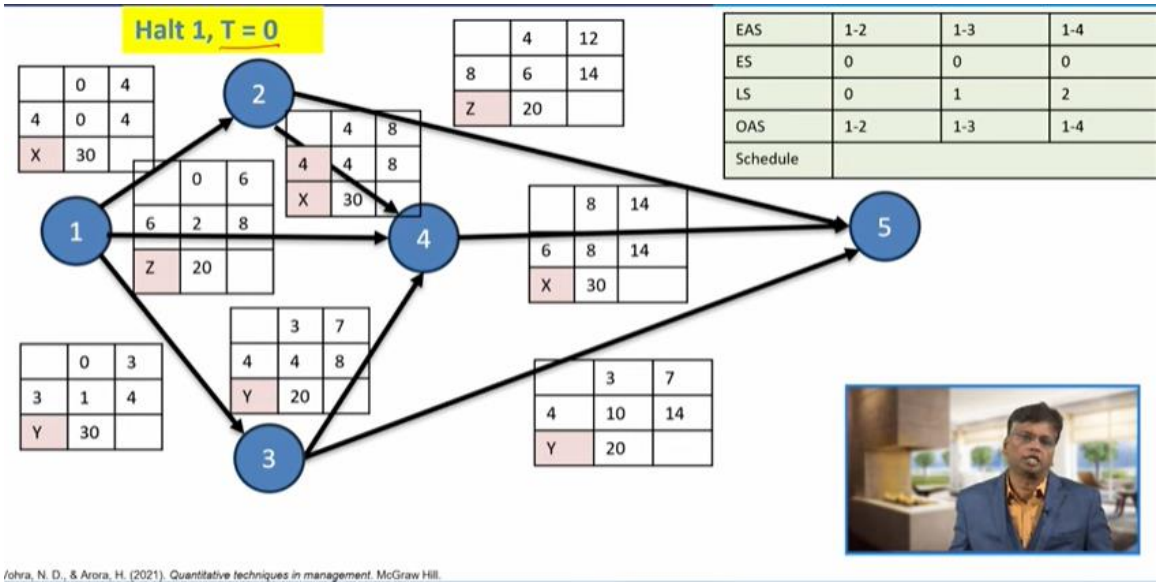
earliest start time and latest start time and set t equal to 0. Then determine the eligible activity set, the set of activities eligible for scheduling. Then from the current eligible activity set choose ordered activity set that is the activities whose earliest start time is equal to t and which are ordered for performance on the basis of their latest start time.

Here we are allocating the resources based on the latest start time. So previously I was talking about when you allocate the resources the preference should be given to the least slack. So there is a connection between this slack and the latest start time that I will explain in the next slide. If there is a tie while allocating the resources with respect to latest start time give the preference to the activity with shortest duration. Schedule the activities in the ordered activity set in the order determined depending upon the availability of resources.

Then have all activities have been scheduled? If it is no then update your eligible activity set by adding activities which can be which can currently be scheduled. Then revise earliest start time for all activities in the current eligible activity set and set early start time equal to earliest of this early start times. So this algorithm I will explain with the help of the problem. Here it is significant to note that the ordering the activities based on the slack would be same as obtained on the basis of their late start time. Just now I told you instead of allocating resources based on the slack what we can do? We can allocate the resources based on the latest start time.

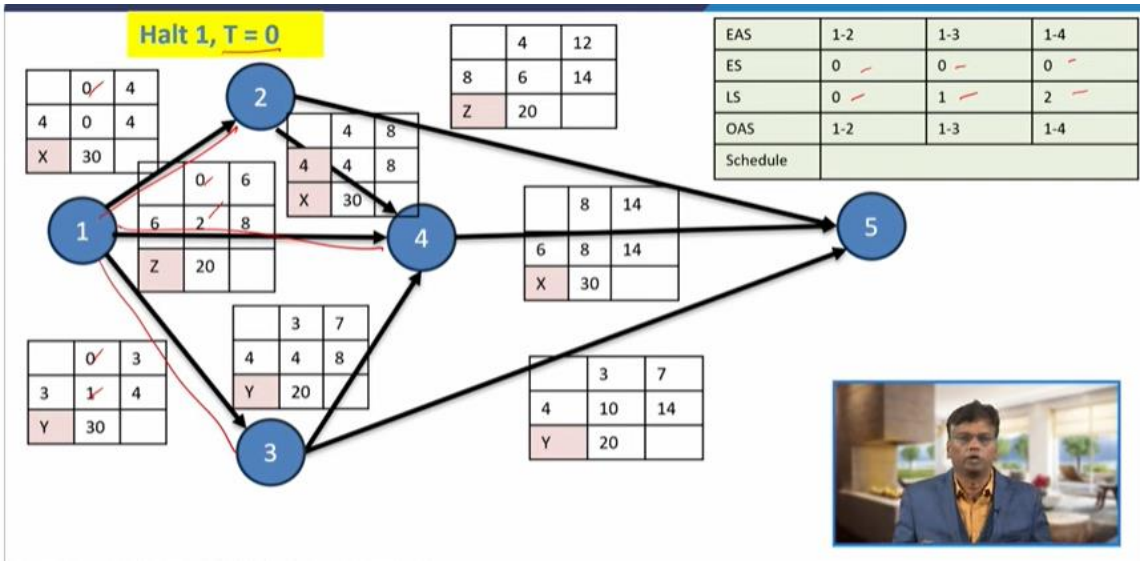


In fact ordering based on the latest start time values has the advantage that they do not change from one time period to another time. So what will happen the slack may change but the latest start time will not change that is why the order of allocation is. First we have to find out which is having least latest start time. So the preference should be given to the latest start time activities. So the first step you see I have taken halt t, T equal to 0, T equal to 0.



So first what is the first task as per the algorithm? First I have to find out eligible activity set. So what are the eligible activity set when time equal to 0? This time 0 is equivalent to here earliest start time. Here 0 is there, here 0 is there, here 0 is there. So what are the eligible activity set 1 to 2? This one.

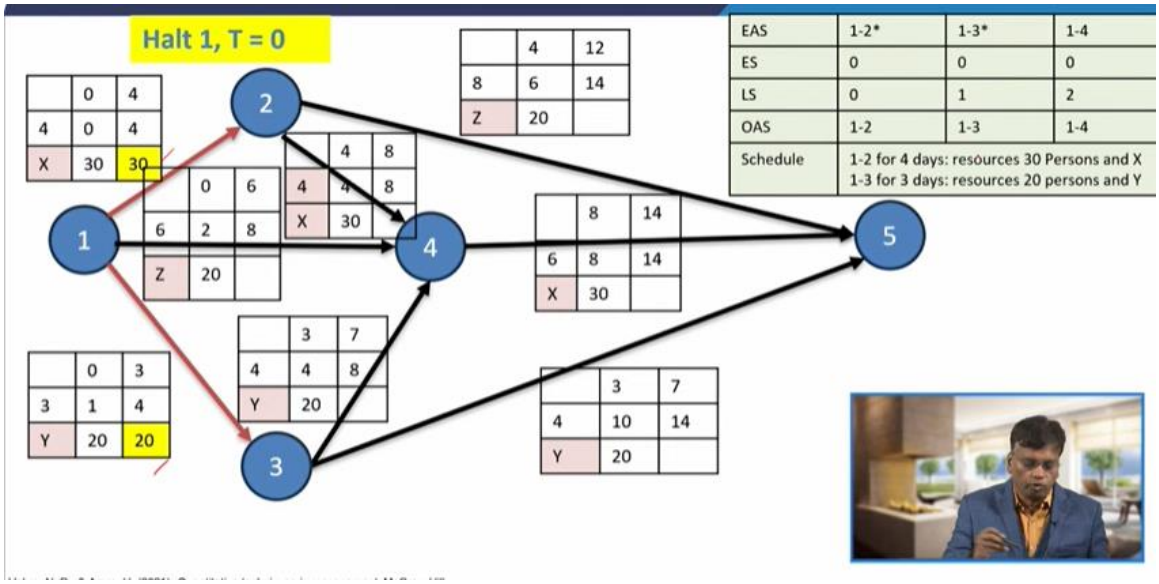
Then 1 to 3, then 1 to 4. The other activities are not eligible. Then for each activity I have to find out the earliest start time here 0, 0, 0. Then 1 to 2 what is the latest start time? It is 0.



1 to 3 latest start time is 1. 1 to 4 latest start time is 2. How I found this latest start time by using the backward algorithm that I already explained when you are doing our critical path method. Now I am going to ordered activity set. So which one is having the least starting time the 0, corresponding activities 1 to 2.

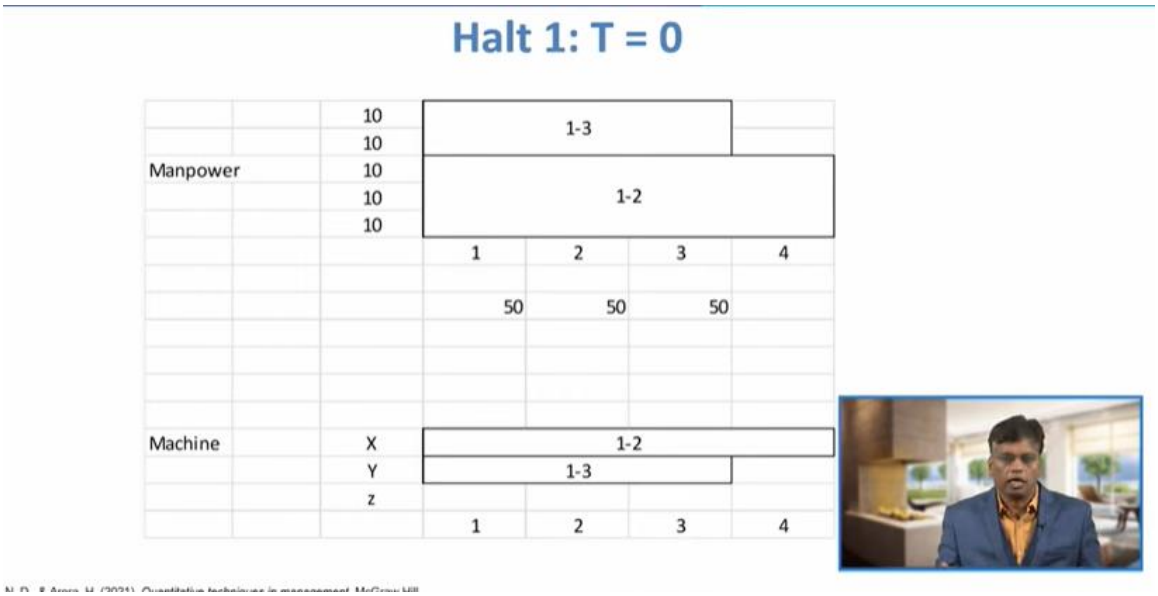
Next 1, so 1 to 3. Next 2, then 1 to 4. So now I have found the eligible activity set, earliest start time, latest start time and ordered activity set. Now I am going to allocate the resources. You see that allocated resource I have highlighted in yellow color boxes. So first allocation is going to be 1 to 2.

So I am making a star symbol here. So what we do? 1 to 2, see the duration of that activity is 4 days. How much resources? 30 labors are required. So we are going to allocate 30 there.



Then it need equipment x. So 30 and x I have allocated. So now we have another 20 manpower is remaining because maximum is 50. So we have enough resources. What is the next preference? We can go to 1 to 3. So I am making a star symbol because I am going to allocate the resources.

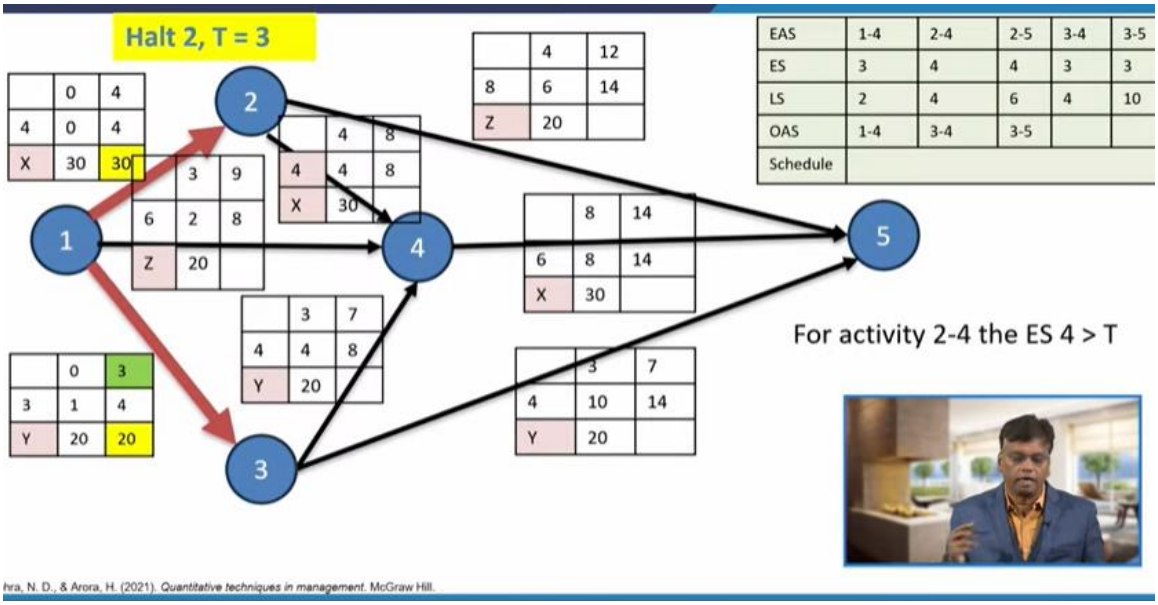
In 1 to 2 we need machine y. So I have allocated. How much manpower is required? 20. So I have allocated 20. So this colored arrow says that two activities are allocated. What is the next step? The next step is I am going to explain this load chart.



As I told you I had two resources. One is manpower, another one is machine. So activity 1 to 2 we need 30 unit of manpower and we need 4 days. So that I have drawn it. Here this is our duration.

Then activity 1 to 3 we need 20 unit of manpower for 3 days. That I have allocated. Next is mission. So we need x mission that is required for activity 1 to 2 for 4 days. Then we need y mission that required 3 days to the activity 1 to 3.

That I have allocated. This is the halt 1, T equal to 0. Next I am going to find out halt 2. The first task is what should be T value. When I go back you see that the manpower are free after 3 days and this equipment y is free after 3 days. So my next updated t value is 3 instead of 4.



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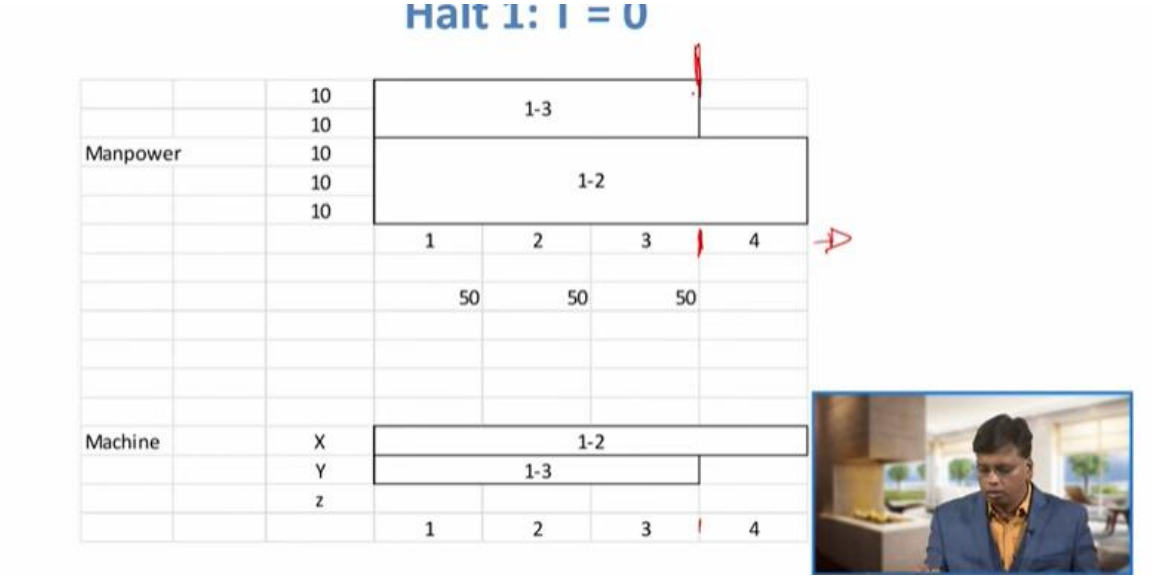
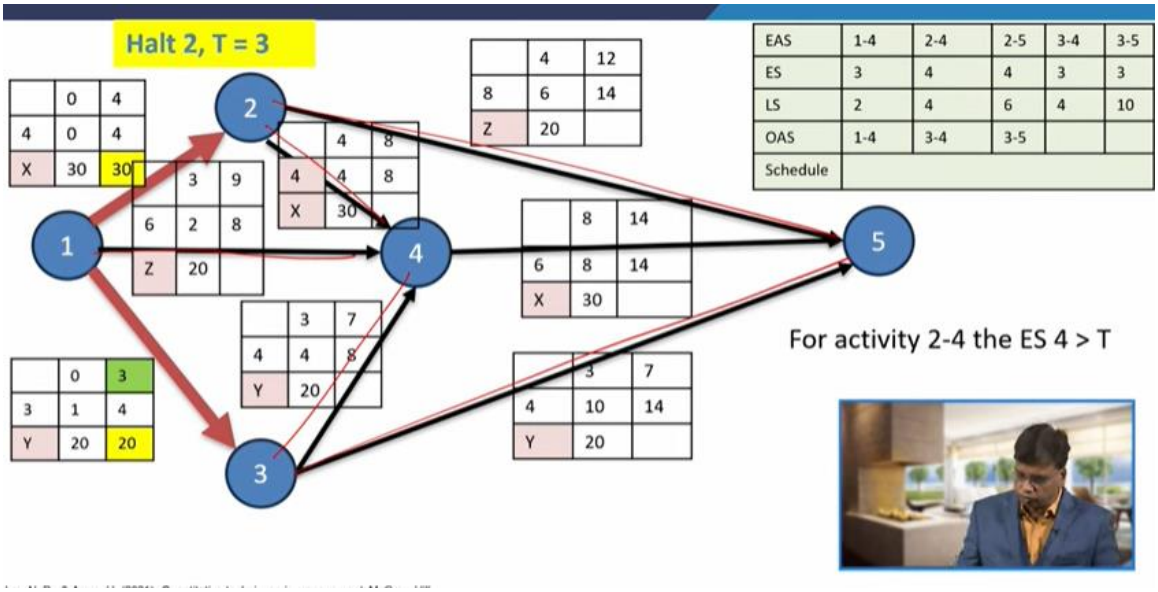


So I have to take the minimum value. Now the halt 2, t equal to 3. Why t equal to 3? I go back. You see that look at this point. Look at this point because after third day 20 manpower are free. That is why I am starting from the 4 also there, 3 also there.

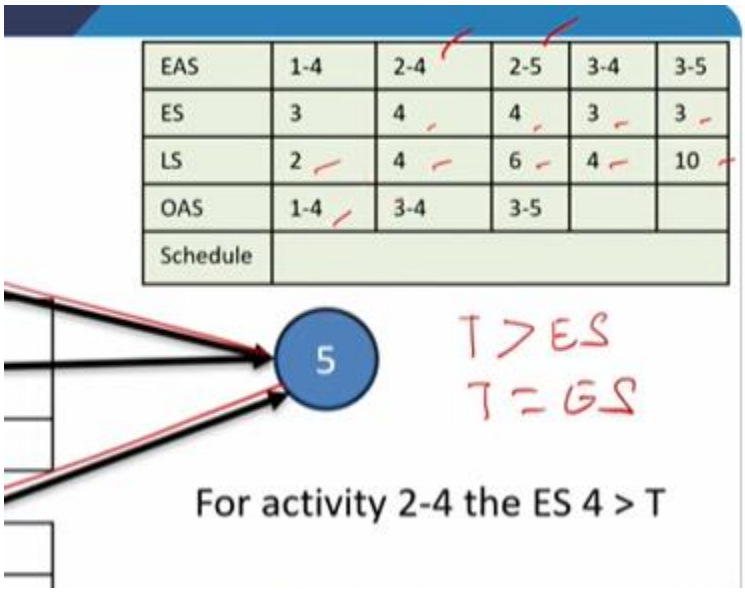


I am choosing the least one. So that is why t equal to 3. So once t equal to 3 next I have to find out eligible activity set. What are eligible activity set? Because 1, 2, 1, 3 is already assigned. So eligible activity sets are 1 to 4, 2 to 4, 2 to 5, 3 to 4 and 3 to 5. Here 4 to 5 is not there because there are some precedence activities for 4 to 5 that are not allocated.

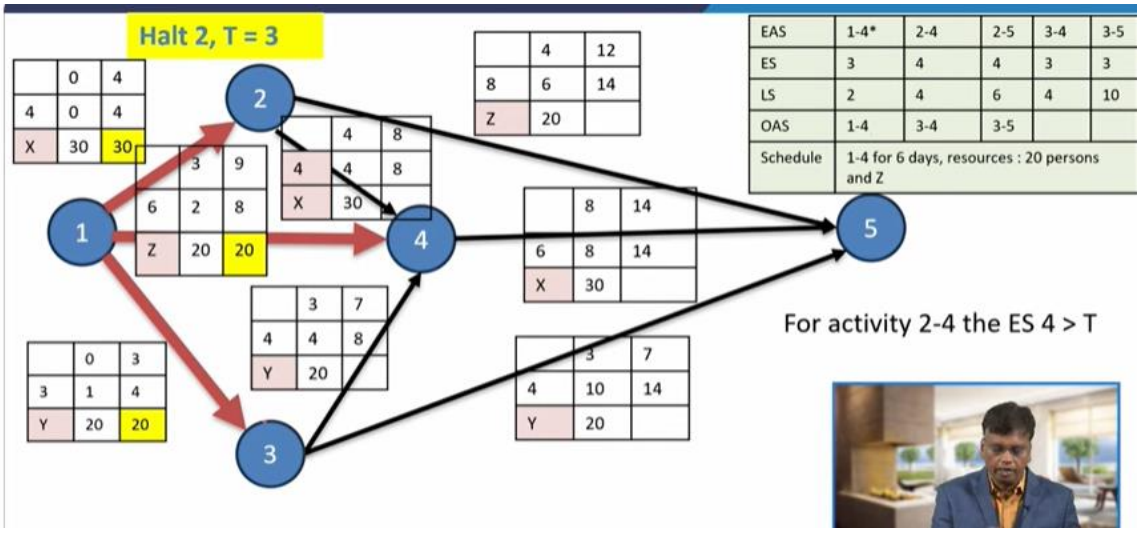
So we cannot allocate any resources on 4 to 5. That is why that is not there in the eligible activity set. Then I have to find out the earliest start time that I have to find out the updated earliest start time. You see that there is updation here. Eliest start time is 3. Why it is 3? Because the t equal to 3 and not only that you see here 20 manpower is free

only after third day.

Similarly, you would update the earliest start time for each activity. So it is 4, 4, 3, 3. Then the latest start time there would not be any change 2, 4, 6, 4, 10. So now at the time of finding ordered activity set, you cannot see 2, 4 and 2, 5 because that value is greater than the earliest start time. So we have 3, but it is 4 that means we have to delay for one more day.

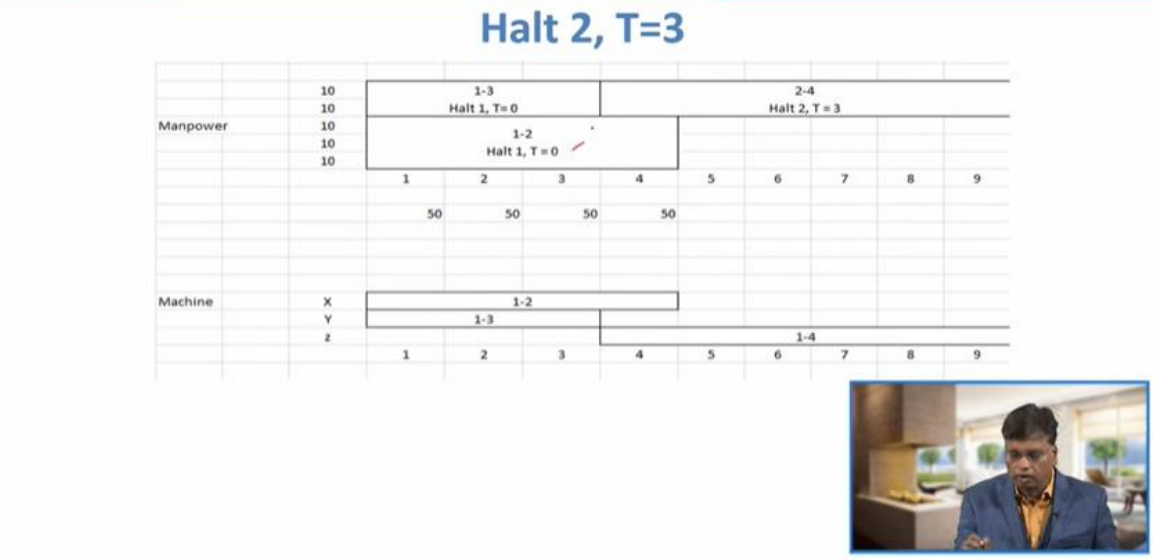


So we have to find out whenever t equal to es. So what are the activities are available 1, 2 is available and it has the least latest start time also. The next one is 3 to 4, the next one is 3 to 5. So this is our ordered activity set. So when we allocate the resources you have to follow this order.



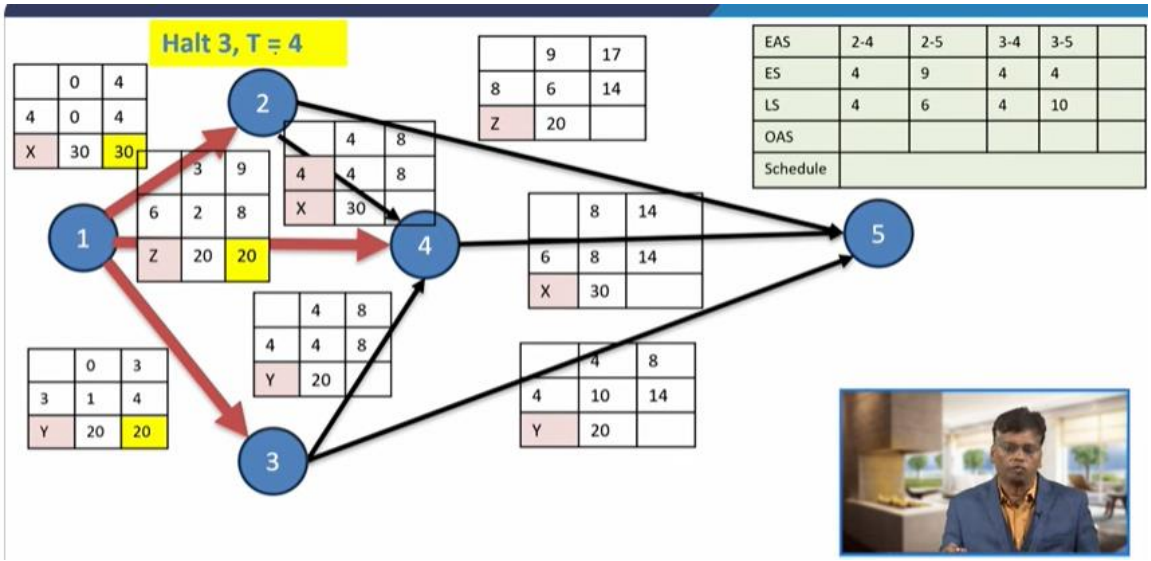
Now I am following this order. So what happening here? 1 to 4, 1 to 4 the duration is 6 days. How much resources required? 20 resources. So I am going to allocate 20 resources. The equipment required is Z that also I have allocated.

Now I allocated 1 to 2, 1 to 3 and 1 to 4. Here 2 to 4 and 2 to 5 their earliest start time is 4 which is greater than t that is why we are not able to allocate it. Now I go to draw the load chart. So this I have halt 1 already I have done it the halt 1 I have done.



Now the halt 2 this should be 1 to 4 for 3 days. So now we have to draw the loading chart. What is the loading chart? Because t equal to 3 I am going to start from here. So 1 to 4 what is the duration? Duration is 6.

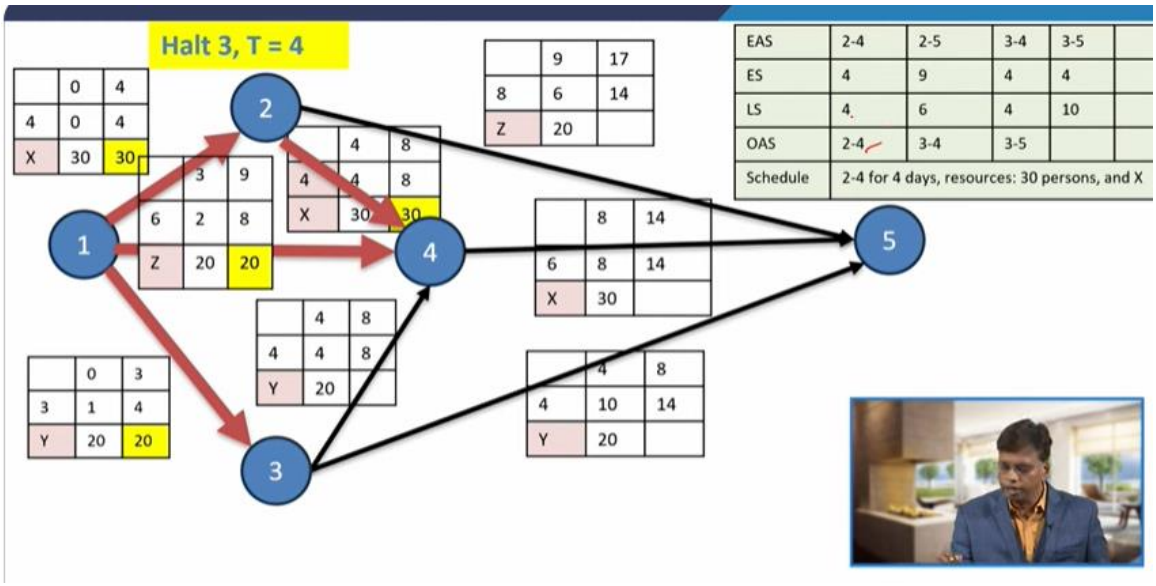
So 1, 2, 3, 4, 5, 6. So in the 1 to 4 equipment Z is required. So for 6 days 1, 2, 3, 4, 5, 6. Now I am going to halt 3. Now halt 3 I got t equal to 4 you may ask how we got it. Go back the chart. Now you see after fourth day see here after fourth day 30 peoples are free.



So that is why T equal to 4. So when t equal to 4 I am going to find out what are the eligible activity set. So now these 3 are allocated. Now what are eligible 2, 4 is eligible

then 2, 5 is eligible 3, 4 is eligible and 3, 5 also eligible. Now I have to update my earliest start time.

So 2 to 4 earliest start time is 4 and 2 to 5 earliest start time is 9. You may ask how it has how we got 9 because this 2 to 5 need resources equipment Z the equipment Z is available only on the ninth day. So it can start only on the ninth day that is why the earliest start time for 2 to 5 is 9. Next 3 to 4, 4 days then 3 to 5, 4 days.



Next there would not be any change in the latest start time. So 4, 6, 4, 10. Now I have to find out the ordered activity set. So what are the ordered activity set? The first priority should you go to 2 to 4. Why it is 2 to 4? The Ls also minimum and the earliest start time also equal to your T.

The next one is 3 to 4, 3 to 4. The next one is 3 to 5. You remember 2 to 5 is not eligible. Why it is not eligible? Because the earliest start time is greater than 4 that is your T. So in 2 to 4 what is the duration 4 days. So we are going to allocate 30 resources there.

I have allocated 30 resources and equipment X. So they have to start on the fourth day. They will finish on the eighth day. Why we are starting at fourth day as I told you because in 1 to 2 after fourth day there are 30 people are free. So that 30 people will be allocated here. Now once I am allocating I have to make a star here 2 to 4 there is a star 3 to 4 there is a star then 3 to 5 it is a star.

EAS	2-4	2-5	3-4	3-5	
ES	4	9	4	4	
LS	4	6	4	10	
OAS	2-4	3-4	3-5		
Schedule	2-4 for 4 days, resources: 30 persons, and X				

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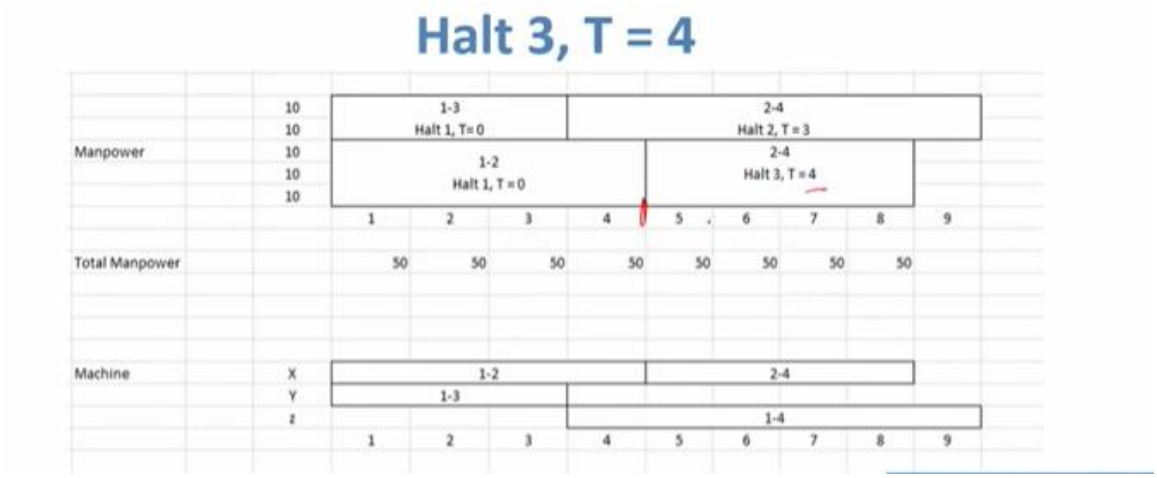
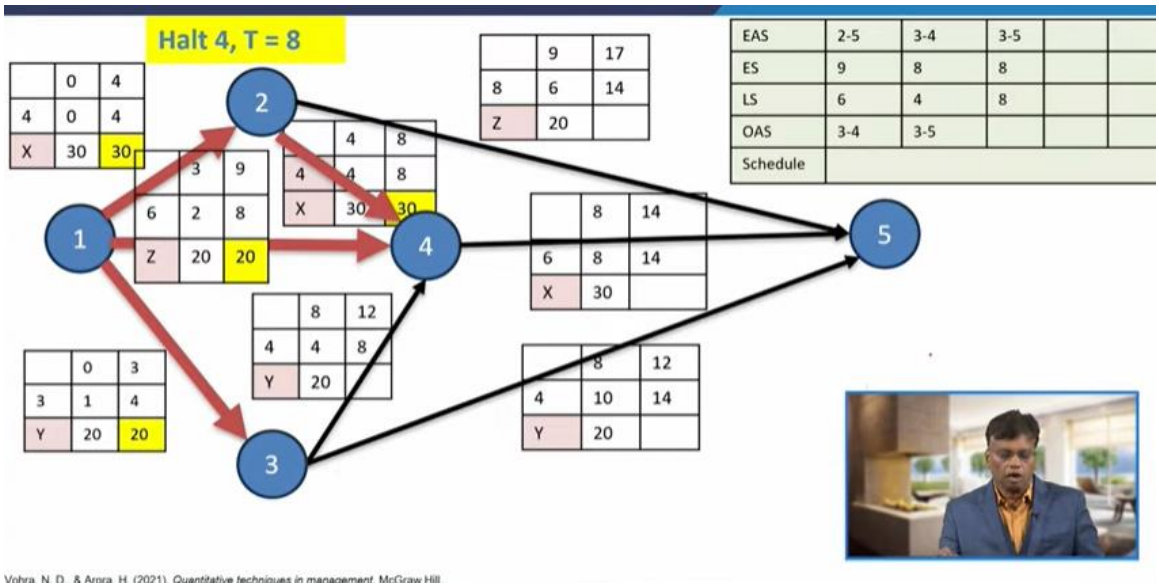


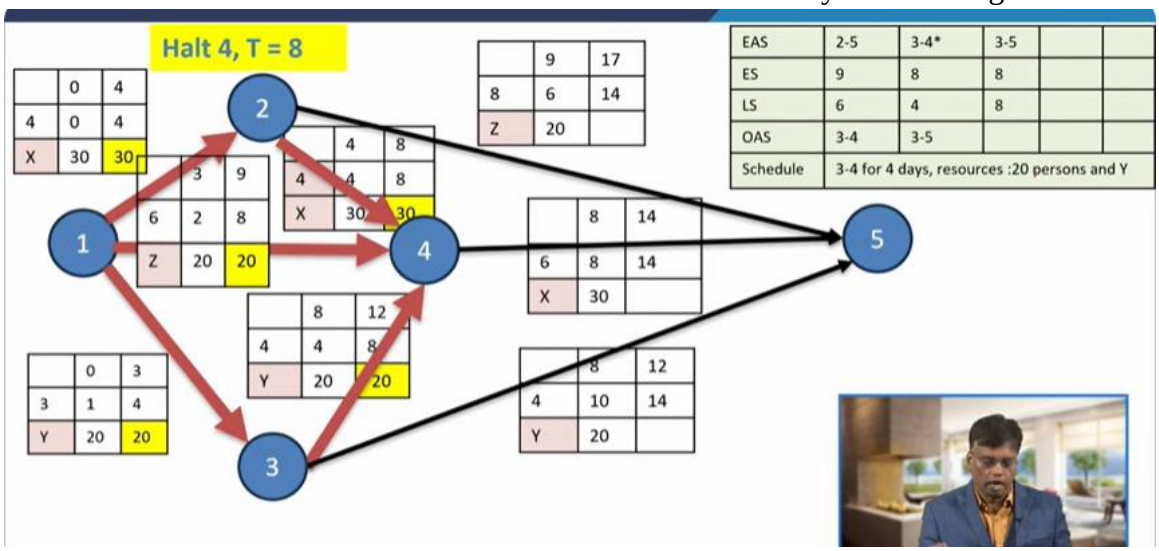
That means that we need not go for further allocation. Now here I cannot allocate it because we have we are not having enough resources. So we have to allocate only 2 to 4 for 4 days. So when T equal to 4 after the fourth day onwards 2 to 4 I go to allocate 30 manpower for 4 days 1, 2, 3, 4 days.

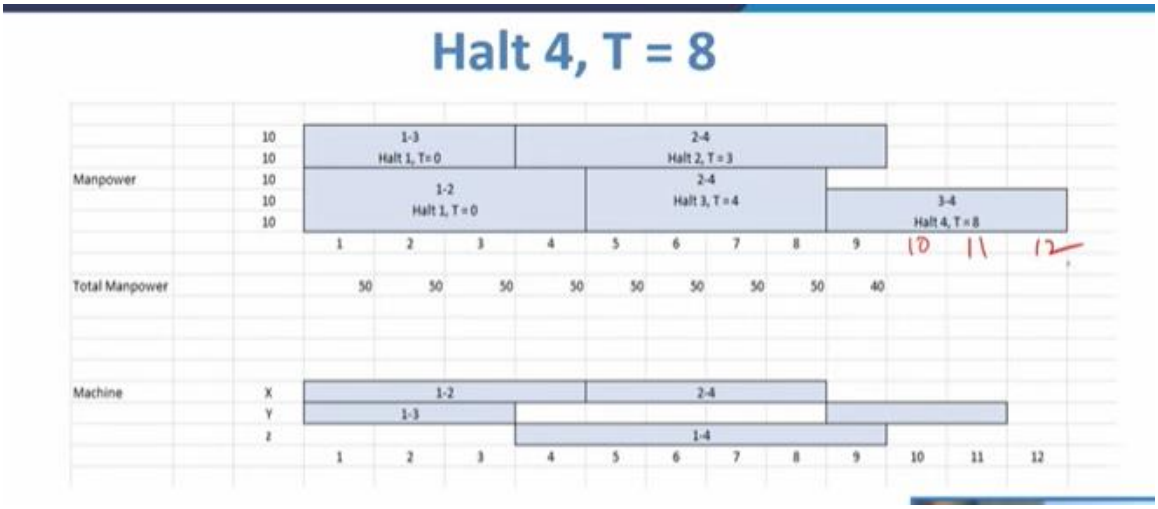
So which machine I am allocating I am allocating 2 to 4 machine X. Now I am going to halt to 4. In halt to 4 T equal to 8. Why I have taken T equal to 8 go back here. You see this after eighth day 30 people are free.



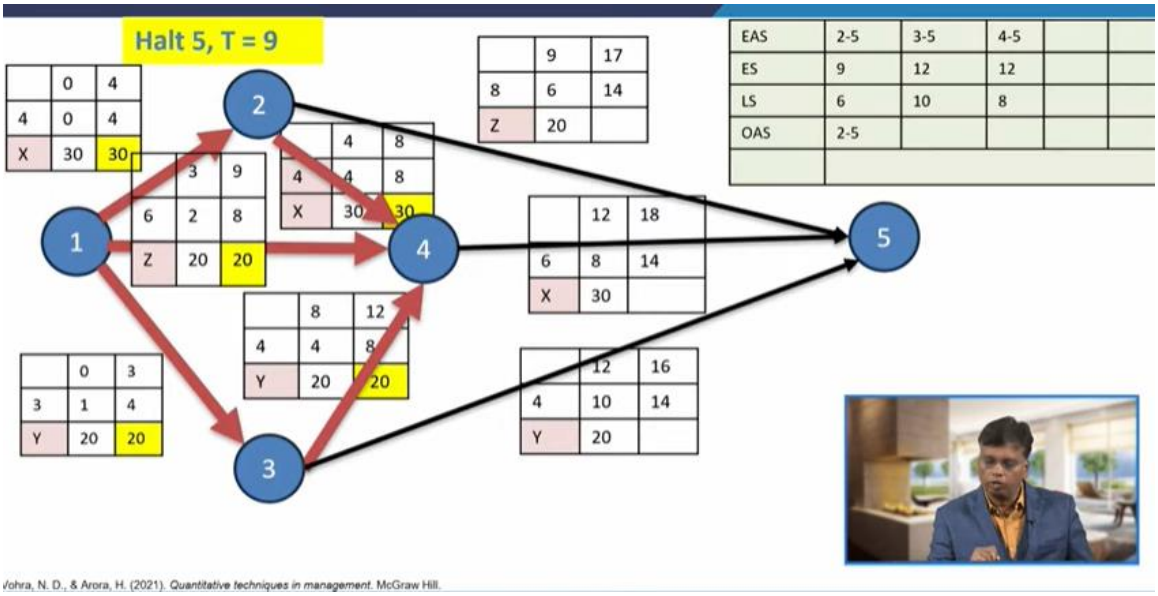
That is why in halt to 4 T I have taken 8. Now halt 4 equal to halt to 4 T equal to 8. Why we have taken T equal to 8 when you go back you see here after eighth day 30 peoples are free. So we have to find there are 2 options for us T equal to 8 and 9 so we have to go the minimum T equal to 8. So when T equal to 8 then the first task is eligible activity set. What are the eligible activity set 2 to 5 is there 3 to 4 is there then 3 to 5 is there 4 to 5 is not there because 4 to 5 has 3 to 4 as the predecessor we cannot allocate anything to 4 to 5 until we allocate to 3 to 4.

Then I have written the updated earliest start time 9, 8, 8. Then latest start time there is no correction that I have taken as it is. Next I have to find out the ordered activity set. So which are what order I have to allocate the resources there are 2 condition we have to say wherever T equal to 8 this is satisfied. Next whichever is having minimum latest start time so this one that is 3 to 4 next 3 to 5. So in the 2 to 5 so in the 2 to 5 not 2 to 5, 2 to 5 we cannot allocate because earlier it started 9 so first you have to go to 3 to 4.





So in the 3 to 4 for 4 days I am going to allocate 20 resources and Y so which is 3 to 4 here so I have allocated. Now the loading chart so here I have manpower for up to 12 days 9, 10, 11, 12 days so 3 to 4 halt to 4 T equal to 8 up to 12th day I am going to allocate 20 manpower. Yes the manpower is allocated up to 12th day. Now we will go to halt 5 T equal to 9 how we got T equal to 9 when you go back you see that after 9th day see here this is the least one after 9th day 20 people are free so that is why T equal to 9. So what are the eligible activity set 3 to 4 already we have allocated so 2 to 5 is there 3 to 5 is there then 4 to 5. Here I have written updated earlier start time 9, 12, 12 the latest start time is 6, 10, 8 which is ordered activity set because T equal to 9 only this is eligible that is 2 to 5.



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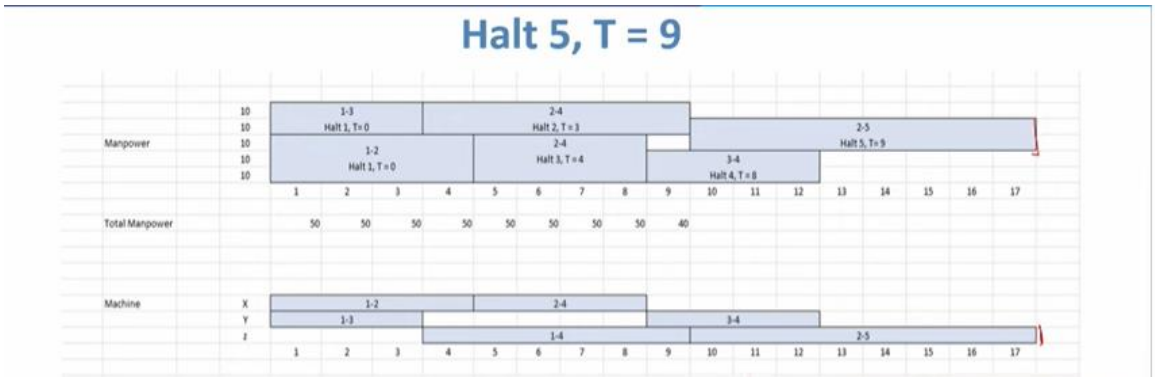
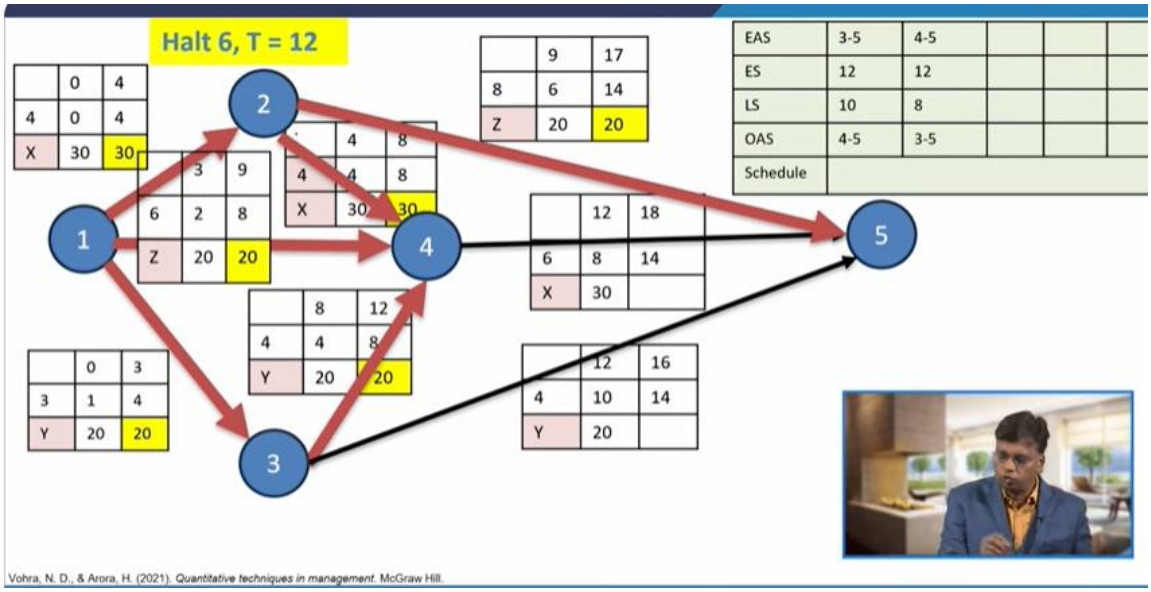
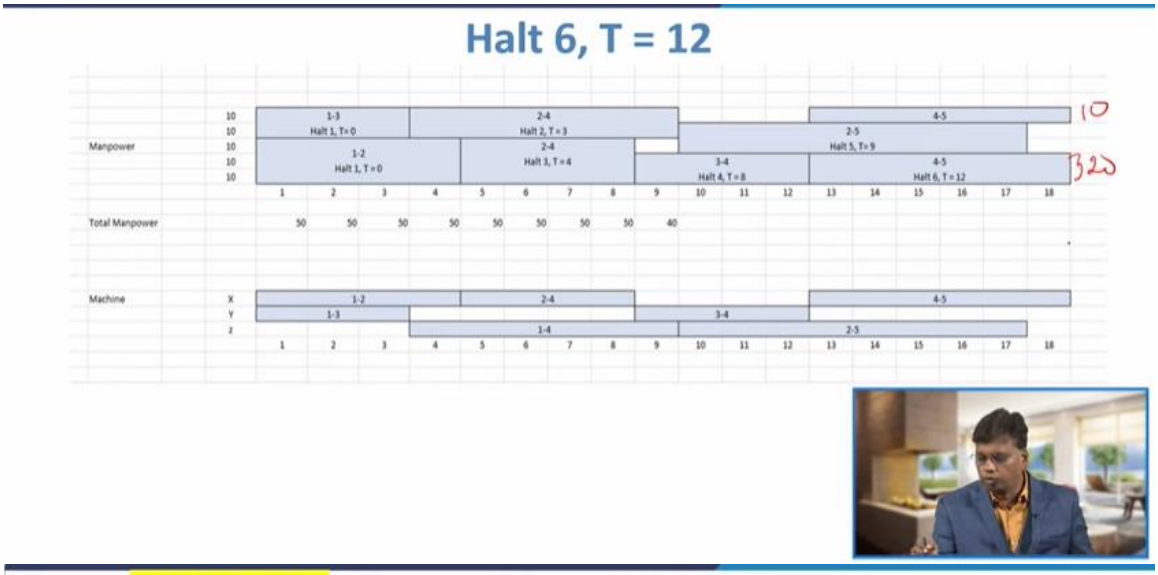
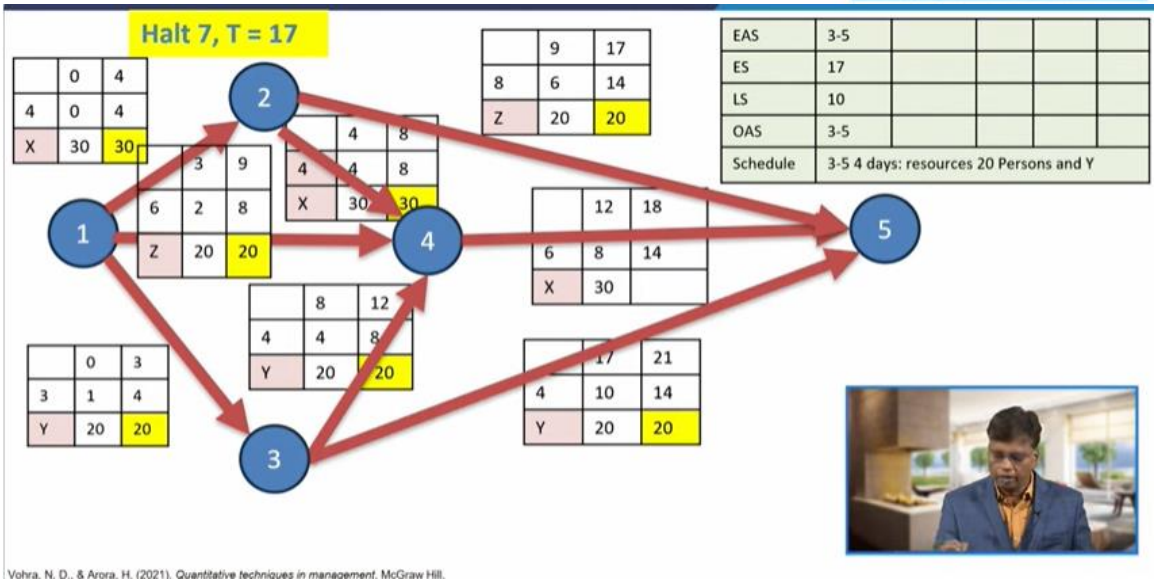


So, in 2 to 5 for 8 days what resources are going to allocate 20 persons and Z. So in 2 to 5 I have allocated 20 people resources Z now in 2 to 5 so here allocated up to 17th day similarly resources Z from here 2 to 5 up to 17th day I have allocated equipment Z and 20 people. The next halt is halt equal to 6 T equal to 12 why I have taken T equal to 12 go back you see after 12th day there are 20 peoples are free here so that is why T equal to 12. So when T equal to 12 this 2 to 5 also already we allocated the remaining eligible activity set are 3 to 5 this one and 4 to 5. Remember that I have updated the earliest start time 12, 12 latest start time there is no change 10, 8 so which are eligible set 4 to 5 is eligible because it has the least latest start time then 3 to 5. So in 4 to 5 for 6 days I am allocating 30 persons here and equipment X so that I have updated here you see 4 to 5 here 20 people here, here 20 people here again 10 people so up to 18th day.







Now halt 7 so T equal to 17 why I have taken T equal to 17 go back on the 17th day see that 17th day 20 people are free that is why T equal to 17. What are the eligible activity set only 3 to 5 is there so how much latest start time is a 10 so there is only one option is there so 3 to 5 for 4 days I am allocating 20 manpower and machine Y. Now this is my T = 17th day this is my complete chart. So what I have done here that I have explained the concept of resource allocation then I have explained the importance of resource allocation then with the help of numerical example I have explained how to load the various activities. I have taken two activities one is manpower another one is equipment so when we move from capital T equal to in the at the increasing order I have keep on allocated various manpower and the equipments so that the resources are without any ideal time for both the resources, resources are optimally utilized. Thank you. Thank you very much.