Course Details	
Subject	Statistics
Year	3rd Year B.Sc.
Paper no	15
Paper Name	Operation Research
Topic no	26
Topic name	CPM
SME	Priyadarshini R
ID	Aditya Shetty

E-Learning Module on CPM

Learning Objectives

By the end of this session, you will be able to:

- Explain the importance of using CPM
- Explain the CPM network techniques

Introduction

The critical path method (CPM) is an algorithm for scheduling a set of project activities.

It is an important tool for effective project management.

The critical path method (CPM) is a widely used technique for analyzing and managing task sequences in large projects.

Introduction

CPM is based on calculating how long it takes to complete essential steps of a process and analyzing how those steps interrelate.

It is a visual and mathematical technique that gives managers the ability to effectively plan, schedule, and evaluate their projects.

Introduction

CPM-associated techniques are probably most often used in large manufacturing and construction projects.

They are also applied to tasks like,

- New product development cycles
- Marketing campaigns
- Software process modeling
- Research programs

Introduction

Any time a manager is trying to determine the date by which a project will be completed, he or she needs to have a basic understanding of the time required to complete each task that makes up the overall project.

Introduction

For small projects, managers are often able to memorize and to coordinate all of the various tasks necessary for their completion.

For larger projects, however, with numerous activities occurring simultaneously, remembering and coordinating these activities can prove much more difficult.

Introduction

CPM and related tools allow managers to determine which particular tasks most affect the total time of the project and enable managers to better schedule each task so that deadlines are met at the least possible cost.

Introduction

CPM is a project modeling technique developed in the late 1950s by Morgan R. Walker of DuPont and James E. Kelley, Jr. of Remington Rand. Kelley and Walker related their memories of the development of CPM in 1989.

Introduction

The precursors of what came to be known as Critical Path were developed and put into practice by DuPont between 1940 and 1943 and contributed to the success of the Manhattan Project.

Given the complexity of the process they developed the critical path method (CPM) for managing such projects.

Introduction

CPM is commonly used with all forms of projects, including

Introduction

Any project with interdependent activities can apply this method of mathematical analysis.

Although the original CPM program and approach is no longer used, the term is generally applied to any approach used to analyze a project network logic diagram.

CPM- Basic Technique

The essential technique for using CPM is to construct a model of the project that includes the following:

- A list of all activities required to complete the project (typically categorized within a work breakdown structure)
- The time (duration) that each activity will take to completion
- The dependencies between the activities

CPM- Basic Technique

Using these values, CPM calculates the longest path of planned activities to the end of the project, and the earliest and latest that each activity can start and finish without making the project longer.

This process determines which activities are "critical" (i.e., on the longest path) and which have "total float" (i.e., can be delayed without making the project longer).

CPM- Basic Technique

In project management, a critical path is the sequence of project network activities which add up to the longest overall duration.

This determines the shortest time possible to complete the project.

Any delay of an activity on the critical path directly impacts the planned project completion date (i.e. there is no float on the critical path).

CPM- Basic Technique

A project can have several, parallel, near critical paths.

An additional parallel path through the network with the total durations shorter than the critical path is called a sub-critical or non-critical path.

CPM- Basic Technique

Although the activity-on-arrow diagram ("PERT Chart") is still used in a few places, it has generally been superseded by the activity-on-node diagram, where each activity is shown as a box or node and the arrows represent the logical relationships going from predecessor to successor

CPM- Benefit

- Provides a graphical view of the project
- Predicts the time required to complete the project
- Shows which activities are critical to maintaining the schedule and which are not

CPM- model

CPM models and events of project as a network.

Activities are depicted as nodes on the network and events that signify the beginning or ending of activities are depicted as arcs or lines between the nodes.

CPM - Steps

- Specify the individual activities
- Determine the sequences of the activities
- Draw a network diagram
- Estimate the completion time for each activity
- Identify the critical path (longest path through the network)
- Update the CPM diagram as the project progresses

CPM- Steps

Specify the individual activities

- From the work breakdown structure, a list of all the activities in the project can be made
- This listing can be used as the basis for adding sequences and duration information in the later steps

CPM- Steps

Determine the sequences of the activities

- Some activities are dependent on the completion of others
- A listing of the immediate predecessors of each activity is useful for constructing the CPM network diagram.

CPM- Steps

Draw the network diagram

- Once the activities and their sequencing have been defined, the CPM diagram can be drawn
- CPM originally was developed as an activity on node (AON) network, but some project planners prefer to specify the activities on the arc

CPM- Steps

Estimate activity completion time

- The time required to complete each activity can be estimated using past experiences or the estimates of knowledgeable persons
- CPM is a deterministic model that does not take into account variation in the completion time, so only one number is used for an activity's time estimate

CPM- Steps

Identify the critical path

- The critical path is the longest- duration path through the network
- The significance of the critical path is that the activities that lie on it cannot be delayed without delaying the project
- Because of its impact on the entire project, critical path analysis is the most important aspect of project planning

CPM- Steps

Four parameters for the each activity:

ES	Earliest start time in which an activity can start given its precedent activities must be completed first.
EF	Earliest finish time equal to the earliest start time for the activity plus the time required to complete that activity.
LF	Latest finish time at which the activity can be completed without delaying the project.
LS	Latest start time is equal to the latest finish time minus the time required to complete the activity.

CPM- Steps

The slack time for an activity,

- Is the time between its earliest and latest start time or between its earliest and latest finish time
- Can be delayed past its earliest start or earliest finish without delaying the project

CPM- Steps

The critical path is the path through the project network in which none of the activities have slack, that is, the path for which ES = LS and Ef = LF for all activities in the path.

A delay in the critical path delays the project. Similarly, to accelerate the project it is necessary to reduce the total time required for the activities in the critical path.

CPM- Steps

Update CPM diagram

- As the project progresses, the actual task completion times will be known and the network diagram can be updated to include this information
- A new critical path may emerge, and structural changes may be made in the network if project requirement changes

CPM- Limitations

- CPM was developed for complex but fairly routine projects within the minimal uncertainty in the project completion times
- For less routine projects there is more uncertainty in the completion time, and this uncertainty limits the usefulness of the deterministic CPM model

CPM- Basics

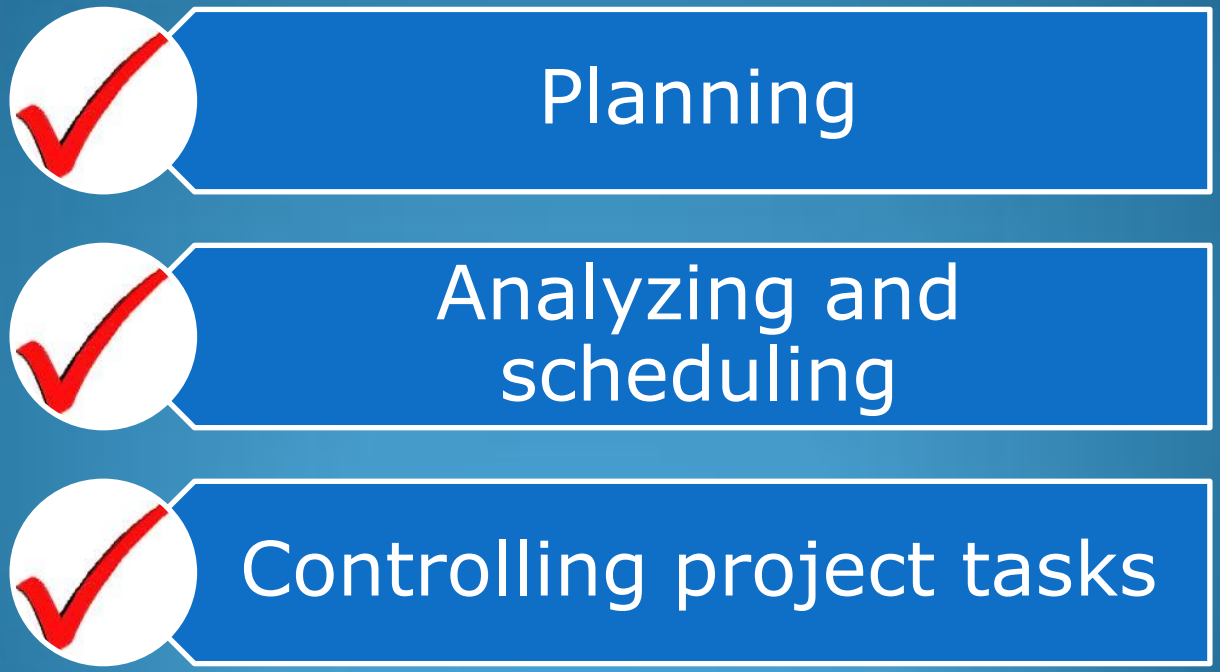
For CPM to be used appropriately, a project should have three attributes.

First	• It must consist of tasks that are independent of each other, which managers can stop and start within the duration of the project
Second	• The distinct tasks, upon completion, must result in the end of the project
Third	• While some tasks can be performed simultaneously, others must be performed in a particular sequence

CPM- Basics

If a project meets these criteria, CPM can be used.

CPM consists of three core steps:

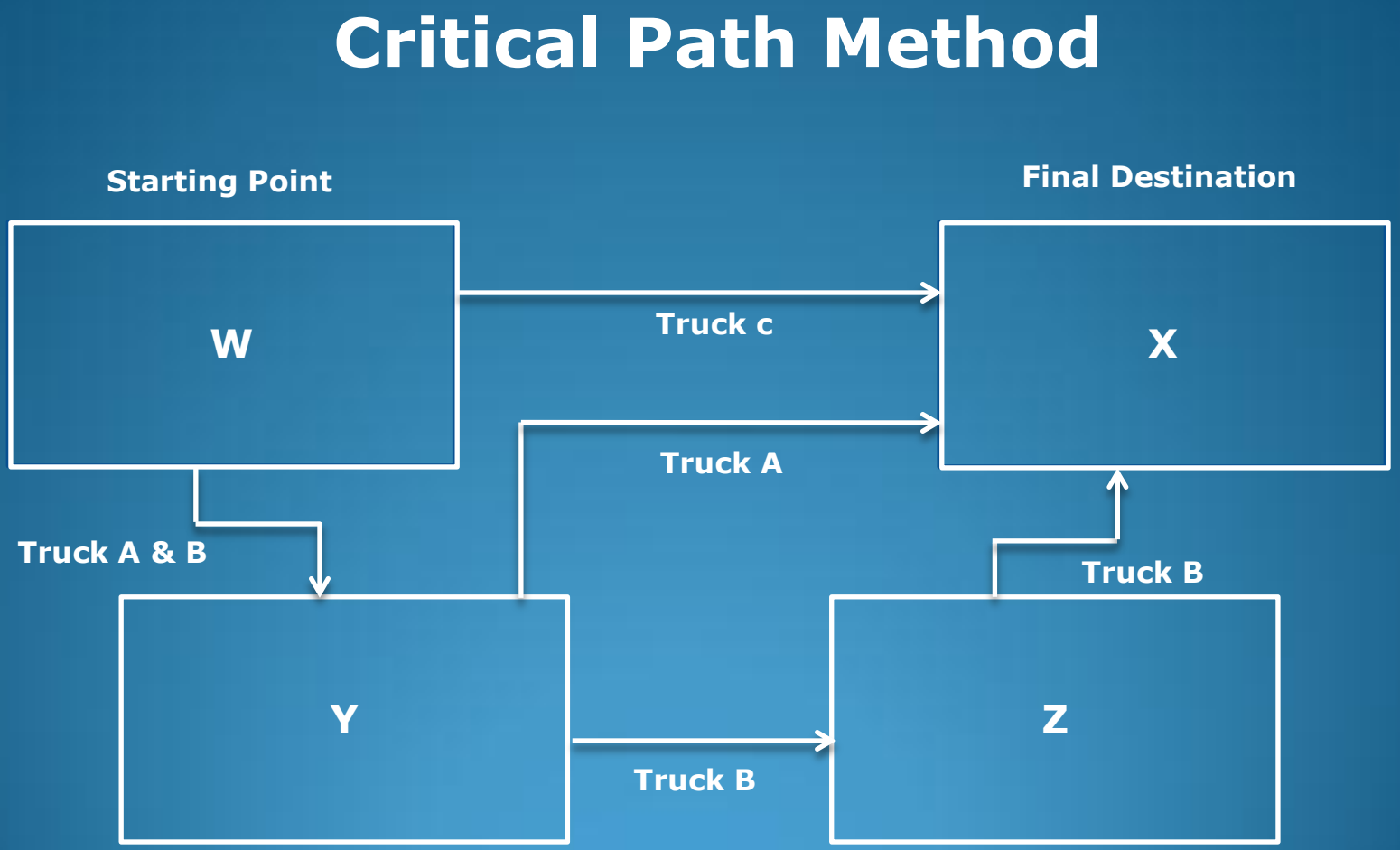


CPM- Basics

To plan a project using this method, a diagram of each of the tasks comprising a project must be devised.

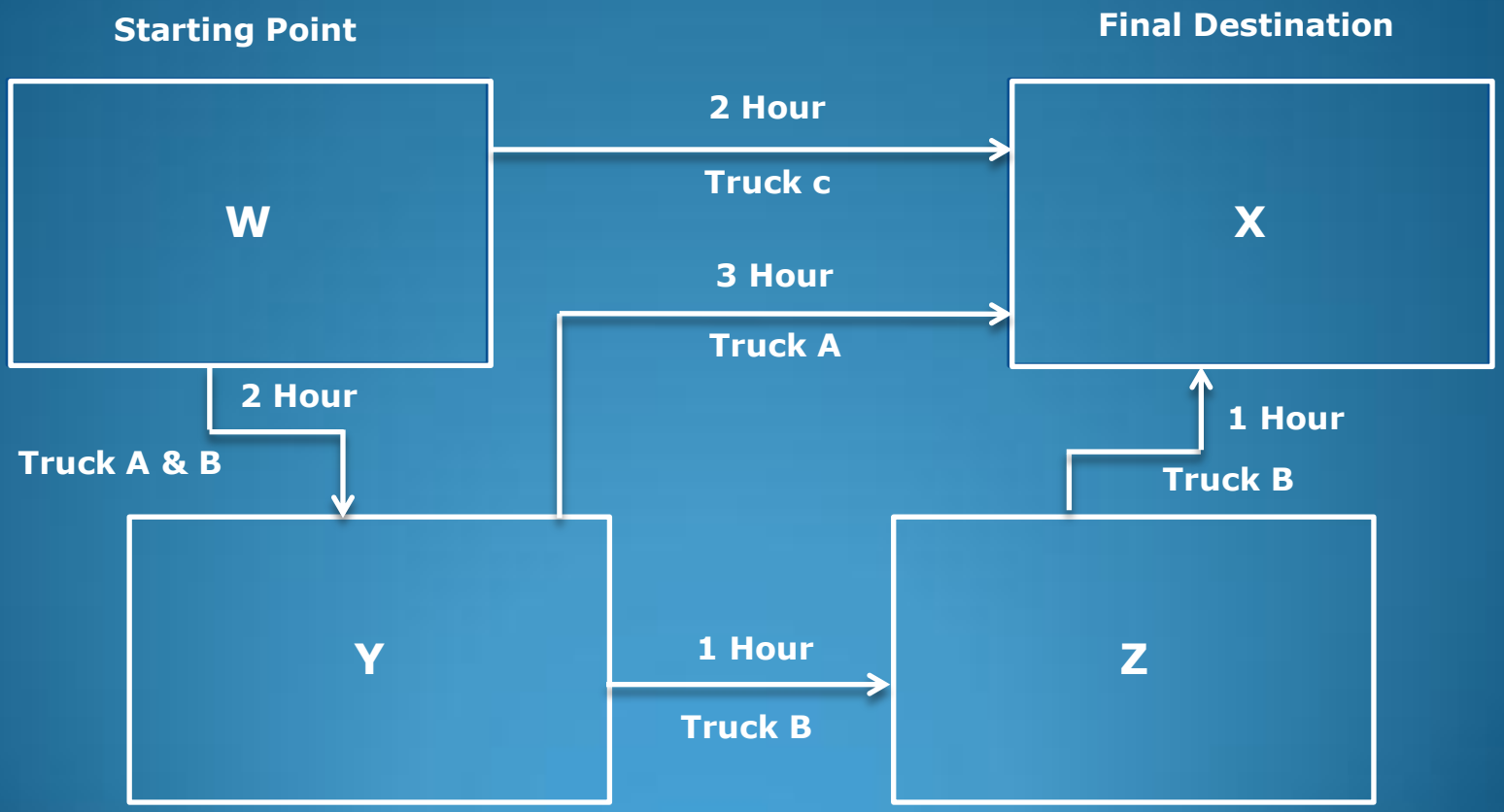
The diagram can be constructed by, first, assigning a symbol (such as X, Y, or Z) or identifying label to all of the tasks and listing them in the order that they are to be performed.

CPM- Basics example



CPM- Basics example

Critical Path Method



CPM- Basics example

Defining the critical path can allow the manager to concentrate his or her efforts appropriately and make optimal scheduling decisions.

Thus, it follows that if the project manager can reduce the time it takes for Truck A to complete its path, the overall project will save time.

He or she will not waste efforts on reducing the time spent by Trucks B and C.

CPM- Basics example

Furthermore, knowing that Trucks B and C have more time to complete their tasks, the manager can schedule them more conveniently.

For instance, Truck C is unoccupied for three hours and could be used for other tasks during that time.

CPM- Basics example

Similarly, from this analysis the manager knows that the drivers for Trucks B and C will be idle during the course of this project and their labor can be used for something else, rather than paying all three drivers for the project's full duration.

CPM- Basics example

Finally, by using CPM, the manager can control the project as the tasks are being completed.

Comparing the actual performance with the planned performance will let the manager know whether or not the project is on schedule.

Thus, if Truck A is behind schedule going from place W to place Y, the truck's trip from point Y to point X will have to be expedited—that is, if the project is to be completed on time.

CPM- Real life application

The principles behind this simple example can be leveraged on much larger and more intricate projects, frequently with hundreds of steps.

In practice, CPM and related project management techniques are usually implemented through the use of **project management software.**

CPM- Real life application

Software packages may be of general use, mass-market titles or specialized project software, such as for the construction industry.

These programs help automate the process of breaking a project into its essential tasks and subtasks and tracking any number of variables associated with each step, including costs.

CPM- Real life application

The software may also offer graphical representations of the project timeline and generate customized reports on various project aspects.

Tasks in a CPM analysis are often identified with a range of potential start and finish times, as opposed to just one, to indicate best- and worst-case scenarios.

CPM- Real life application

Most software packages allow this kind of tracking. This enables management to consider a more complete set of possibilities, rather than simply querying whether the project is on or off schedule.

It also opens the door to more nuanced analyses, such as finding the maximum allowable time for a problematic task if all other tasks are performed at optimal times.

CPM- Real life application

In real life, one project's schedule often impacts other schedules, and thus CPM software and analysis is also applied to a multiple-project environment.

In this case, individual steps within projects or the entire outcome of a project can be linked with phases of other projects, providing managers a means through which they can optimize scheduling across projects to maximize efficiency and serve other strategic functions.

CPM- Real life application

When integrated with cost tracking, CPM is sometimes known as "least cost scheduling."

By linking time variations with anticipated costs, the CPM model can be used to calculate the optimal project schedule to minimize costs.

CPM- Real life application

This can indicate, for example, that it is cheaper to take longer at some things, but not others.

At the very least, it can indicate what the financial consequences will be if the project falls behind schedule at any particular stage.

CPM- Real life application

CPM has also been used in conjunction with statistical process control, a set of mathematical methods aimed at monitoring and improving efficiency and quality, to maximize these benefits in the course of completing a project.

Difference between CPM and PERT

There are many techniques for faster and more efficient completion of complex projects.

CPM and **PERT** are two powerful tools to achieve this objective.

There are similarities in the two techniques as they serve the same basic purpose.

Difference between CPM and PERT

Due to complexity of projects, it is often difficult to eliminate time delays and cost overruns.

However, if suitable techniques of planning, controlling and organizing are used, it is possible to reduce these cost overruns and project delays by a considerable margin.

Difference between CPM and PERT

Problem with many tools lies in the cost of implementing and executing which makes them more of a liability than an asset.

Such programs, because they require a large amount of reporting and monitoring far outweigh the benefits that accrue because of their use.

Difference between CPM and PERT

These problems are very much done away with when a project manager uses either **CPM** or **PERT**.

Let us see what these techniques stand for and how they differ.

Difference between CPM and PERT

PERT

There is high degree of uncertainty pertaining to completion time of certain activities. Particularly in research and development projects, it is difficult to gauge the time the project will take to complete.

In such cases we can take probabilistic approach for each activity and define optimistic time estimate, most likely time estimate and pessimistic time estimate.

Difference between CPM and PERT

PERT

With expected time for each activity, it is possible to determine the critical path.

Thus, PERT is a probabilistic tool that makes use of 3 estimates for completion of activities and is a tool for planning and control of time for completion of a project.

Difference between CPM and PERT

CPM

CPM on the other hand is a deterministic tool taking only a single estimate of time for completion of any activity in a project.

It also allows for estimate of costs, thereby being a tool that can control both time as well as costs.

Difference between CPM and PERT

PERT was developed by the US Navy for the planning and control of the Polaris missile program and the emphasis was on completing the program in the shortest possible time

CPM was developed by Du Pont and the emphasis was on the trade-off between the cost of the project and its overall completion time.

Difference between CPM and PERT

PERT considers optimistic, likely and pessimistic time, thereby adding an element of probability to the final figure one obtains

CPM takes only a single time for any task. This time typically would be the 'likely' time for the task

Difference between CPM and PERT

PERT is a probabilistic tool using 3 estimates of duration for completion of activities of a project and is basically a tool for planning and control of time

CPM is a deterministic tool, with only single estimate of duration. CPM also allows an explicit estimate of costs in addition to time, thereby CPM can control both time and costs.

Difference between CPM and PERT

PERT is more suitable for R&D related projects where the project is performed for the first time and the estimate of duration are uncertain.

CPM is best suited for routine and those projects where time and cost estimates can be accurately calculated.

Difference between CPM and PERT

PERT is event oriented

CPM is activity oriented i.e. CPM network is built on the basis of activities Also result Of Carious calculation are considered in terms of activities of the project.

Difference between CPM and PERT

PERT is used in Project management for non-repetitive jobs (research and development work), where the time and cost estimates tend to be quite uncertain. This technique uses probabilistic time estimates.

CPM is used in Production management for the jobs of repetitive in nature where the activity time estimates can be predicted with considerable certainty due to the existence of past experience.