Software Project Management
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Lecture – 27
Project Scheduling Using PERT/CPM

Welcome, to this lecture. In this lecture, we will discuss about Project Scheduling Using PERT and CPM. In the last lecture, we had looked at the various issues in project scheduling; we had discussed about breaking down tasks in the project using a work breakdown structure and then we had looked at a task network.

Over the years, that is over the last century or so, these techniques have been used the project scheduling techniques for various types of projects and therefore, different ideas that were proposed regarding project scheduling have now been merged into very strong and useful technique the PERT and CPM. And the focus of this lecture is to discuss about how to use PERT, CPM for project scheduling. Let us proceed from this point.

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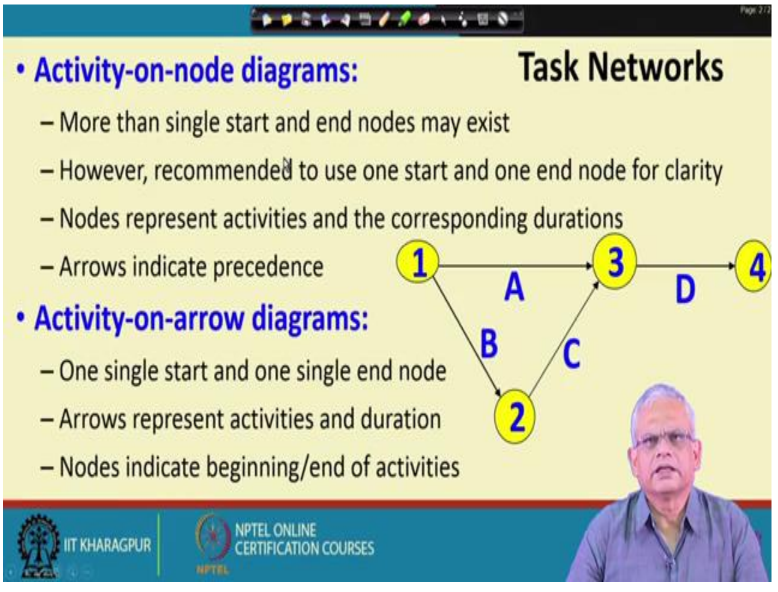

If you remember, in the last lecture, we had discussed about task networks. In the task network, we represent the different tasks in the project and also the precedence relationships, that is, which task must complete before another task can start. But, then over the last century or so, there are two main types of task networks that have gained popularity, one is activity-on-node diagram.

In the activity-on-node diagram, as the names says, this network consists of nodes and edges. In this network nodes and lines connecting the nodes and the names of the node are labeled with the activity names. So, each node represents an activity that is why it is called as an activity-on-node diagram.

On the other hand, we have another variant of task network which is activity-on-arrow diagram. In this the nodes they represent end or start of activity, but the activity itself is represented on the arrows or the edges connecting the nodes in the diagram. But, the activity-on-arrow diagram had some issues. It is much more complicated than the activity-on-node diagram. The activity-on-node diagram is very intuitive; whereas, here in the activity-on-arrow diagram we have nodes representing start and end of activity and the activity itself is represented by edges and on that count there are few complicacies that arise and we might have to insert dummy activities and so on to model a project.

And possibly for that reason over the years activity-on-node diagram have become very popular used overwhelmingly by the project managers very simple and also the different CASE tools the computer tools and project management that are available they also use largely the activity-on-node diagram. And in this lecture we will focus on the activity-on-node diagram, but as a background knowledge we will just keep in mind that there is a variant of the test task networks which are activity-on-arrow diagram.

In the activity-on-node diagram we might have more than single start node that is to start the project we might have a few activities which are no dependencies, that is they can start anytime and similarly there may be many end nodes in any project. But, then it makes a bit complicated to use various computations on such a activity-on-node diagram which has multiple start nodes and multiple end nodes we will make it complicated to apply various project scheduling techniques.

And therefore, it is recommended that we use a dummy start node and dummy end node which are single nodes single start node and single end node, so that application of the techniques is becomes very intuitive and easy. And this point we need to keep in mind that whenever there are multiple start nodes, we will have a dummy nodes start node which will be single start node, similarly for the end node.

And here in the activity-on-node diagram as the name says that the nodes represent the activities. The nodes are labeled with activities and also not only we have the activities on the nodes, but also we marked the duration that the activity will require. And will have arrows which will indicate the precedence of one activity with other activities.

The activity-on-arrow diagram here the nodes indicate the start and end events of activities, but the activities themselves are marked on the arrows and also the duration of the activities are marked on the arrows. Here also one single start and single end node that makes it easier, as we already mention. Arrows represent the activities unlike the activity-on-node diagram where nodes represent the activities; in the activity-on-arrow diagram. The arrows represent activities the arrows are labeled with the activity names and also the duration. And nodes indicate the beginning and end of activities.

Just to give an example of a activity-on-arrow diagram, we have this activity A starting at node 1 ending at node 3; activity B is marked on this edge or arrow which is starting at node 1 and ending at node B sorry, node 2. But, as I already mention that will not really use activity-on-arrow diagram all our examples will restrict to activity-on-node diagrams.

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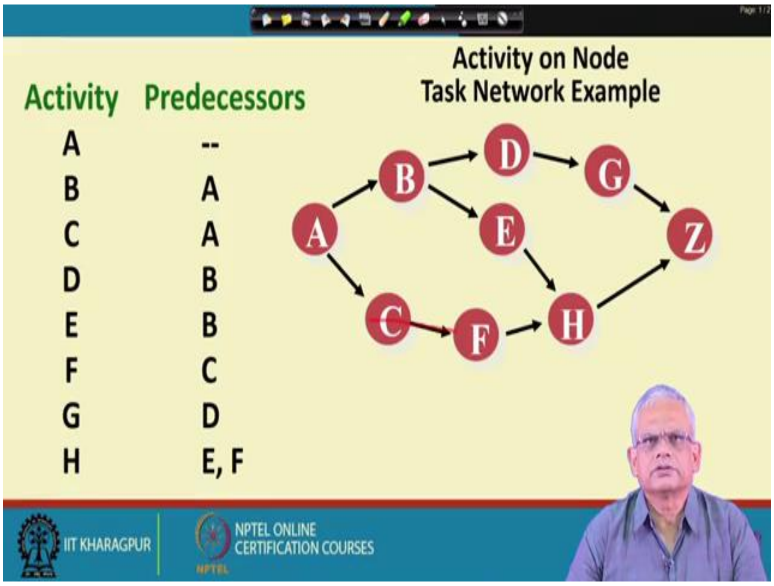

Now, let us try to draw an activity-on-node task network diagram. Given that, we have from a work breakdown structure we have identified what are the activities and then later we also identify what are the predecessors of the activity. A has no predecessor; B has predecessor A; C also has predecessor A; D has B as the predecessor; E has also B as the predecessor; F has C as the predecessor; G has D as the predecessor and H has two nodes E and F as the predecessor.

So, how do we draw this? Of course, we can straight away draw A, because A has no predecessor. So, we can draw A here which has no predecessor and then we have B has A as the predecessor. So, we can draw B which has A s the predecessor and then we can look at C and C also has A is the predecessor. So, let me draw C here C also has A as predecessor.

And D has B as the predecessor we draw D here which has B as the predecessor and then E has B as the predecessor. So, we can draw E here, E has B as predecessor and we have F has C as the predecessor. Let me draw F here; F has C as predecessor and G has D as the predecessor. So, let me draw G here, G has D as the predecessor and H has both E and F as the predecessor H has both E and F as its predecessor.

And we can since there are two nodes here which are two end nodes we can have a end node here and this can be the task network, activity-on-node diagram. And if I redraw this nicely so, we have this A has B has A as predecessor, C has A as predecessor H has both E and F and Z is a end node. So, the same diagram just drawn it here. As you can see that it is not very difficult very intuitive actually to draw a activity-on-node task on network.

I am sure that given any other example you can draw the activity-on-node network diagram. But, the activity-on-arrow diagram would have more complications and we are not going to discuss that because overwhelmingly activity-on-node diagrams are being used.

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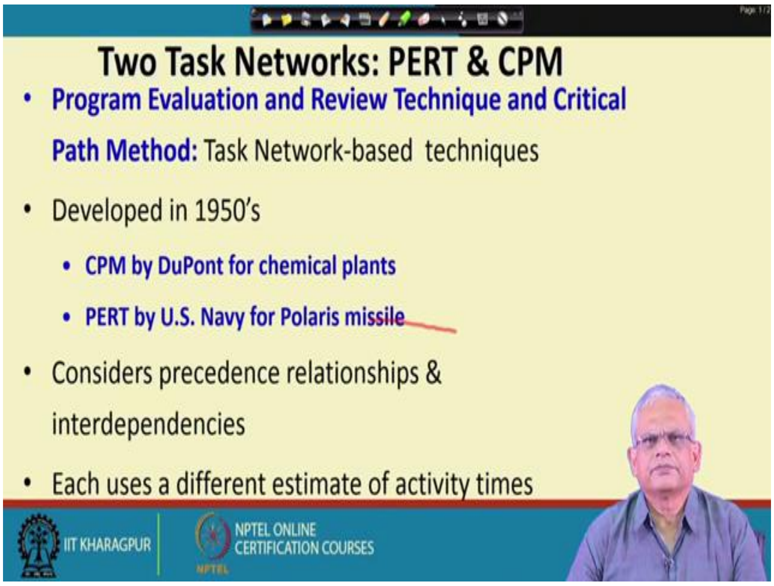

Now, the techniques PERT and CPM these are two task network based techniques as you are saying that these have been developed over the last century or so. These are two different techniques PERT and CPM; PERT stands for Program Evaluation and Review Technique and CPM stands for Critical Path Method. These are two task network based techniques. The PERT initially use the activity-on-arrow diagram and because these have long history over the years sometimes the activity-on-node diagram was adopted.

If we look at the history of this both of these were developed based on the Gantt chart. Gantt chart was a older diagram and Gantt chart is used for project monitoring, control, resource allocation etcetera. And later in this course will be discussing about the Gantt chart, but the project scheduling is done by PERT and CPM diagrams.

And this were developed in 1950s and Gantt was much earlier than this, may be 1920s and 30s. The CPM was developed from Gantt chart and was used by the company DuPont in its chemical plants for managing maintenance projects of chemical plants. The PERT was used by US Navy for development of the Polaris missile.

But, just want to mention here that the CPM was used by DuPont for managing maintenance activities and maintenance activities we know what are the type of maintenance, what will be the activities, what is their duration can be precisely known. And therefore, here the task durations are more deterministic; whereas, the other one, the PERT was developed by US Navy for development of the Polaris missile.

And this is a development project unlike the maintenance of chemical plants which is a routine work. The PERT was for development project where there are much more uncertainties regarding the tasks. For example, the task start time, the task duration end time these are all random because there can be delays. The durations etcetera are not known deterministically unlike the maintenance projects and therefore, PERT uses a statistical techniques for the task durations.

Both these techniques the considered precedent relationships on the task just like any task network which represent the interdependencies among the tasks. And as I mention the CPM uses a deterministic estimate of the activity time and the PERT uses a statistical estimate of the activity time.

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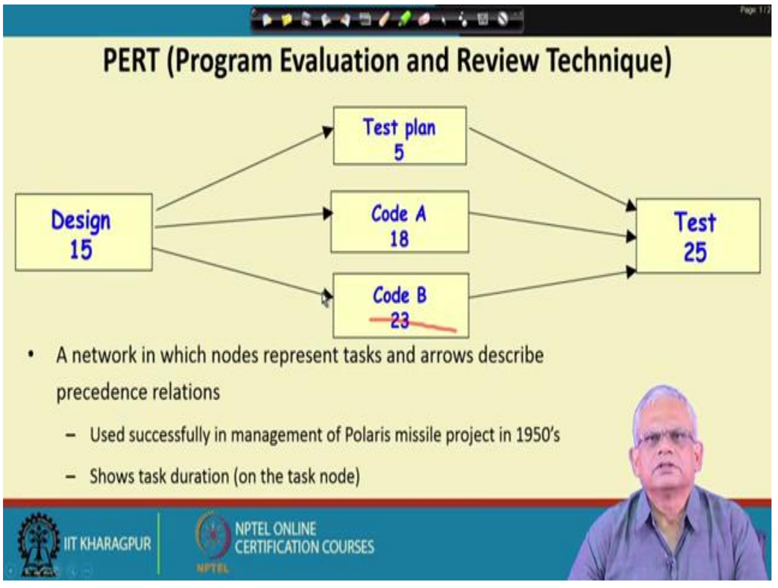

Let us look at our first diagram. This is the simplest PERT diagram and here we have used a deterministic times for design, test plan; the test plan can start only after the design is complete. The design is expected to take 15 weeks; test plan is expected to take 5 weeks and testing is expected to take 25 weeks. There are two main modules A and B; after the design test plan can be done or coding of module A can be done which will take 18 weeks or the coding of B can be done which takes 23 weeks.

There is a parallelism possible that is these three tasks can be carried out in parallel if sufficient resources exist. But, then it may so happen that we have only one developer, one coder we have available and one tester. In that cases all the three cannot proceed parallelly; testing can be done by the tester and the coder can take one of this and then after completing it needs to do this.

And then after all of them complete the testing, coding of A and B then the actual testing activity can be done, but then in the PERT diagram we do not show this constraint that, are resources available to carry out all these in parallel and so on. These are done later in the project planning, where the project manager use as a Gantt chart to do the project scheduling where these allocation of resources to the tasks are done.

And also the Gantt chart is used for project monitoring and control, where the schedule needs to be refined if there are any variations that are observed. For example, the design instead of 15 it completed by 13, what is the impact on the other parts of the project? We need to redo the schedule. What if the test plan instead of 5 it took 10 weeks, what will be the impact on the schedule? So, these are all better than using Gantt chart. The resource allocation monitoring and control done using Gantt chart and that will discuss later in this lecture series.

This kind of network as we said was done for development of the Polaris missile 1950s. And here each node we write the name of the task; you may use just a label instead of the task name. If there are too many tasks it becomes unwieldy to write the task name like this. We might use A, B, C, D etcetera and then those are the labels and then we will have task names for those labels stored in a table.

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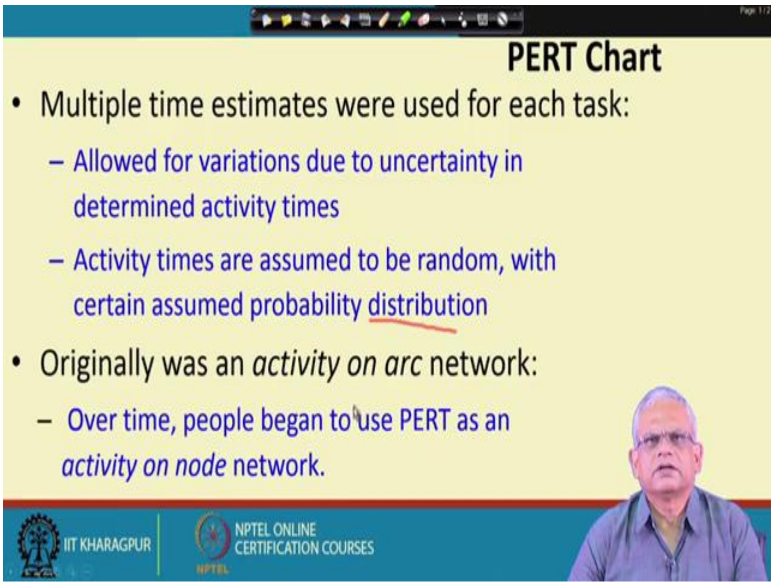

The PERT chart, the tasks have uncertainty and therefore, multiple time estimates were used for each task. This allowed for variation in the activity times that is completion times of the task, the preceding task and so on. This can be accommodated represented in the PERT chart and statistical inferencing can be drawn from the PERT chart. The activity times are assumed to be random with some probability distribution.

As you are mentioning these techniques have been used over time, over a large number of years and this technique has developed from its start 1950, that is about 70 – 80 years back and originally it was an activity on arc network. But, then as I was mentioning that now it is mostly used as a activity-on-node network.

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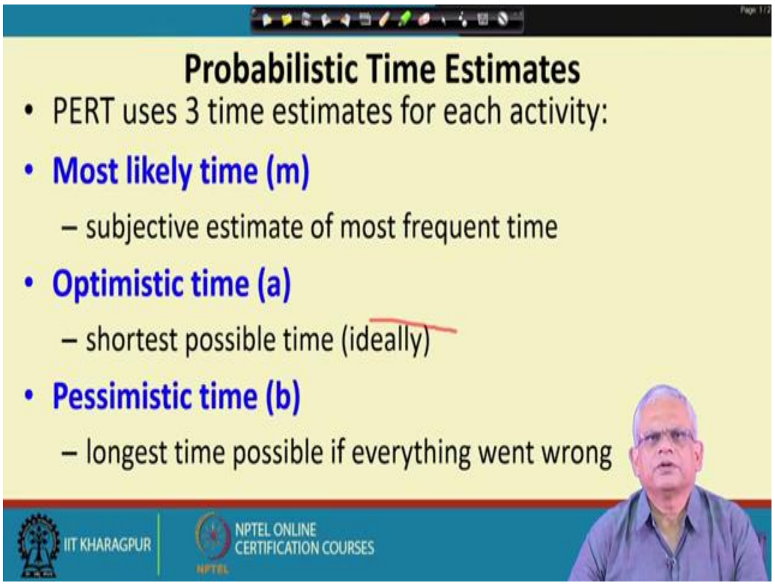

For each activity in the PERT, 3 estimates are provided: one is the most likely time. This is a estimate of the project manager that what is the time that it is most likely to take. The optimistic time – this is the shortest possible time which the task the activity can take. The pessimistic time is the longest possible time if things did not work out; the developer became unwell, the resources broke down that is the computer hardware had problems and so on.

The project manager provides 3 times for activity most likely optimistic and pessimistic and each activity is provided 3 time estimates. And based on that a probabilistic inference on the project duration is made that what is the likely time that the project will take to complete what is the optimistic and what is the pessimistic time.

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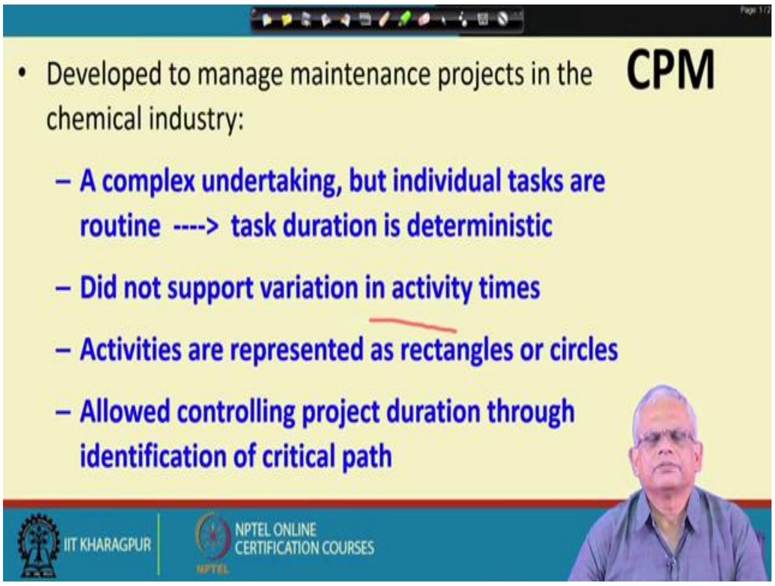

The CPM, the Critical Path Method, as you are mentioning it was developed for managing maintenance project in chemical industry on DuPont. Here the maintenance is a complex activity. There are many tasks here, but the tasks are routine and therefore, the task durations are deterministic. And therefore, CPM did not required to use variation in the activity times and the times there are estimated for activities or constant times.

The activities are represented as rectangles or circles. If you look at books and so on, as I was mentioning that these techniques have been developed over large number of years and therefore, there is a evolution of these techniques. And, we will find that some places they use circle, some places use rectangles and so on, but in our lecture will use rectangles for the PERT CPM technique.

And one important thing of CPM that it allowed to compute the critical path and therefore, the critical path indicates the project duration and it give a method how to use the task network diagram to compute the critical path. But, then nowadays we also do the same thing with PERT. We can have the critical paths there and we can compute them from the diagram.

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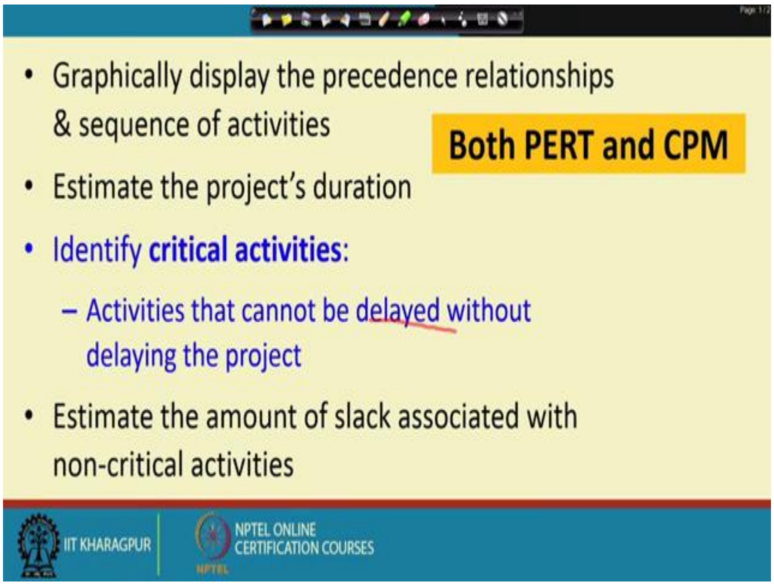

Over the years, even though this were two very separate techniques for project scheduling, but over the years both the techniques have merged into a single technique. Both the techniques they are graphical techniques, they are similar, precedence relations, the sequence of activities these are all represented here. Both are used to estimate the projects duration; one uses statistical, other use deterministic.

And using both now we are able to identify the critical activities. The critical activities are the ones which are on the critical path on the network and these are the activities which cannot be delayed without delaying the project. If a critical activity gets delayed the project duration will be affected and therefore, the project manager has to be extra careful about the critical activities.

And not only that it indicates to the project manager the amount of slack associated with non-critical activities. Some activities even though those are not critical activities, are very a small slack associated that is they can be delayed only a little bit without affecting the project schedule. On the other hand, there may be some activities which have large slack or float time that is they can significantly vary the completion time. They may get delayed and so on, without really affecting the project completion time.

And this is a very important hint to the project manager that he can redistribute the resources so that he may take out a man power from a task which has lot of slack associated with it. And put the man power on a critical tasks, so that the critical tasks get completed and the one which is having slack even if it gets delayed little bit because is withdrawn the manpower here and redeployed on the critical activity. But, the overall the project will be managed well, it will complete on time.

And therefore, for every project manager it is very important to know what are the critical paths, what are the activities on the critical path which cannot get delayed without affecting the project completion time and what are the non critical paths and which tasks have the maximum slack so that he can have little leeway in redistributing the resources if required so that the critical activities at least proceed without delay and therefore, we can meet the project schedule.

We are almost at the end of this lecture and in the next lecture, we will discuss how to use the PERT, CPM network to compute for each activity the start times, end times, the slack or the float time that is available and so on and also identify the critical paths.

Thank you.