Project Planning & Control

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Lecture - 34

Review Problem 1, Problem 2 (Cash Resource)

Resolving Over-Allocation

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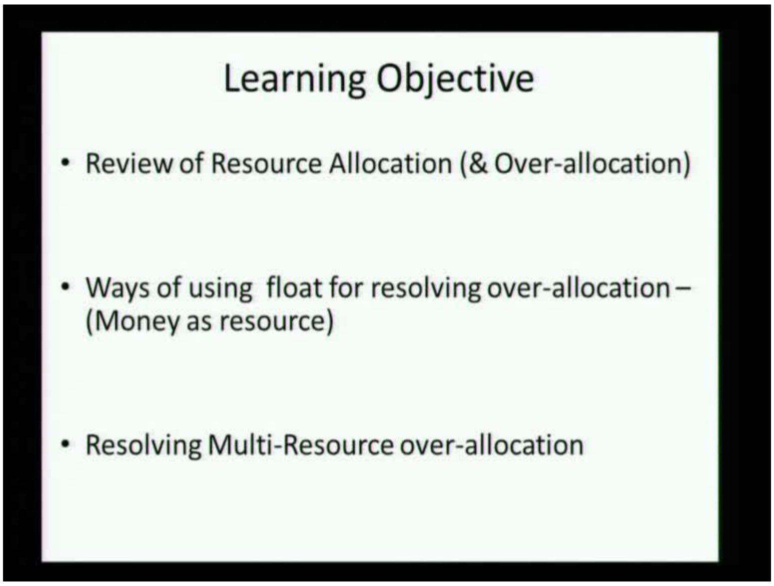

Yeah, in this lecture will continue with resource scheduling. We will look at resource allocation, we already covered this last lecture will look at how resources are allocated and over allocation problem. So, we will review this then we will go into the different ways of using float for resolving over allocation. We will try to use a spread sheet, so that the calculation will be done in quickly for us to see how we can really resolve over allocation problem different ways to do it. And finally, will take a look at a multi resource over allocation and see what strategies one can use for this.

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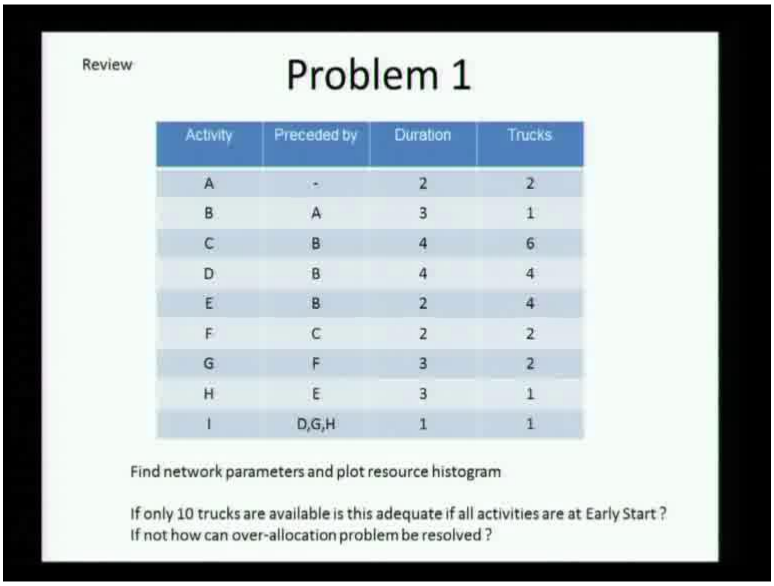

Now, let us review the problem we took last time, if you recall we had a problem with trucks as a resource, and this was the problem statement we said we should find the network parameter plot the resource histogram, and then we limited saying only 10 trucks are available. So, if you look back in your notes you will find that we solved this problem last time

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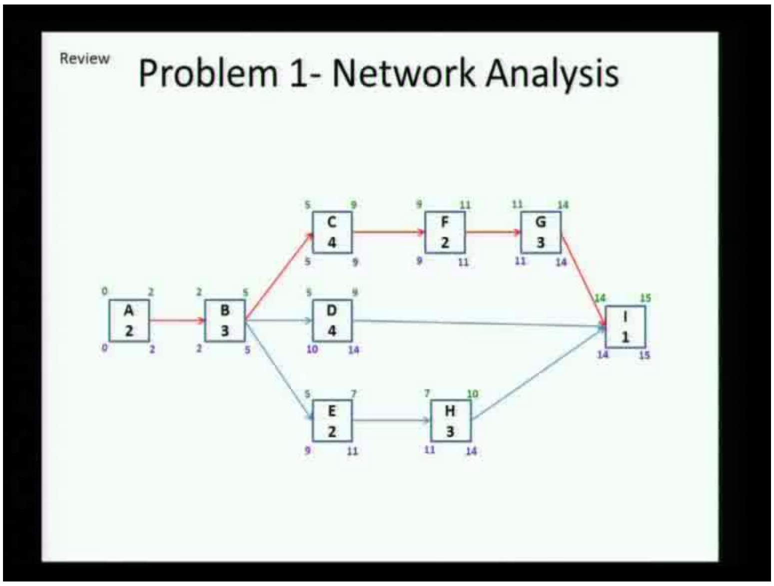

This was the network, we had 15 day project duration, we had the critical path going through ABCFG and I

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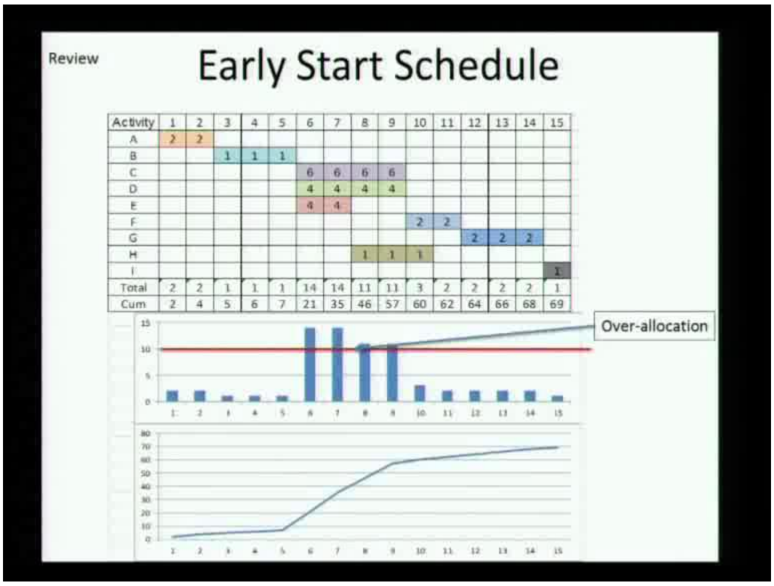

And we when we actually took the early start schedule and we put resources required for each day, we found that there is we said there is only 10 trucks available, but we found in a few days be needed more than 10 based on early start. So, if we actually go back to the problem statement, we have talked about the number of trucks being required in this column of the problem statement. So, again just to refresh and review. So, if A needed 2 trucks we said its actually 2 trucks for each day of A, B requiring 1 is 1 truck for each day of B and this was the early start schedule which we got. So, what we did was actually add up their requirement for each day for various activity. So, when came in here you have 14 trucks required on day 6, and 14 trucks on day 7, but only 10 is available. So, what was solution?

Student: ((Refer Time: 02:39))

Yes, we have to utilize floats, and if we go back we can see that ABCFG and I are critical. So, we could only move we chose last time to move D. So, we actually move D all the way to the end, and that actually resolved this. So, this 4 actually moved the end that resolve the over allocation form. So, we had this come down to 10, and this went up to 6, now the question is… So, what we did is actually moved D all the way and moved it to 14 that is what we did last. The question is, is this the only solution.?

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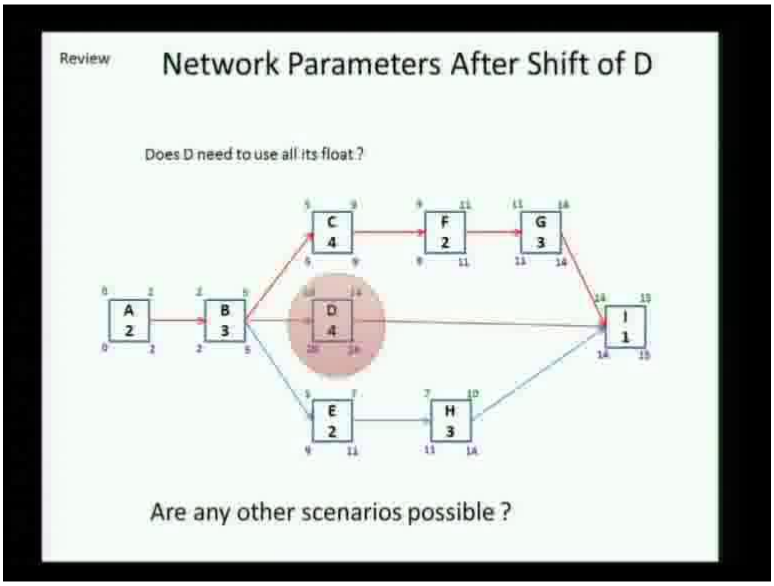

First question does D need to use all all its float. So, right now when I brought D here, I have made it actually critical. So, does D need to use all its float.

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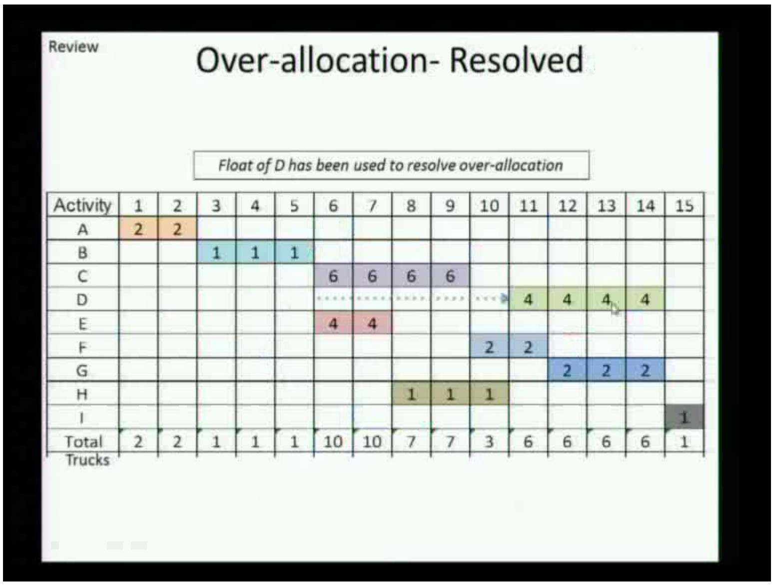

Activity	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
A	2	2													
B			1	1	1										
C						6	6	6	6						
D											4	4	4	4	
E						4	4								
F										2	2				
G												2	2	2	
H								1	1	1					
I															1
Total Trucks	2	2	1	1	1	10	10	7	7	3	6	6	6	6	1

No? what are my options with just D.

Student: Day 10…

Yeah, I can start it from day 10. So, there are 2 possible solutions with just D, what if I started on day 9? Over allocation - 6 4 1, it would have gone to 11. So, if I chose to move D I have 2 options, are there any other options,

Yeah.

Student: C is an critical.

C, it is critical. So, cannot move C. So, I can move E and H, can I move E right.

Student: ((Refer Time: 04:26))

So, if I moving E I first have to move H first. So, you can see E is here, H is here. So, there possibly another solution moving E and H, we will explore this at a later stage, but realize that when we move D last time it was only one of the options, and we chose to move D all the way to the late start, but again that is only one option, within D itself there is 2 options, but in addition to D there are other options of resolving over allocation.

Now as a in planning engineering or project manager when you look at these options, you have to now there are other constraint which will work into which option you have choose. So, for example, D might be done by sub contractor who is not easily available. So, you will say that look I, I fix this person to start on the early start day then I am there is no way I am going to change my schedule on whereas E and H are sub contractor types of work in which more kinds of people are available to do are the subcontractors flexible or not. So, there are many constrains that come into finally deciding which activity to move, but the important thing here is to realize there are multiple options.

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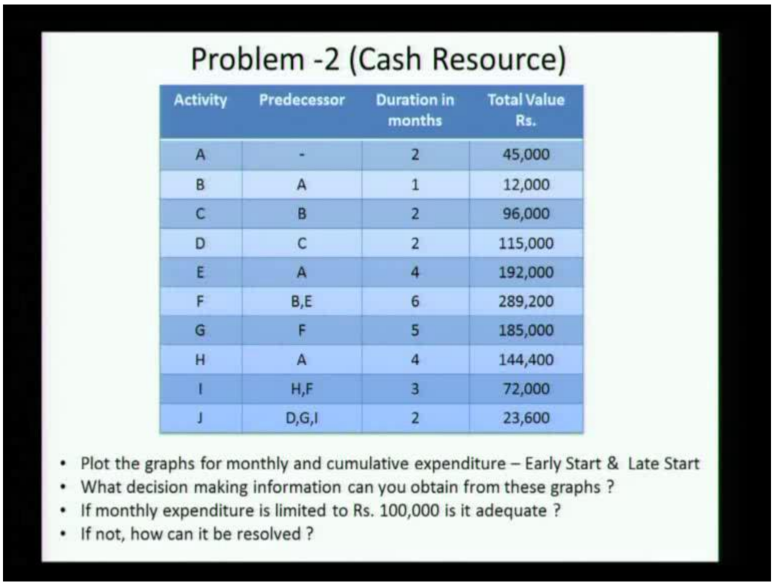

Now, let us move to another problem, this time we are taking cash as a resources, and you can see the problem statement here, the network is a little different from what you have done earlier, but I would like you to start drawing this network we will not solve the whole, do not want you to solve the network in first, but I want you to get a feel about the network, and please try to drawing the network.

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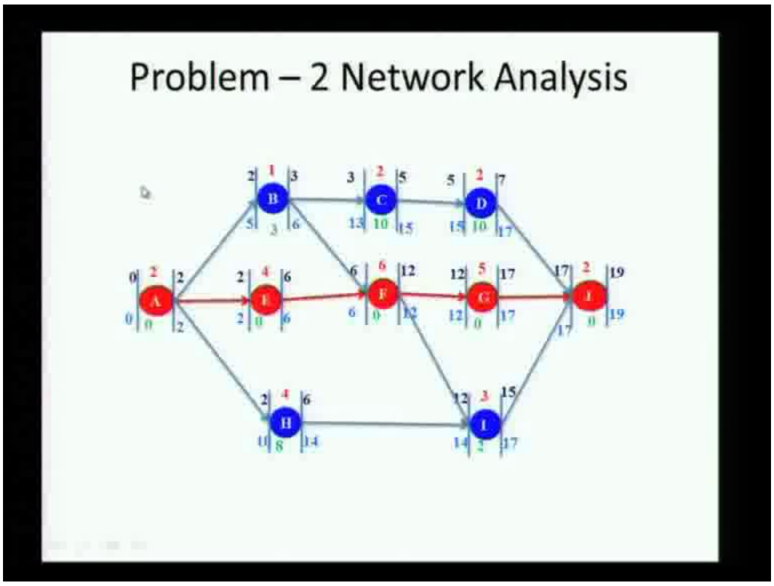

And you will find I do not want you to solve the network as of now I just want you to get a feel. So, there are if you look at there is path going ABCD to J, then there is A E F G J which is critical and AHIJ, and then there is a actually another path ABFIJABF there are few more paths then are simple network we consider so on. So, the project duration here is 19 months and once we do this, if you go back the problem statement says a total value of money for activity A is 45000 is spent over 2 months. So, unlike where we said the daily requirement of a truck was 2 per day, here this is the total value of that activity. So, if we want to find the monthly monthly expenditure the cash money that is going to go what do we need to do, how do we need to apply the same principles of resource.

Student: ((Refer Time: 07:17))

Yes.

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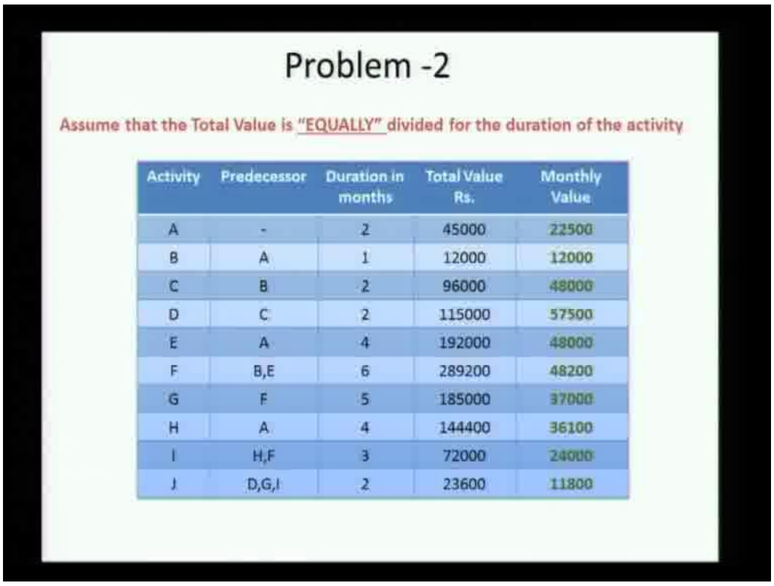

Activity	Predecessor	Duration in months	Total Value Rs.	Monthly Value
A	-	2	45000	22500
B	A	1	12000	12000
C	B	2	96000	48000
D	C	2	115000	57500
E	A	4	192000	48000
F	B,E	6	289200	48200
G	F	5	185000	37000
H	A	4	144400	36100
I	H,F	3	72000	24000
J	D,G,I	2	23600	11800

That is the first task. We will assume that the total value is equally divided to the duration activity, that is for our purposes in class today we are going to assume it is equally divided, in reality it is certainly not equally divided. And one of the challenges becomes actually finding what is the how will you divide this over the time period which you are doing that one. So, they will be different variations some others simpler software only allow you to do equal proportioning of the resource or cost or whatever it is. Most professional software will allow some function or some variation where you can talk about how you are going to actually, how you are spending the money how it varies.

And there need not be a function is can just it can be totally based on, you know factors which is totally discrete it will depend on the activity, it will depend on other activities you know it will depend on, so many things; some activities you might want to load it in the beginning and ease of later you know. So, it is discrete, which you it is I mean you can have a function, but in general it is this discrete. So, here we have assumed equally. So, we have taken just the total value here and then divided by the number of months to see monthly value. So, this gives you the monthly value of the monthly expenditure on each to the activities is that is ok.

Now so the first point be want to address is to find out the month, if I am going to be spending if I am going to be doing this activity on this schedule how much money will I be spending on each activity.

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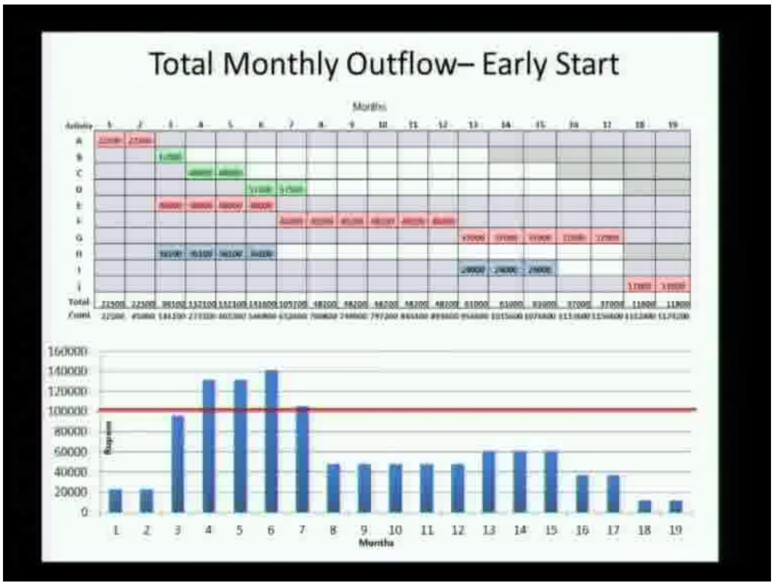

So, here we go we have taken the schedule, this is the early start schedule, we have put this in the form of bar chart, we have loaded the bar chart with the value. And all we do is in the first total here what we have done is just added up, just as we did for trucks we are just added up, but this is money. And you find this is the bar chart you get for monthly outflow. Now you can see that the outflow here is in certain months has exceeded what has been allowed. So, we can say that you know you are only can you get 100000 rupees to spend a month, if you exceed that limit I cannot allow you to do it might be there is some kind of a credit limit or something, which is which has exceeded. So, this is when we look at it from an early start perspective.

Now when we go to a late start perspective what we have done is moved all the activities is float. So, you can see I have the area here which is all the white area shows float, the grayed out area is where there is no float. So, what you have done in a next step is moved everything to the late start, this is everything to the late, and this still does not resolve the problem. Now the question is there a solution in between these 2 which will resolve the problem, and what we would like to discuss here is there might be is there only one solution, multiple solutions, how would we go about finding the solution. So, I think when we look at this when we look at this representation we should be able to find a solution right, but one I mean one is can we come up certain set of rules or can be kind of what are the ways and which we solution points should go about looking of the solutions and now we will do it manually, but at a later stage is if a computer is going to do is how do we automate such a process.

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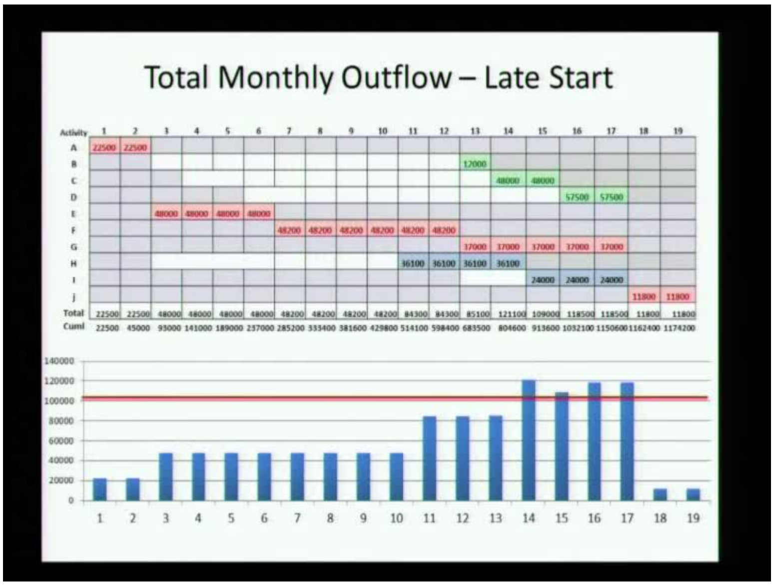

Those are some other challenges actually in the resources allocation domain, but as of now let us see how we can do this manually, what I have done is put this into spread sheet, you can see the early start, the the loaded bar chart, and the the equivalent bar chart is below. So, put it into this forms, so that we can move things around. So, as I decide to move this here the bar will change, and you know the limit we have is 100000. So, let us. So, you can make suggestions and we can actually move the bars around. So, even now we have exceeded 100000. So, what are what let us explore the possibilities with which we can works so that this is below 100000. So, now let us discussed how far can I move C?

Student: ((Refer Time: 12:47))

No, remember…

Student: ((Refer Time: 12:51))

Yeah, it is still constrained with the…

Student: D

D, yeah, exactly. I cannot move C beyond D, we have to go back to that, I cannot move B beyond C, if I am move D then I can move then it give space to move C. So, remember that you have a BCD they are linked and H and I are linked. So, here you have B C D. So, right now here C can move, but it has to stop here, because it cannot move beyond that once C moves B can move. So, what would be the order of... So, right now if I look at look at what is being over allocated here is C, that is loading right and right now E, I cannot move E at all; the other option I have is to move H, remember H can also move and H has free float on its own. Now, how did H get free float on its own, without even though H and I are link how did H get free float on its own.

Student: I is linked to H

Yes. So, F has a critical activity and that precedes I. So, I early start is controlled by F. So, that is how each got free float. So, I can move this now does it resolve my problem does it solve my problem no, it is lot a bit better. So, now, I can move this 1 more step no. So, looks like here there is I can… So, this is a bit of what we call a trial and error process. So, this is now again exceeding. So, should I move it here and move this out. So, I have resolved this path, now I can just move.

Student: ((Refer Time: 15:27))

Yeah, does not matter in this particular case. So, this now is this the only solution.

Student: We can shift H also

Yeah I can. So, if I can go back to my old, let us take back all the moves you need. And now I am actually going to bring this back to the early start, I am going to simply move H more. Now it that did not solve my problem. So, here I have what can I do now?

Student: I

Yes, move I out all the way at the end and then now move D in between. So, yeah I have to move it by 1 more. So, here is a second solution, now because this is a simple network and because we are we have only one resource here we are able to shift these things around and find solutions and obviously we are not adding context to the what activities are ABC. In the real world we have like we discussed early we have to see what we can move and the cost of taking of float and things like, but the ultimate goal would be to find some way of associating cost with these moves, and find the least cost solution to resolving the over allocation problem.

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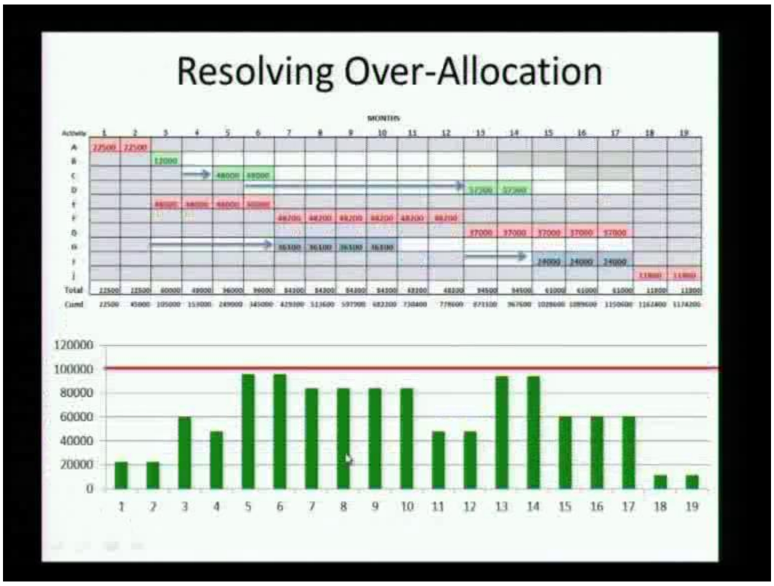

So, in this particular case look at this slide resolved over allocation by moving, this is an was this was the solution we came up with right, yes this was the second solution, which we came up with any questions?

Student: We can formulate a linear program

Is it a linear program, think about are these, what is the dependency between the value, is there any kind of dependency between the values. Assume that the cost is equally divided per for each activity, that is fine other than that what is the what is a relationship between the activity precedences are relationships other than the… After that there is almost no relationship between you know… other than if they each activity has its floats, each activity has its free float. And there is a dependence between the successor and its float. Other than that the critical activities or I mean there is a very complex dependency what how is E dependent on for example, C what is the relationship between E and C? There is no specific relationship, but there is a relationship between E and I, yes there is a relationship, but when I come in here and look at E and look at I in what way do I is that relationship modeled or how will model it in a linear program.

So, this the optimization when you model it is an optimization issue, it is it is one of the toughest optimization models it, but again when we say trial and error; that means, what would be the solution space for something like that. You know in this particular case it is reasonable, but as number of activities grow and number of steps you can move it grow will become very large, it is programs. So, this is something which you can try if you know solver, solver is not just linear programming, it goes into you know a more advance algorithms, but spaces like this are good for genetic algorithms and other techniques of optimization.

Student: Variables…

Yeah. So, how many variables are here, how a what are your decision variables cost is here, no no; cost is a objective minimizing or I mean actually we are not changing you want to make. So, you have you want monthly cost to be less than 10000 is an object, what are the decision variables?

Student: Total duration of the activity

Right now we are not changing duration,

Student: Start and end date

how much to shift an activity right. So, if you look at the combination of shifting possible, how many combinations are there?

Let us tell me of we can start counting so for each shift of this of example in a right now this cannot move any. So, this I can move this by 1 2 3 4 5 6 7 8 9 10, and for each of those shifts 10, I can move this independently, this independently. So, that is the solutions space we are talking about, its going to be very large, and that is so that ultimate the decision variable is how much should I move each activity. And in some some solution might be all 1 2 3 here we have 5 activities which could be moved. So, my decision space is you know activity B comma number of steps number days by which I should move activity C number of days activity D number of day, that is my decision variable and the number of days might be 0.

So if we go into the solution which has got the solution says C by 1, D by 1 2 3 4 5 6 7, and I by 2, and H by 1 2 3 4, so that would be the solution which gave a acceptable result. Now solution which says B by zero C by zero will would that given acceptable result, I bring C back here yes it could also give an acceptable result C by zero and D by the same amount H by the same amount I by the same amount would also give an acceptable result. So, we a kind of... So, that would that is the more advanced areas of looking at resources optimizing resource allocation, and here again we are taking about the cash resource and a single resource in a single project. Now when we scale it to a multi resource multi project can your problem it becomes more complex.

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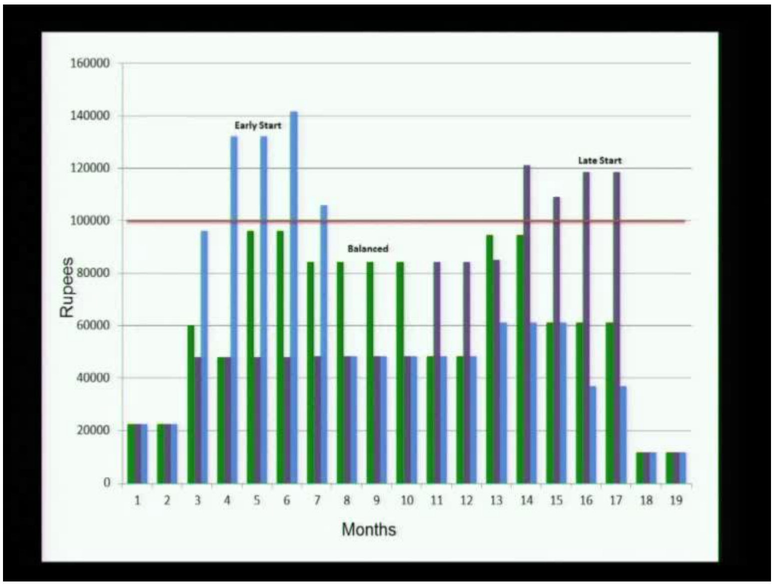

So, when we look when we need actually put all of these the 3 charts, we have the early chart here in blue in purple we have the late start, and then the balanced chart here you can see how again the emphasize is how float can be used to vary your resource profile. So, far we have actually talked about, we are talked about mainly looking at moving a whole activity, what are the other possible strategies, yeah. So, now, right now we are moving a whole activity by 2 months, we were keeping the duration constant. So, one other very, very in other possible way yeah, yes I can increase the duration in which case my cost per month, and no I am assuming my total cost will remain the same, yeah no my total cost will remain I am assuming my total cost remain the same by this so mine cash required each month will decrease.

Student: Increase the duration

I am going to increase duration, I am going to increase that duration, yes.

Student: cost will increase….

The cost will increase, but my monthly cash flow will decrease. So, my total cost might I mean even if in the assumption, which one could work with the saying cost won't increase, my monthly cash flow will decrease and then I could bring it within the limit I want.

Student: ((Refer Time: 24:58))

Yeah, and a lot of times.

Student: …total cost of the project so if we increase a particular activity duration by a month and the cost increases slightly it won't affect because we are able to optimize the cost

And if see if you are going to increase the duration of a critical activity certainly the project duration will increase, right now we going to increase the duration of a non critical activity project duration won't increase, but overall cost might increase. And right now that is we are not looking I mean that is one possibility the other possibility is that increase duration by just mobilizing less resources and my monthly expense declines, and this is very, very commonly done on projects. They do not have the cash flow to sustain a intense activity, they will decrease the level of the activity it might not be a very most efficient way to finish the project total cost might be more.

What about compressing instead of trying to do this in 2 days, I try to do the whole thing in 1 day in 2 months, I tried to whole thing in 1 month, it will spike my cost, but if I have a slot I can fit it in that will also help me to manage my over all monthly expenditure. If I have a 1 month where there is low and my float can overlap that then I will do that any other strategy you can think of, I could split I can take. For example, something like C and I can say I am not going to do it on 4 in consecutive time I am going to do 1 part of it here and then another part of at later, does not apply in this case, but I could actually split an activity meet expenses in different stages. Again not necessarily the most efficient way to do it, but if my cash flow dictates that is what I am saying.

So, I mean we can we can kind of illustrate some of these things I can take this, let me take. So, I can just decide to take this and split it here, this would the splits and this can actually move all the way to here, if I had a even you know if I had a different bench mark, that is what I could do. So, that would be this way.

Student: ….rules for the solutions so that we can get better solutions

Yeah, right. So, now you need rules. So, their depending on project situation, yes there is based rate solution. And ultimately what you want to use minimum amount of one rule you can says I want to use minimum amount of float. I want I want my solution to be in such a way that I do not go to the late extreme, but I use minimum amount of float of all my non critical activities, that would be a simple way to write.

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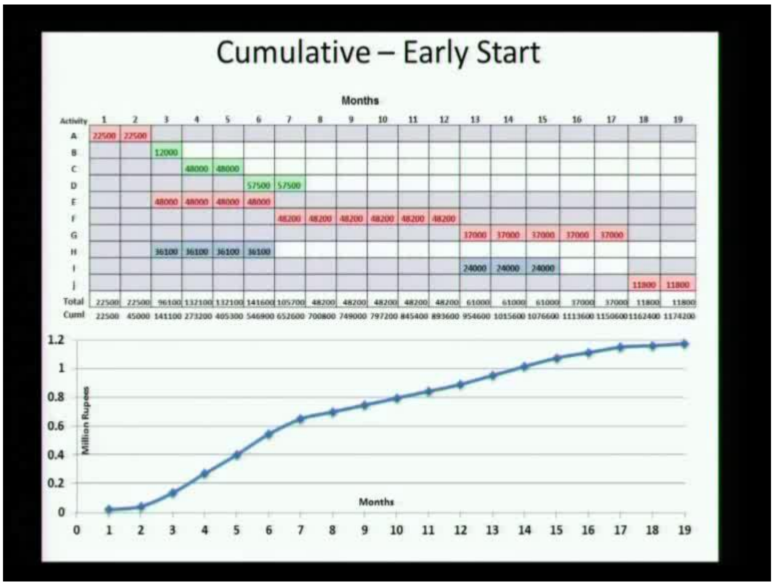

Activity	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
A	22500	22500																	
B			12000																
C				48000	48000														
D						57500	57500												
E			48000	48000	48000	48000													
F							48200	48200	48200	48200	48200	48200							
G													37000	37000	37000	37000	37000		
H			36100	36100	36100	36100													
I													24000	24000	24000				
J																		11800	11800
Total	22500	22500	96100	132100	132100	141600	105700	48200	48200	48200	48200	48200	61000	61000	61000	37000	37000	11800	11800
Cuml	22500	45000	141100	273200	405300	546900	652600	700800	749000	797200	845400	893600	954600	1015600	1076600	1113600	1150600	1162400	1174200

Now, what we have here is just the cumulative the s-curve, this is for the early start, this is for the late start, and this is for the balance, what the balance solution which we got the s curve and if we want if we put all 3 curves together this what we get So, you get an envelope, you can we know we said this is the early start curve, the late start curve and this particular case we have decided the cash flow which is in between. And all of the other flow, so long as we are within the floats will be between these two s-cuves((Refer Time: 29:07)).