Project Management for Managers
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Lecture – 44
Simulation of Networks- II

Welcome you all. In previous session, we were discussing this question, and we have been asked to calculate how the duration of this project would distribute, what is expected time what is the probability that the project would be completed in 14 or less than 14 days and critical indexes of all the activities. And we have to simulate this network for 5 times we have been even these two activities 1, 2, and 1, 3 having fixed duration

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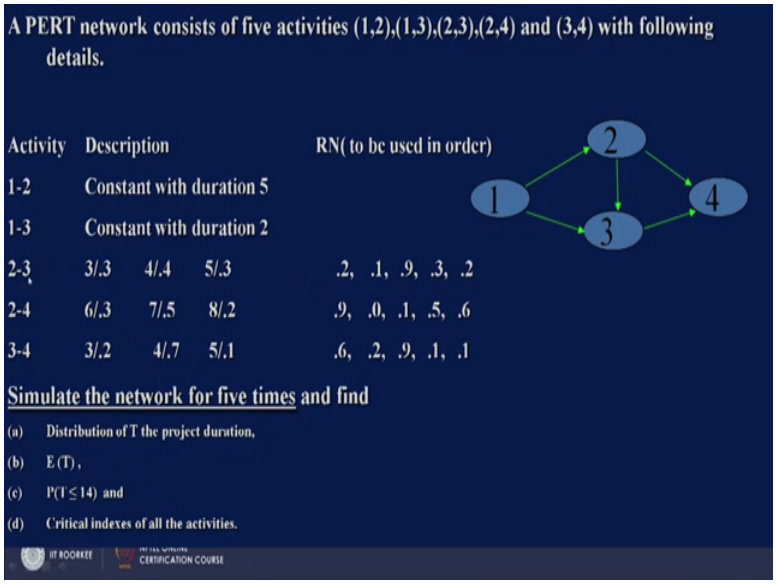

as far as 2,3, 2,4 and 3,4 are concern we have been given their time durations along with probabilities and the random numbers which are to be used for these three activities are this. So, let us start simulating this network since we have to simulate this network for 5 times we will be simulating it now 5 times. So, first of all, let us go for first simulation run.

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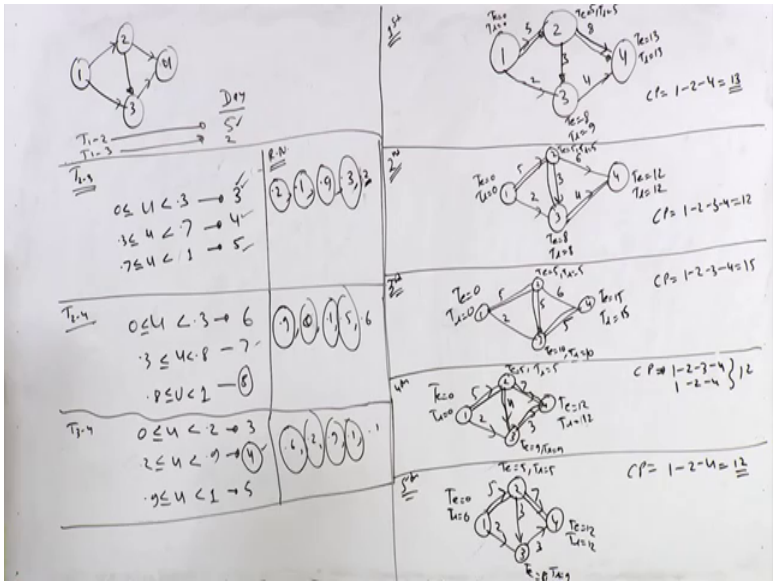

So, first simulation run right and the network is this, this is our network 1, 2, 3 and 4. So, first time what is the duration of activity 1-2 is 5; for 1-3 it is 2; for activity 2-3, random number is this 0.2; and 0.2 is in this range, it needs the duration is 3 days, for activity 2-3 duration is 3 days. For activity 2-4, first random number is 0.9; and 0.9 is in this range it means duration is 8, for activity 2-4 is 8. For activity 3-4, first random number is 0.6; 0.6 is in this range, it means duration is 4. Let us find out what are different critical paths and what is the total duration of this project. So, T e is equal to 0 T e at this point is 5; T e at this point is what from this side it is 2; from this side it is 8. And from here to here, it is 12 and from this side it is 13, let us take T l also as 13.

So, T l here is 13 minus 4 – 9. T l at this point will be 13 minus 8 is 5. And T l from this side also can be calculated, so 9 minus 3 that would be 6, but we have to take a smaller value, so 5 is the right, T l value right. T l at this point is this is 5 minus 5 this is 0. So, T l is 0. So, which is critical path where you got T and T l are same. So, this is your critical path, this path is your critical path. So, critical path is 1, 2 and 4 and total duration is 13 this is our first run.

Now, let us calculate the duration for second run. Second run same network 1, 2, 4; as far as 1-2 and 1-3 are concerned there the durations are fixed right. Now, let us look at activity 2-3; 2-3, its random number is 0.1; 0.1 is in this range. So, the duration would be again 3, for activity 2-3, this is 3. For activity 2-4 random number is 0, so this here right,

so this would be 6; 2-4 it is 6. For 3-4, random number is 0.2; 0.2 is 0.2 is in this range or in this range, in this range it is less than 0.2, so for 0.2 duration is 4. So, for 3-4, it is 4.

Let us find out critical path T e at this point is 0; T e at this point is 5; T e at this point is 5, from this side it is 8 right. Now, T e at this point is what this 8 plus 4 – 12, 5 plus 6 - 11. So, this is 12. So, this is critical path. If you want you can calculate T l also lets calculate T l also. So, T l - 12 this is T l – 8, 12 minus 4 – 8; 12 minus 6 – 6; and 8 minus 3 - 5. So, T l at this point would be 5 for this node for node 2 T e is 5 and T l is 5. What about T l here T l from this side it would be 0. So, you have got how many critical paths you got more than one critical path and the total duration of this network is 12. So, you have got this critical path. This is your critical path right and the total duration is 12. So, cp is what it is 1, 2, 3 and 4 with total duration of 12 this is second run.

Let us do it for third run. Third run this is let us say we will draw network here like this. This is third run, fourth and fifth right. So, we will do it in this particular row right. So, this is third run, this is 1, 2, 3 and 4 right. So, there is some problem I think we did a mistake. In fact, in second run, the duration for activity 1-2 is 2; for 1-2 it is 5; for 1-3 it is 2 right. So, this is two actually. So, T e will remain same right. So, this 0, 5, 5, 3, 8 yeah this is now correct. In fact, this duration did not affect our critical path as well as total duration. Now, activity 1-2, its duration is 5; for 1-3, its duration is 2.

Now, what to do will take up third random number right for activity 2-3, third random number is this 0.9, 0.9 is here, so 5 is the duration. For activity 2-4 third random number third random number is 0.1, which is 6. For 3-4, it is 0.9 which is here right 5. Calculate T e and T l. So, T e at this point is 0, T e here is 5, T e here is 10; 5 plus 5 – 10, 10 plus 5 15 yeah. So, this T e is 15 here. T l is 0; T l here is 10; then T l here is 10 minus 5 – 5, and this is 15 right. So, T l 10 minus 5 is 5; 15 minus 6 is 9, so we will take T l is equal to 5 at this node 2. Then T l here is 0. Critical path is it is 1, 2, 3 and 4. So, this is 1 to 2, 2 to 3, and 3 to 4. What is the total duration 15 days. So, C P critical path is 1, 2, 3 and 4 is 15.

Let us take for fourth time will do it quickly 0 this your network 1-2 three four this is 5 this is two right fourth time this is 0.3, 0.3 is here right. So, the duration would be 4, 2-3 duration is 4. For 2-4 random number is point 5, which is here right, so duration is 7, 2-4 duration is 7. And 4-3, 4, it is 0.1 it means 3. So, T l 0 this is 9, this is T e at this point is

5. So, nine plus three 12 from both the sides we are getting 12. Now, T l let us take T l is equal to this 0 sorry 12. So, 12 minus 7 - 5 and 12 minus 3 - 9. So, T l at this point is also 9, T l at this point is 5. Now, T l is 0. So, now, you have got two critical paths right you got 1, 2, 3, 4; 1, 2, 3 and 4, and 1-2 4. So, CP there are two CPs 1, 2, 3 and 4 and 1, 2 and 4 and the duration is for both these paths is same right 12.

Let us do it for fifth run also. Fifth run, this is 5, this is 2. Let us calculate for last run on the durations for remaining activities, so 0.2, 0.2 is here right 3. So, for 2-3 it is three right for two four it is 0.6 right 0.6 is here right seven for 2-4, it is 7. For 3-4 it is 0.1 right. So, it is three. So, T e here is T e is 0; T e is 5; T e is 8 right, this 5 plus 3 – 8, 8 plus 3 – 11, 5 plus 7 - 12. So, t at this node is 12 right T l is also 12. So, this is T l at this point is nine right 12 minus 3 is 9, 9 minus 3 – 6; and 12 minus 7 – 5, so we will take 5 from this path. So, this would be the critical activity right and T l here will be 0 right. So, what is critical path, this path is critical path right. So, in fifth case in fifth run we are getting just one critical path which is one cp is equal to 1, 2,4 and its value is 12 days.

So, let us now solve the first question distribution of T e of the project duration distribution of this project duration. So, if you look at and you time estimate over there you have got 12, 13, 15, 12 and 12 right. So, what we can do is the distribution of T. So, we know the T and we know the probability also.

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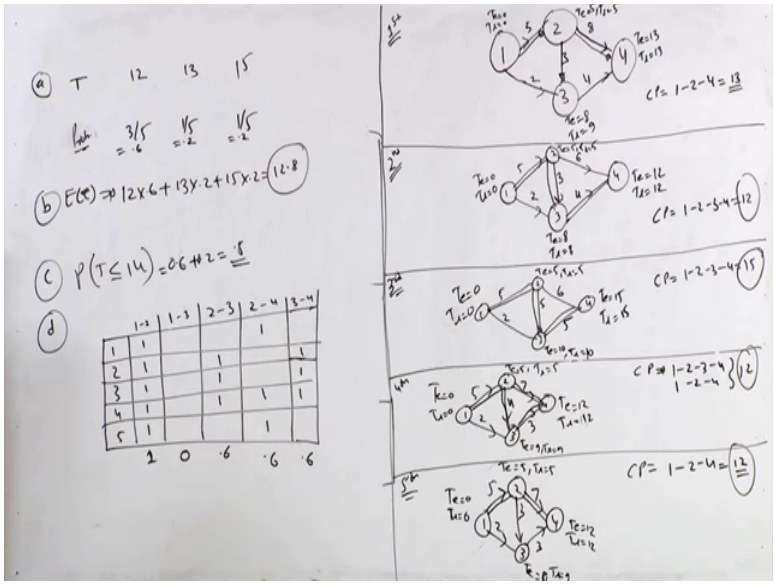

Since we have done it 5 times. So, duration is let us say the minimum duration is 12. How many times you are getting 12 1, 2 and 3, so three by 5 right out of 5 times 5 runs 3 times we got 12 is the duration. Then 13 is how many times just one time yeah, first time 1 by 5. And 15 is did we get 15, yeah here it is right, so 15 is for one time. So, this is the first part of the question right a distribution of this project. Now, what is expected time expected time, just take the average of all these values and that would be expected time is since you can also find out probability is here 0.6, 0.2 and 0.2. So, what is the expected time you just multiply 12 into 0.6 plus 13 into 0.2 plus 15 into 0.2. So, this would be 12 point 8. So, this is the duration of this project right the expected duration of this project is 12 point 8 days right.

The third point is what is the probability that project will be will take less than or equal to 14 days less than or equal to 14 days. How you will do that? Probability that the project would be completed in less than or equal to 14 days; so for that less than or equal to 14 days right this is for 15 days right 0.2, this is for 12, 13. So, for less than 14 is this. So, this is 0.6 plus 0.2, this point 8 is the answer.

Now, the next part is critical index of all the activities now since there are different activities we will have to find out critical how many times which activities were critical right. So, let us look at d part here. So, we did run we did go for 5 runs right, so first, second, third, fourth and fifth. I will let us write here different activities. So, let us say activity 1-2, activity 2-3, activity 2-4, activity 3-4, you do not have any other activities right you got only four activities or 5 activities is 1-2, 1-3, 2-3, yes it is one yeah very. So, this is 1-2, 1-3, then 2-3, 2-4 and 3-4, there are 5 activities right.

Now, let us find out which activity was critical are which activity were critical in first run. In first run, you have get 1-2 and 4, 1-2 and 2-4 critical right. In second run you have got 1-2 yes 1-2 was critical 2-3 and 3-4 right this was also critical. Third run, you have got 1-2, 2-3, and 3-4. Fourth time 1-2 was critical then 2-3 yes 2-3 was critical, 2-4, 3-4 both were critical because there are two paths here right. Fifth time 1-2 is critical and 2-4 critical. So, out of 5 times this was critical 100 percent time right this was not a critical even once; right out of 5 times this was critical for three times it means 0.6 is the critical index. In other words 60 percent times this would be critical this also 0.6 and this also 0.6 right. So, this is the fourth part of this particular question.

Now let me repeat what we did in this session. Let me try to summarize what we did in this as well as in previous session. As I said in real life, you will not know exactly what is the time of an activity, it may take any shape, it depends on different factors. Let us say if you are constructing a bridge and you know that a particular activity takes let say 5 days time right from your past experience, but next time it is possible that due to non availability of some resource it may take 10 days. So, it is very difficult to predict the duration of the activity. So, the simulation is the best method. Why simulation is best, because you can always prepare computer program and simulate an activity for thousands of times; in fact, if the duration of the activities let say distributed let say it has got beta distribution right or it has got normal distribution or some fled distribution or triangular distribution or some other distribution. It is always good to simulate it, but you need to simulate in certain situation.

And there is only one specific situation it is uncertainty right. When we think that situation is very uncertain you should simulate right. And for simulation, you need to know something about random numbers; and random numbers can be generated in different ways. You can always ask me question from where did I get these numbers right. So, there are multiple methods of generating random numbers. The first and the most easiest method of generating random number is you got random number tables. In all the books of statistics and in the books of mathematics also sometimes, you will get you will have a random number tables. So, from those tables you can take of random numbers. And random numbers can be of different digits, you can have a single digit random number, you can have two digit random number, you can have 5 digit random numbers and so on. If you do not have a random number table then you can simply prepare chits and let say if you want to pick random number between 1 to 10. So, you just prepare 10 chits and pick one chit, so that chit would give you random number. So, this is second method.

There are several computer programs available for generating random numbers. Apart from this, you would have seen there is something called row let wheel right you would have seen in movies also right. So, row let wheel will also give you random numbers. And there are some mathematical methods available which will also give you random numbers. So, there are multiple ways of generating random numbers the moment you select a set of random numbers for particular activity for example, for this activity we

have chosen these 5, and each time we got different time estimate. So, the moment you change random numbers, your solution will also change. So, it is suggested that you should generate more and more random numbers, and you should perform more and more simulation runs. As far as this particular question is concerned we did go for 5 runs. And in first run since in this particular case two activities have got fixed durations 5, 5 and 2. For all other threes, we have been given random numbers and their time estimates along with probabilities.

So, in first random number what we did we calculated all T es and T ls and the critical path is 1 to 4. So, only two critical activities the duration is 13. For second run, there were three critical activities and the duration is 12. For third run, there are again three critical activities, this is 1-2, 2-3 and 3-4, total duration is 15. Fourth run, there are two critical paths, in fact, in no other run we found two critical paths, but in this run we have got two critical paths right. So, this is a 1-2-3-4 and 1-2-4, total duration is 12. In fifth run, you have got again two critical activities 1-2 four right and total duration is this.

So, what we have said at the end of that probability that this project would be completed in 12 days is 60 percent; it would be completed in 13 days it is 20 percent; it would be complete in 15 days 20 percent right, 15 by in fact since we got this only once. So, this 1 by 5, 1 by 5 and 3 by 5 for duration this one right for this duration right expected time you just multiply their durations with the probabilities, so it is 12.8. So, at the end of the day we will say that the duration of this particular project is12.18. Probability that it will take less than 14 days is 0.8 and this is critical index. So, we will say that in this example the most important the most important activity is activity 1-2. So, whenever you go for a run this in as far as this these 5 runs are concern, activity 1-2 was critical. So, with this let me finish here.

Thank you very much, we will have some more topics in next session.

Thank you.