Network Analysis for Mines and Mineral Engineering
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Lecture – 05
Rules of dummy job, redundancy & cycles

Let me welcome you Swayam NPTEL online certification course of a Network Analysis for Mines and Mineral Engineering. This is the lecture 5 and in this lecture we will discuss the Rules of dummy jobs redundancy and cycles.

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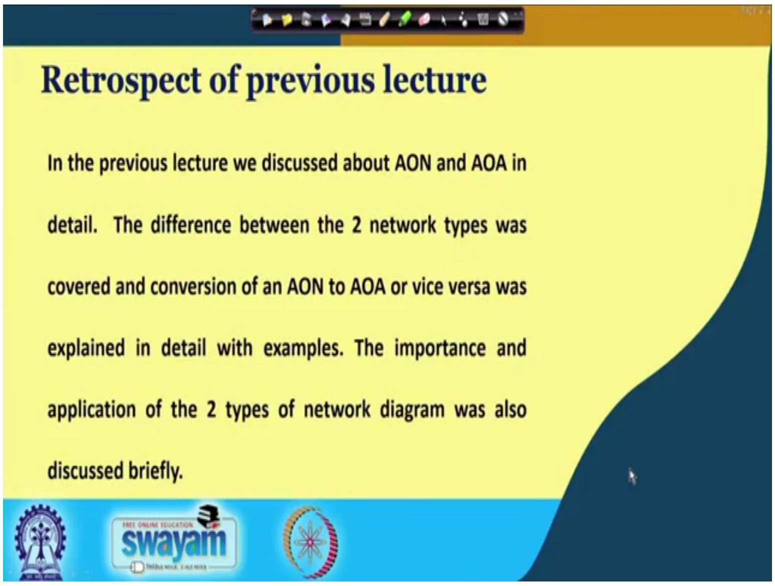

Retrospect of previous lecture

In the previous lecture we discussed about AON and AOA in detail. The difference between the 2 network types was covered and conversion of an AON to AOA or vice versa was explained in detail with examples. The importance and application of the 2 types of network diagram was also discussed briefly.

So, before that let us retrospect what we have covered. So, far at this point I believe you have already observe the lecture 1, 2, 3, 4 and from that now, you are accustomed with the activity on network on nodes network diagrams. You also accustomed with the activity on arrow diagrams and you know what is called network? How the jobs are identified? And all these details are known to you. You and also in the last class have discussed that how the dummy jobs are required in the activity on arrow diagram to plot the network for the understanding of the user to identified which are the predecessors and the successors jobs for a particular job.

But to cater that problem activity on node diagram is much much easier where the jobs are identified in the node and thus predecessors and successors can be easily corrected with the arrows from one node to another node. Where arrow activity on arrow diagram their nodes are only for the showing the terminate as a initiating and the terminating point and that is why arrows are basically depicting the jobs.

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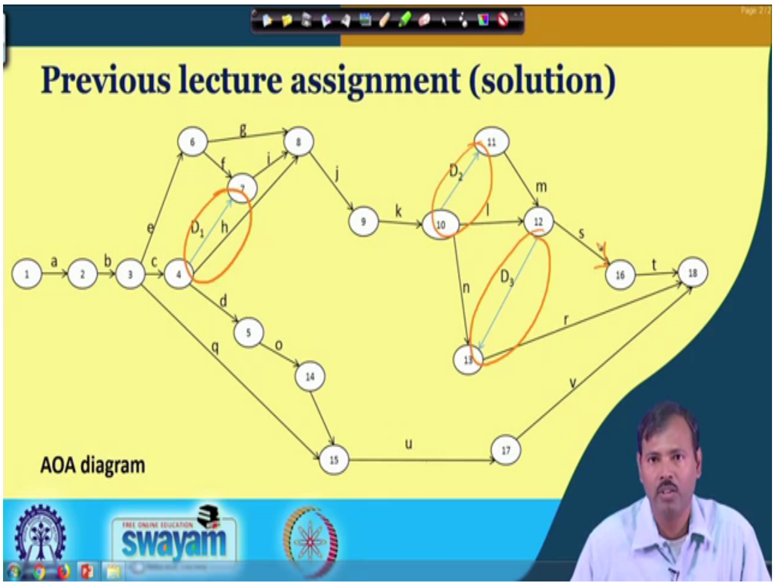

Previous lecture assignment (solution)

AOA diagram

So, this so, far we have accustomed with all these things and in the last class we concluded with a big network jobs and activities table was given to you and I ask you to solve try to solve that in your house by your own I believe the civil engineering problem has been solved by you by yourself.

And I show you once the solution of that one this is the solution of that one; now I am showing you and this problem is also available in the Wiest and Levys book you can follow the same for getting the details of that one.

So, this is the activity on node diagram for the solution of that problem and the next one is the activity on arrow diagram. And you can see you need to use you need to use some dummy jobs you need to use some dummy jobs in this activity on arrow diagram. So, these dummy jobs are there, but in activity on node diagram that is not required. So, unfortunately instead of the dotted line I forgot it. So, it is showing in a colour line, but these are the dummy jobs so, but the general understanding is that dummy jobs has to be mentioned in a dotted line.

And you last time also in last lecture I have also mentioned it. So, you do not forget to put the arrow; arrow is very very important which shows the direction of the flow of the job. So, that is very very important you never forget to use the arrow while you are giving the idea about the networks.

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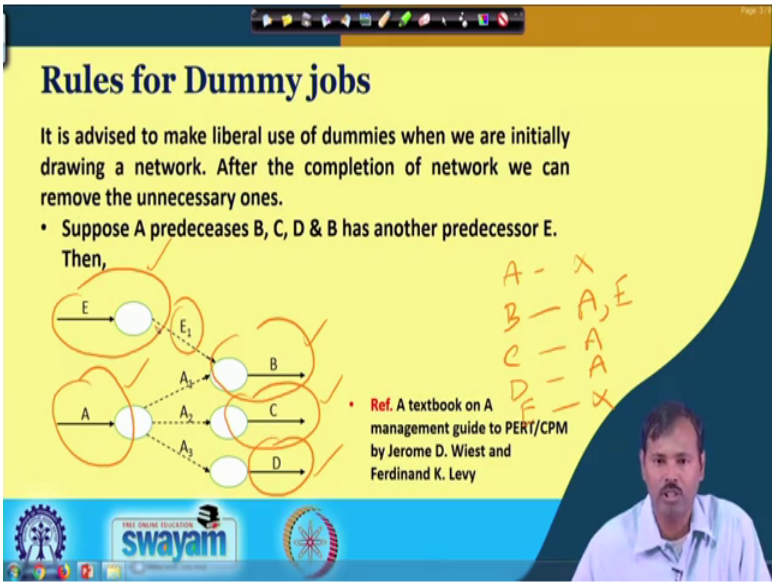

Rules for Dummy jobs

It is advised to make liberal use of dummies when we are initially drawing a network. After the completion of network we can remove the unnecessary ones.

- Suppose A predeceases B, C, D & B has another predecessor E. Then,

A - x
B — A, E
C — A
D — A
E — x

- Ref. A textbook on A management guide to PERT/CPM by Jerome D. Wiest and Ferdinand K. Levy

So, now in this lecture we will discuss about the dummy jobs first ah; that means, we will consider only the arrow diagram that is the activity on arrow diagram because dummy jobs are required in the activity on arrow diagram. So, we will try to understand how the dummy jobs can be placed or while your complex network is given a number of jobs has to be placed in that network in those condition how the dummy jobs can be assigned judicially.

So, that that can be addressed now for that we let us understand the rules for dummy jobs. So, you can see the first requirement is that, it is advised to make liberal use of the dummy jobs when we start the diagram for constructing the network at the very beginning.

That means say suppose it is mentioned to us that job A; job A is the predecessor only predecessors of the job B, but instead of placing a node here. So, that that can be shows like that A is the predecessors of job B let us first separated all that jobs with the initial and terminal nodes and connect them with the dummy activities let us say A 1. So, that is the essential requirement in the initiation, where initial point when we are trying to draw the network because, in a complex structure you do not know now we are observing only job A and job B. May be there are job t job u job v all those jobs are there some of them may be having a the predecessors of a which is not known to us at this present point.

So, initially when we are constructing we are constructing like this A is here B is another one which are connected by A, B is another one which is connected by A dummy job at this point. So, this is the essentially we are caring out this wholehearted or wholesome way we are providing the dummy jobs by placing in every actual jobs individually and we connect them with the dummy jobs and later on we remove those dummy jobs because these are more number of dummy dummy jobs are assigned in the network.

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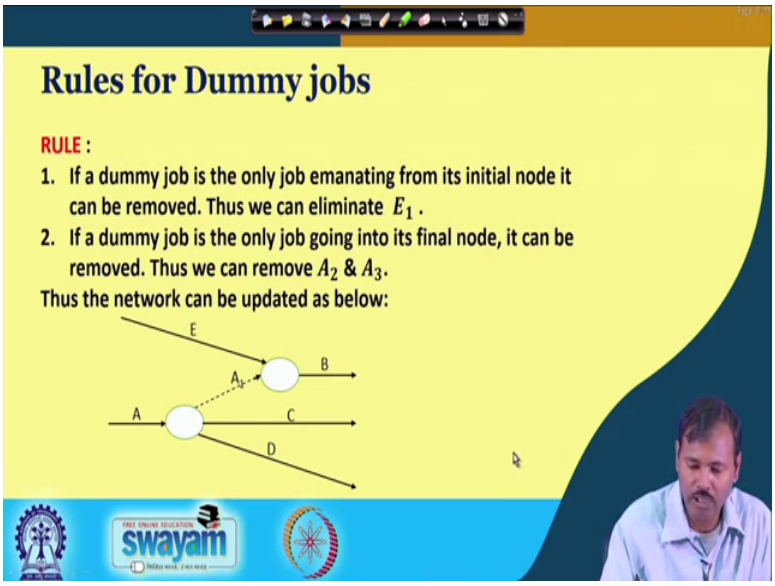

Rules for Dummy jobs

RULE :

1. If a dummy job is the only job emanating from its initial node it can be removed. Thus we can eliminate E_1 .
2. If a dummy job is the only job going into its final node, it can be removed. Thus we can remove A_2 & A_3.

Thus the network can be updated as below:

So, let us see the first rule the rule first rule is first rue is that if a dummy job is the only job emanating from its initial node it can be removed. So, if you see these activities in this activity you can see the first job A here, second job E is here and the B C and D these 3 jobs are having predecessors A and B is having another predecessors E.

So, we can draw the table is like this ABC D E, where A is having predecessors, none B is having predecessors A and E, C is having predecessors A, D is having predecessors A and E is having predecessors none. So, we are trying to construct this one and by the that way as we have individually distributed those each and every activities.

So, this is the activity E and A placed here B C D are placed here and the dummy activities A 1 A 2 A 3 are assigned to B C D to show they are dependency on the A as they are predecessors and also the E 1 dummy job is assigned here to show the dependency of B as the predecessors on A on E. So, this is the way it is distributed, but we fill the more number of dummies are assigned.

So, we need to reduce some dummies from that diagram for that what we what the rules we are following? The 1st rule is the dummy job which are only job emanating from its initial node can be removed and that is why the E 1 dummy job is removed and we directly connect the E to the job B as its immediate predecessors. Now see the rule number 2 which is telling that A dummy job if it is the only job going into its final node it can be removed so; that means, thus for C and D the dummy jobs provided A 2 and A 3 are the only jobs which are having the final node reaching at the C and D and that is the only node reaching at the C.

So, C and D that is why remove those dummy jobs and we can directly connect C and D job if the final node of the A. So, that is why by this way we are able to remove A 2 and A 3 jobs because that is if we are removing that one then also the outcome of the complete network will remain same, but the analysis time given to the computer will be much much less as we are computer earlier computer need to analysis for 3 mode dummy jobs which is not required at this stage.

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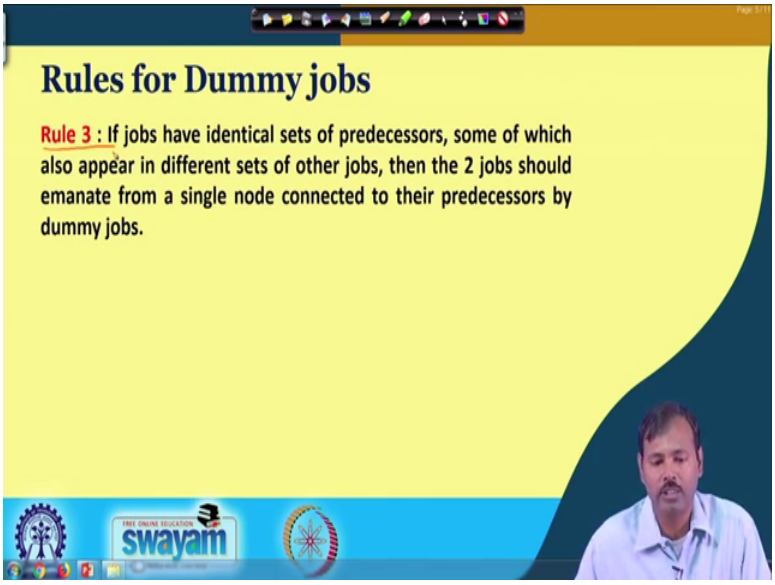

Rules for Dummy jobs

Rule 3 : If jobs have identical sets of predecessors, some of which also appear in different sets of other jobs, then the 2 jobs should emanate from a single node connected to their predecessors by dummy jobs.

Let us look into the other rules the rule number 3; the rule number 3 says if jobs have identical sets of predecessors some of which also appear in different sets of other jobs then the 2 jobs would emanate from a single node connected to their predecessors by dummy job. That means, if there are number of dummy jobs which are common predecessors for the some successors successive jobs in that case, that can be connected to a common node which can be connected as the predecessors of those job can be used and that is the by that way we can eliminate a number of dummy jobs.

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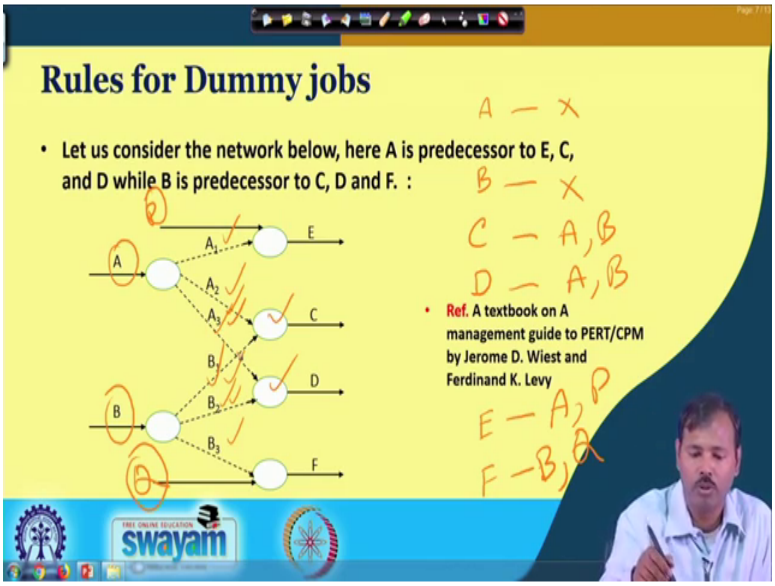

Rules for Dummy jobs

- Let us consider the network below, here A is predecessor to E, C, and D while B is predecessor to C, D and F. :

- Ref. A textbook on A management guide to PERT/CPM by Jerome D. Wiest and Ferdinand K. Levy

A — X
B — X
C — A,B
D — A,B
E — A, P
F — B, Q

Let us look into the details of this one; say we are having a network like this where two jobs A and B, if we construct the table we will say it is like this A B C D sorry let me do it once more A B so, this is A B C D E and F. And if we see that there is no predecessors for A there is no predecessors for B, C is having predecessors both A and B, D is having predecessors both A and B, E is having predecessors A and say another one is available let us put the value P say let A and P.

And F is having predecessors A sorry let me rub it once say B and let us term it as Q. So, this one is Q and this is the predecessors table provided to us and initially when we are placing we have used all this dummy jobs A 1 A 2 A 3 B 1 B 2 B 3 for showing their dependency on C D E A and F. And P and Q these two jobs are only the predecessors job for E and F that is respectively and that is why we place them accordingly and directly connecting them to the E.

But in this case as per the previous rule we have discussed you can see for C and D the only two predecessors are there and they that is A and B that is common to them. So, we can replace A 2 A 3 B 1 B 2 with a common joining point from which the C and D can be coming out. So, let us see how you are solving this one or reducing the number of reducing the number of dummies.

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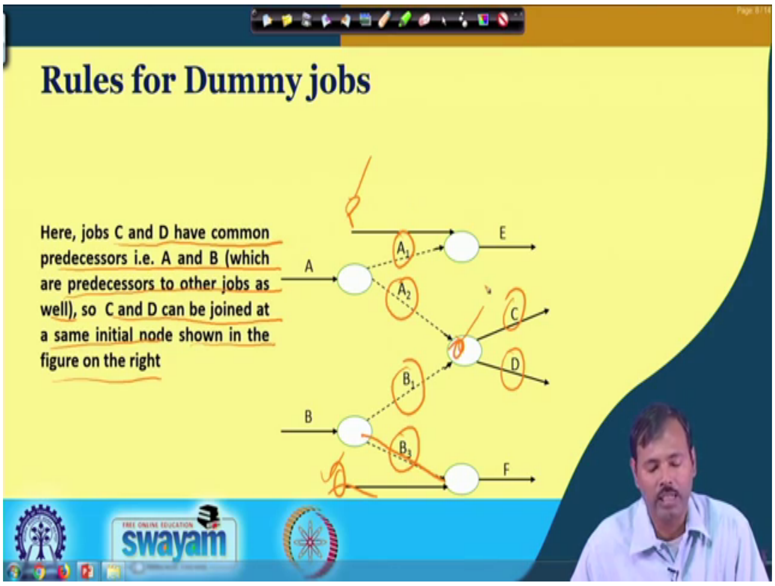

Rules for Dummy jobs

Here, jobs C and D have common predecessors i.e. A and B (which are predecessors to other jobs as well), so C and D can be joined at a same initial node shown in the figure on the right

So, we can see the A 2 B 1 these two dummies are placed to bring the A and B as the predecessors for these particular nodes from which the C and D jobs are initiating. So, C and D jobs are now able to show that their predecessors A and B can be well defined in this condition. The rest for A 1 and B 3 are required to be kept because the P and Q points are already available here; otherwise if this P job and Q job we are not available there then we could start the F point directly from this place instead of removing this dummy.

So; that means, you can see the job C and D have common predecessors that is A and B which are the predecessors to other jobs as well. So, C and D can be joined at a same initial node shown in the figure here. So, that from which the C and D can come out or can be initiated. So, let us see what are the, I hope you are able to understand this one.

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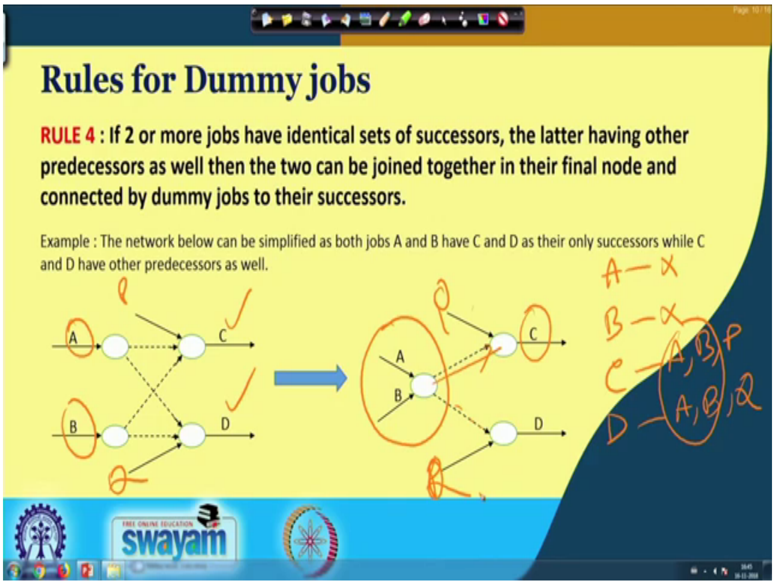

Rules for Dummy jobs

RULE 4 : If 2 or more jobs have identical sets of successors, the latter having other predecessors as well then the two can be joined together in their final node and connected by dummy jobs to their successors.

Example : The network below can be simplified as both jobs A and B have C and D as their only successors while C and D have other predecessors as well.

Now, let us see what is the rule 4 ; rule 4 is telling if two or more jobs are identical sets of successors the latter having other predecessors as well then the two can be joined together in the final node and connected by dummy jobs to their successors. So; that means, if there are two jobs commonly becoming the success becoming the predecessors of some job and there are no other jobs dependent on then individually. In those cases we can allow the two jobs to come at a same point from which the jobs can be initiated dummy jobs can be initiated to show the dependency on them of them on the other successive jobs.

Say I can give you one example suppose you consider of a television in television suppose you need to have a screen LCD screen which needs to be attached to a power source.

So; that means, say this is the LCD screen which is manufactured and a power source is attached to them. So, LCD screen this is the LCD screen manufactured which is the job A, this is the power point or power board for these is manufactured which is activity B. But after that onward when it is required both will be joined together and that has to be used together so; that means, dependency of A and B has to come in a certain point from that onwards it will be used for a number of purpose.

So, the dependency of; these are essentially required side by side. So, that they will be joint together then only that can be useful. So, in this type of cases what we do we go for this activity A and activity B which are the predecessors of C and D along with C and D along with A B C AB AB predecessors they are having other predecessors of say P and Q respectively. So; that means, in this case if you draw the predecessors table A B C D if you look into this then A has none, B has none, C and is having A B and P and D is having A B and Q.

So, in this case what will happen the A B are the common predecessors always for all the activities for which it is required. So, we are combining A and B at this point and we allow C to have the combined predecessors to this dummy of A and B and the precedence for this one P jobs also and D is having the combined precedence of A and B so, this dummy and the along with that the precedence of Q also.

So, basically in rule 4; while the jobs are connected together and for all further activities that jobs means those jobs needs to be fulfilled together in those cases which combinely join those jobs as the predecessors of the all the other successive jobs. So, this is basically the rule 4.

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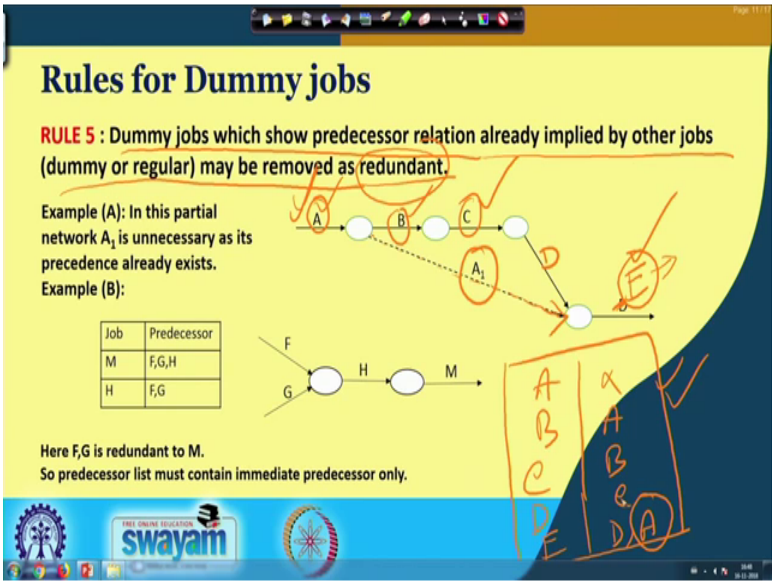

Rules for Dummy jobs

RULE 5 : Dummy jobs which show predecessor relation already implied by other jobs (dummy or regular) may be removed as redundant.

Example (A): In this partial network A_1 is unnecessary as its precedence already exists.

Example (B):

Job	Predecessor
M	F,G,H
H	F,G

Here F,G is redundant to M.

So predecessor list must contain immediate predecessor only.

Now, let us look into the rule 5; which says the dummy jobs which show predecessors relation already implied by other jobs dummy or regular can be removed as the redundant. So, the new term has come which is called redundant. So, if you see in this particular activities where ABC, I think this one is another one D and so, this one is E. So, all these A B C D E jobs are there where as per the table it is given to us that A is having predecessors none, B is having predecessors A, C is having predecessors B, D is having predecessors C and E is having predecessors D and A.

So, as per this given format we have tried to compute this one and to give the dependency of A to the successive job E which is not the immediate successors of A, but the distance successor of E we provide a dummy job A 1 at this position. So, this dummy job A 1 is provided only to construct the network as per the given table it provided in the problem. But if you look into these in some other way you can see for job B we need A has to be completed before hand, for starting the job C we need the completion of B beforehand which in turn required the completion of job A beforehand.

So; that means, whether I am mentioning or not thus job C can only be initiated if the job A is already complete; similarly, the job E can only be started if the job A is complete because on which the B C D etcetera dependent. So, E can be started only if the job A is already complete and in that case whether I am mentioning that E is a predecessors of E or not A A must be already covered before the starting of E ; that means, if we look into this in some other way say A is the immediate predecessors of B and B is the immediate successor of A, similarly B is the immediate predecessors of C and C is the immediate successors of B.

But, in other way A is the distance predecessors of C and C is the and C is the distance successors of the A. So, basically the precedence and suceedence are of two types; one is the immediate predecessors and another is the distance predecessor. And in other ways other term there is immediate successors and there is distant successors. So, if you see into these we will find out say for job H in this example having the immediate predecessors of F and G and M the H is the immediate predecessors, but F and G are the distant predecessors.

So, basically if I am mentioning A, I am mentioning A as the immediate predecessors of D it is also it is also the distant predecessors of A D. So, that is I mentioning A as a immediate predecessors has no meaning, but unnecessary if we are mentioning it then the while we are mapping the computer program the computer will be (Refer Time: 23:46). So, that is why unnecessary if takes longer time and for the analysis it also may arrive at a difficult condition.

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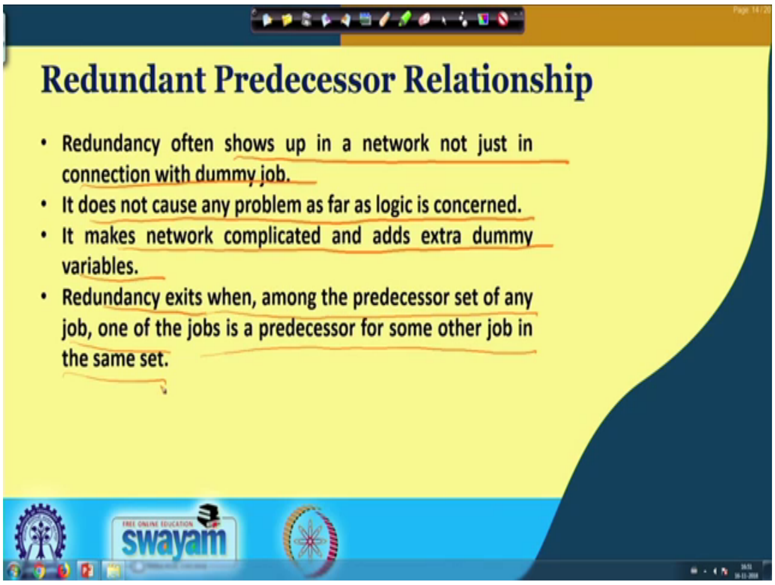

Redundant Predecessor Relationship

- Redundancy often shows up in a network not just in connection with dummy job.
- It does not cause any problem as far as logic is concerned.
- It makes network complicated and adds extra dummy variables.
- Redundancy exits when, among the predecessor set of any job, one of the jobs is a predecessor for some other job in the same set.

So, redundancy often shows up that is this phenomena is called redundancy and redundancy often shows up in a network not just in connection with dummy job, it does not cause any problem as for the logic is concerned, but it makes network complicated add extra dummy variables and in the other term it also takes longer time for the solving of the network.

So, redundancy if exist among the predecessors set of any job one of the jobs is a predecessor for some other job in the same set. So, we have to remove the redundancy that is the essential requirement while we are carrying out the network analysis.

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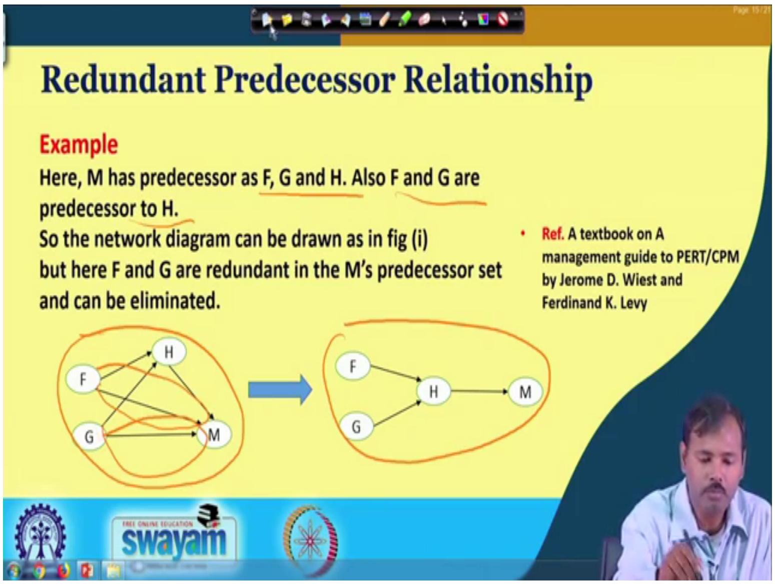

Redundant Predecessor Relationship

Example

Here, M has predecessor as F, G and H. Also F and G are predecessor to H.

So the network diagram can be drawn as in fig (i) but here F and G are redundant in the M's predecessor set and can be eliminated.

- Ref. A textbook on A management guide to PERT/CPM by Jerome D. Wiest and Ferdinand K. Levy

So, this is another example of the redundancy shown here where it is shown that the M has the predecessors F G and H, M has the predecessors F G and H F G are also predecessors of H which we have already discussed. So, we can come out with the network like this instead of having a constructed network like this. So, this is better for us not to go for this one because putting these two arrows showing the dependency of M on F and G have is of no use.

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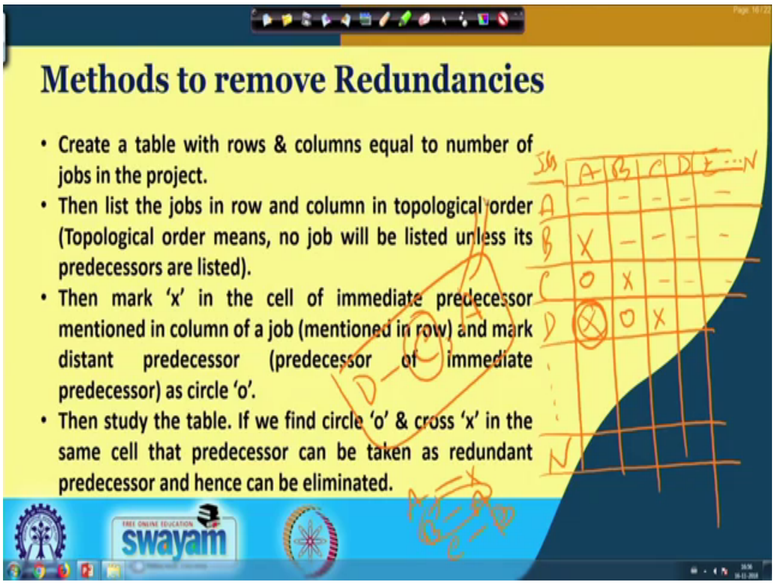

Methods to remove Redundancies

- Create a table with rows & columns equal to number of jobs in the project.
- Then list the jobs in row and column in topological order (Topological order means, no job will be listed unless its predecessors are listed).
- Then mark 'x' in the cell of immediate predecessor mentioned in column of a job (mentioned in row) and mark distant predecessor (predecessor of immediate predecessor) as circle 'o'.
- Then study the table. If we find circle 'o' & cross 'x' in the same cell that predecessor can be taken as redundant predecessor and hence can be eliminated.

Jbs	A	B	C	D	E …N
A	–	–	–	–	–
B	X	–	–	–	–
C	O	X	–	–	–
D	⊗	O	X		
⋮					
N					

So, now let us look into the method of removal of redundancies. So, to remove this redundancy let us construct a table where we remove the redundancy. So, what is the requirement is that the table will be prepared in this manner where all the number of jobs are mentioned at this point say A B C D N. Similarly, the dependencies are possible for all the jobs to all the jobs are mentioned in the column in this side.

So, it is again A B C D E and up to N we will formulate it. So, it is basically N by N table where we will mark the dependency in each and every box so; that means, say if A does have a predecessors will provide in this will lift all the boxes black ok, let us prepare the box like this. So, will leave all this point boxes blank, but suppose B is having A as its immediate predecessors we will mark A cross on A and say for rest it is not mentioned. Suppose C we are marking as the mentioned B is the immediate predecessors so, will marked an x on the B as the immediate predecessors of C and nothing is mentioned in this point.

But as B is the immediate predecessors of C and B is having the predecessor of A; that means, A is becoming the distant predecessors of C as B dependent on the A. So, A is the distant predecessors of C and they will mark A circle in this box. So, basically by this area we are able to mentioning the cross for the immediate predecessors and circle for the distant predecessors.

So, by this way if you try to mention this one suppose it is mentioned us the D is having immediate predecessors, A is having non, B is having A, C is having D sorry C is having B and say it is mentioned D is having C and A. So, what will happen as per the mention table we are placing A cross for D C and as well as A, then we go for trying to search out who are the distance predecessors of C. So, let us see who was who is the immediate predecessors of C it is mentioned immediate predecessors of C is B.

So, we will make a circle at B because, B is the distance predecessors of D; now after getting this B as the distant predecessors of D let us check who are the predecessors of B. So, looking at this you have found the predecessors of B is A. So, you mark a circle at A because, A is now becoming the distant predecessors of D. So, you can see there is the point A where we are having cross and circle together so; that means, which as per the table we are saying that this is the immediate predecessors, that is actually our distant predecessors also.

So, it is not over the at all to mention a distant predecessors as the immediate predecessors though it is understood the which is the result of the A that is essentially required in the B, but the time requirement of manufacturing that one is already taken into the network in the first point as the job A is already there.

So, the distant activity distant predecessors is already complete as A and that is why it cannot be mentioned as the immediate predecessors here. So, we have to remove we have; we have to remove A from the table as the immediate predecessors of D. So, this is the way we are basically removing the redundancy in a network.

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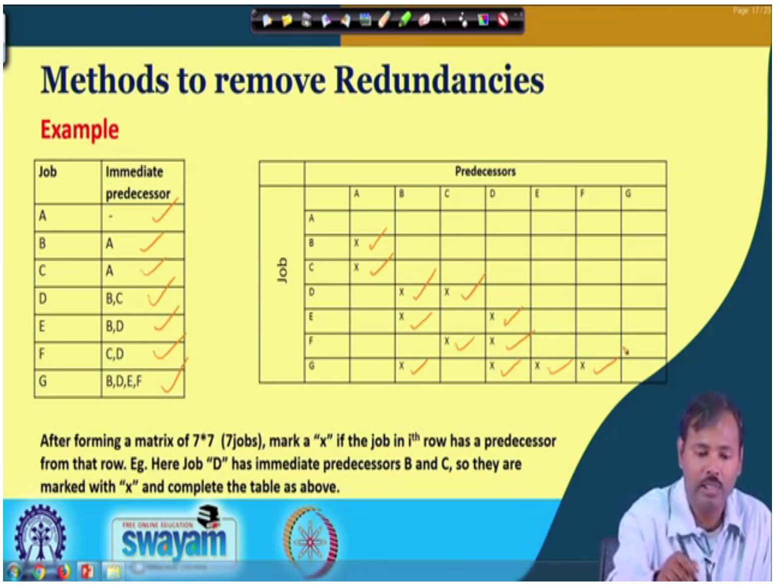

Methods to remove Redundancies

Example

Job	Immediate predecessor
A	- ✓
B	A ✓
C	A ✓
D	B,C ✓
E	B,D ✓
F	C,D ✓
G	B,D,E,F ✓

		Predecessors						
Job		A	B	C	D	E	F	G
	A							
	B	X ✓						
	C	X ✓						
	D		X ✓	X ✓				
	E		X ✓		X ✓			
	F			X ✓	X ✓			
	G		X ✓		X ✓	X ✓	X ✓	

After forming a matrix of 7*7 (7jobs), mark a "x" if the job in ith row has a predecessor from that row. Eg. Here Job "D" has immediate predecessors B and C, so they are marked with "x" and complete the table as above.

So, the same is now showing here for the given example you can see A does not have a any predecessors, B is having A, C is having A, D is having B and C, E is having B and D, F is having C and D and G is having B D E F. So, all the immediate predecessors are mentioned here B as A, C as A, D as B and C, E as B and D and G as sorry this is E as B and D F as C and D and G as B D E F. Now let us see place the distant predecessors of this.

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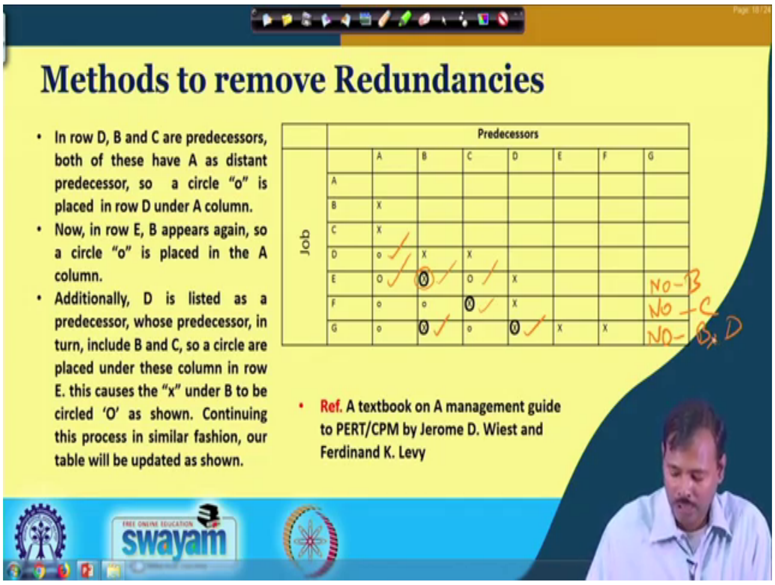

Methods to remove Redundancies

- In row D, B and C are predecessors, both of these have A as distant predecessor, so a circle "o" is placed in row D under A column.
- Now, in row E, B appears again, so a circle "o" is placed in the A column.
- Additionally, D is listed as a predecessor, whose predecessor, in turn, include B and C, so a circle are placed under these column in row E. this causes the "x" under B to be circled 'O' as shown. Continuing this process in similar fashion, our table will be updated as shown.

		Predecessors						
		A	B	C	D	E	F	G
Job	A							
	B	X						
	C	X						
	D	o ✓	X	X				
	E	O ✓	⊗ ✓	o ✓	X			
	F	o	o	⊗ ✓	X			
	G	o	⊗ ✓	o	⊗ ✓	X	X	

NO-B
NO-C
NO-B, D

- Ref. A textbook on A management guide to PERT/CPM by Jerome D. Wiest and Ferdinand K. Levy

So, after placing the distant predecessors you can see when you place it for D you have got a distant predecessors A here, when you are placing it for E you have found the distant predecessors E B sorry A B and C are mentioned and you can see the B at this point is mentioned at the immediate and distant both the predecessors.

So, in the previous table as we have carried out this B can be removed as the immediate predecessors from job E; similarly you have got for job F where C is coming actually for both immediate and distant predecessors. So, no C can be required as the immediate predecessors, for job G similarly you can see the B and D are mentioned here as the immediate and distant predecessors both so, you do not need B and D here.

So, if you look into the table now you can find out; you can find out in this we have to remove B from here, we have to remove C from here and we have to remove B and D from here. So, that the new table will be A A B C D D and E F and accordingly we can construct the network.

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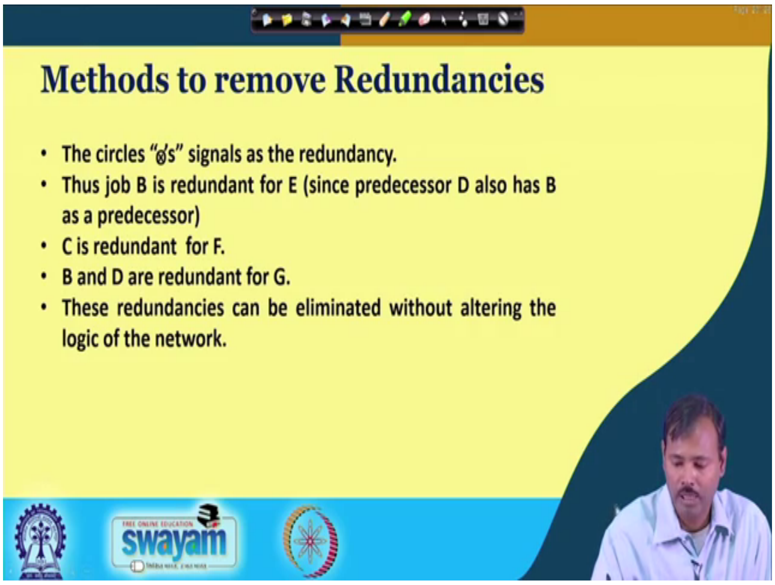

Methods to remove Redundancies

- The circles “⊗s” signals as the redundancy.
- Thus job B is redundant for E (since predecessor D also has B as a predecessor)
- C is redundant for F.
- B and D are redundant for G.
- These redundancies can be eliminated without altering the logic of the network.

So, I hope you are now able to understand how to remove the redundancy you can have your own terminology but, this circle and cross is a very good option for carrying out this one.

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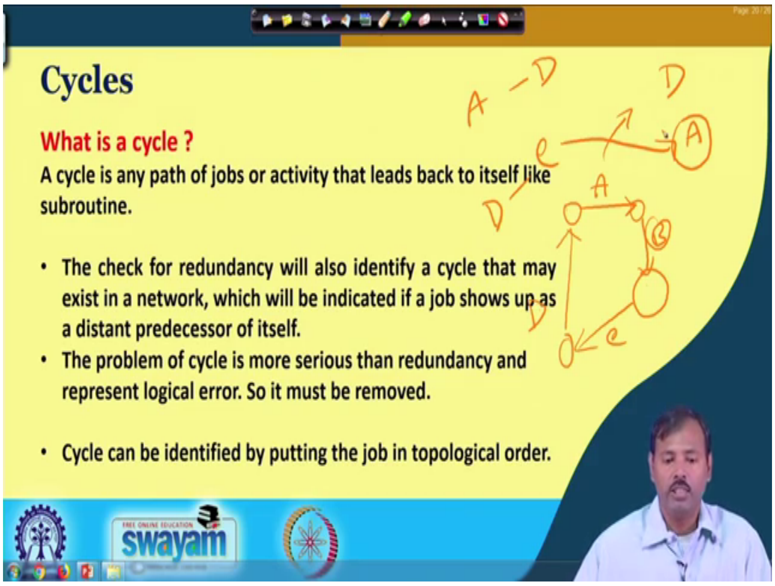

Cycles

What is a cycle ?

A cycle is any path of jobs or activity that leads back to itself like subroutine.

- The check for redundancy will also identify a cycle that may exist in a network, which will be indicated if a job shows up as a distant predecessor of itself.
- The problem of cycle is more serious than redundancy and represent logical error. So it must be removed.
- Cycle can be identified by putting the job in topological order.

There is another problem may arise if the redundancy leads to a cycle; cycle means if it is shown, but job A is depending is having A successors of job B, then job B as job C is mentioned as the successor of B, then say job D is there job D is there which is mention successors of C, but A is mentioned as the predecessors of D.

So, what is happened if A is mentioned that A needs a predecessors D and D needs a predecessors C which in turn is having distant predecessors A then it clears a cycle condition. So, these cycle condition if it is arises this is impossible to solve. So, in this type of case it is essentially required or the constructor of the network must be very very careful to check whether any cycle is existing in the network path or not if it is existing then all the dependency has to redefined and the cycle must be removed prior to the analysis of the network.

So, I hope this is the way you can remove the dependency of the dummy job on the dummy jobs we can remove the redundancy and we can take care of the cycle situation which can be arise in the network analysis. So, I expect that now you are able to practice the construction of network more for the more critical cases you use more number of activities for the construction of the network and find out the dummy jobs search out for the removal of the redundancy search out for the cases where the cycle condition may arises.

Thank you.