



**Everyone's Smart
University**

Project Feasibility Study

Lecture 8

PMG 201

SCHEDULING THE PROJECT

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PERT and CPM Networks

Project Uncertainty and Risk Management

Simulation

The Gantt Chart

Extensions to PERT/CPM

Introduction

- **The project schedule is simply the project plan in an altered format. It is a convenient form for monitoring and controlling project activities. Actually, the schedule itself can be prepared in several formats.**
- **In this chapter, we describe the most common formats— Gantt charts and PERT/CPM networks — and demonstrate how to convert a project plan or WBS into these formats. We also note some of the strengths and weaknesses of the different displays.**
- **In addition, we apply risk management directly to the project schedule. From this analysis we show how to estimate the likelihood that a project can be completed on or before a specific time.**

Introduction

- **Consider the job of planning a project, developing a budget for it, and scheduling all of the many tasks involved.**
- **It should be obvious that these three activities are not actually separable. Because a budget must include both the amounts and timing of resources received or expended, one cannot prepare a budget without knowing the specifics of each task and the time period(s) during which the task must be undertaken.**
- **Similarly, the project plan implies a schedule just as a schedule implies a plan. It is useful to begin study of these interdependent, partial descriptions of a project with an examination of the planning process because this process is the foundation of all that follows.**

Introduction

- The decision about whether to turn our attention first to the budget or the schedule is arbitrary. We chose the budget largely because most readers have some familiarity with the subject.
- The problem is that planning, budgeting, and scheduling are parts of the same basic process. They are considered separately only because we cannot write about all three at the same time.

Project Scheduling

- ☐ **Identifying precedence relationships**
- ☐ **Sequencing activities**
- ☐ **Determining activity times & costs**
- ☐ **Estimating material & worker requirements**
- ☐ **Determining critical activities**

Purposes of Project Scheduling

- ☐ Shows the relationship of each activity to others and to the whole project.
- ☐ Identifies the precedence relationships among activities.
- ☐ Encourages the setting of realistic time and cost estimates for each activity.
- ☐ Helps make better use of people, money, and material resources by identifying critical bottlenecks in the project.

PERT and CPM Networks

- *The Language of PERT/CPM*

Several terms used in discussing PERT/CPM analysis have been adopted from everyday language but have quite different meanings than in common usage. These terms are defined here as used in PERT/CPM.

The Language of PERT/CPM

- **Activity** — A task or set of tasks required by the project. Activities use resources and time.
- **Event** — An identifiable state resulting from the completion of one or more activities. Events consume no resources or time. Before an event can be *achieved* or *realized* , all its predecessor activities must be completed.
- **Milestones** — Identifiable and noteworthy events marking significant progress on the project.

The Language of PERT/CPM

- **Network** — A diagram of nodes (may represent activities or events) connected by directional arcs (may represent activities or simply show technological dependence) that defines the project and illustrates the technological relationships of all activities. Networks are usually drawn with a “ Start ” node on the left and a “ Finish ” node on the right.

The Language of PERT/CPM

- **Path** — A series of connected activities (or intermediate events) between any two events in a network.
- **Critical path** — The set of activities on a path from the project 's start event to its finish event that, if delayed, will delay the completion date of the project.
- **Critical time** — The time required to complete all activities on the critical path.

Building the Network

- There are two ways of displaying a project network. In one we depict the activities as arrows and events as nodes. This gives an activity - on - arrow (AOA) network, usually associated with PERT. Alternatively, we can create an activity - on - node (AON) network by showing each task as a node and linking the nodes with arrows that show their technological relationship.

Project Uncertainty and Risk Management

- **Uncertainty and risk management are introduced. Optimistic, most likely, and pessimistic estimates of task duration are made and expected activity times are calculated as well as the standard deviation and variance of task time distributions.**

Project Uncertainty and Risk Management cont.

- **From this data the mean times for all paths are calculated, and the probability of the apparent critical path completion on or before a predetermined date can be found.**

Project Uncertainty and Risk Management con. ...

- **In addition, the probability of completion can be set in advance and the path delivery date consistent with that probability can be determined. The problem of merge bias is then investigated.**

SIMULATION

- **In this section we can take a different approach to managing risk. Specifically, we build on the probabilistic foundation established in the previous section and use simulation to handle the arithmetic as well as help us to understand the consequences of uncertainty. Simulation analysis can provide insight into the range and distribution of project completion times.**

Traditional Statistics vs. Simulation

- **At many conferences and in the literature of project management, there are sessions devoted to risk management. The participants at one recent conference, all highly experienced PMs from several different industrial sectors, were not of a single mind about the optimum way to handle the problems we have discussed in this chapter.**

Traditional Statistics vs. Simulation cont. ...

- **Some favored the traditional statistical approach, some favored simulation, and some favored adding sizable contingency allowances in both the budget and the schedule, and then ignoring uncertainty. A decade ago, the group that ignored uncertainty would have been in the majority, but they were the smallest of the three groups at this discussion. Dealing with risk is no longer the esoteric interest of a few statisticians, but is now an everyday problem for the PM.**

THE GANTT CHART

- The Gantt chart is a useful complement to a project network. It is easily constructed and read. It can contain a considerable amount of information and is an excellent communication device about the state of a project.
- Its major weakness is that it does not easily expose the project's technology, that is, the technical relationships between a project's many activities.
- Even with predecessors marked on a Gantt chart, it is difficult to see the project technology and, thus, to use the Gantt chart alone to manage a complex project. PERT/CPM networks are often used as complements to Gantt charts.

THE GANTT CHART

- ✓ Establish a *time-phased network*
- ✓ Can be used as a *tracking tool*

Benefits of Gantt charts

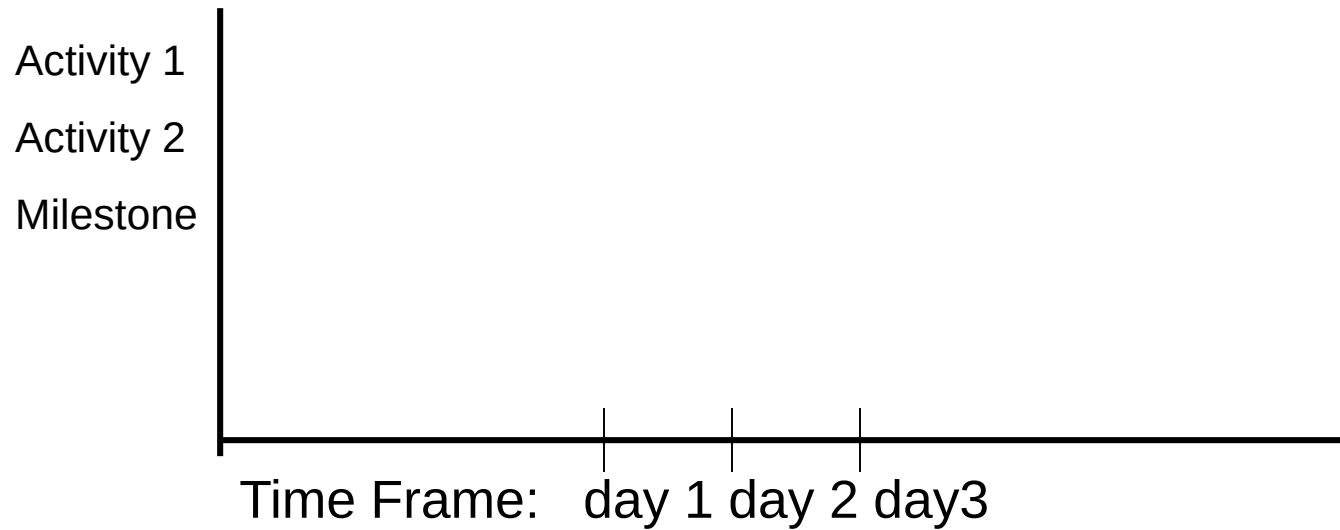
1. Easy to *create* and *comprehend*
2. Identify the schedule *baseline* network
3. Allow for *updating* and *control*
4. Identify *resource needs*

Gantt Chart

- Visual scheduling tool
- Graphical representation of information
- Show dependencies between tasks, personnel, and other resources allocations
- Track progress towards completion

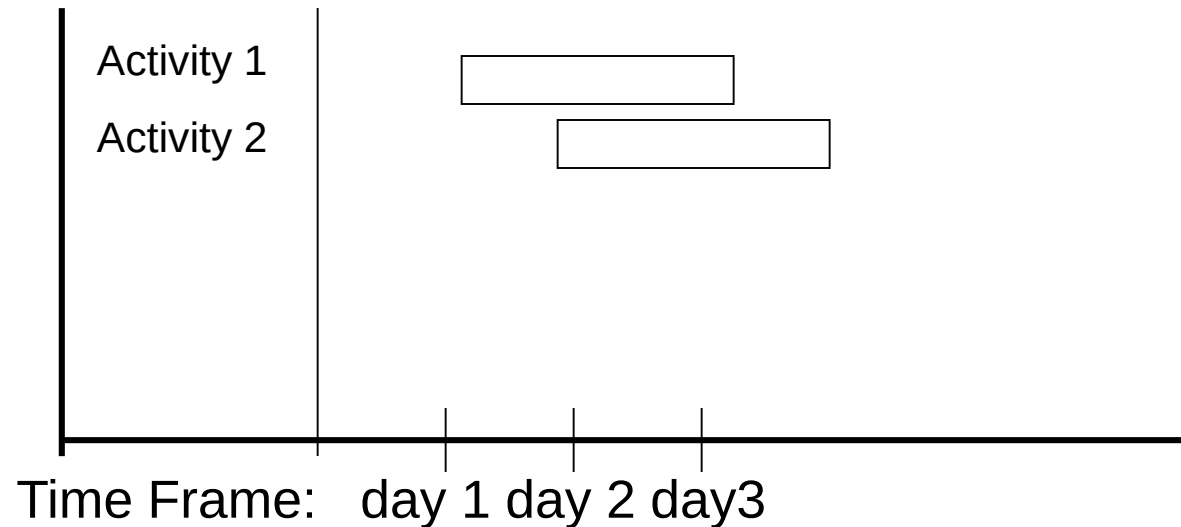
Building a Gantt Chart

- List all tasks and milestones from the project along the vertical axis
- List time frame along the horizontal axis



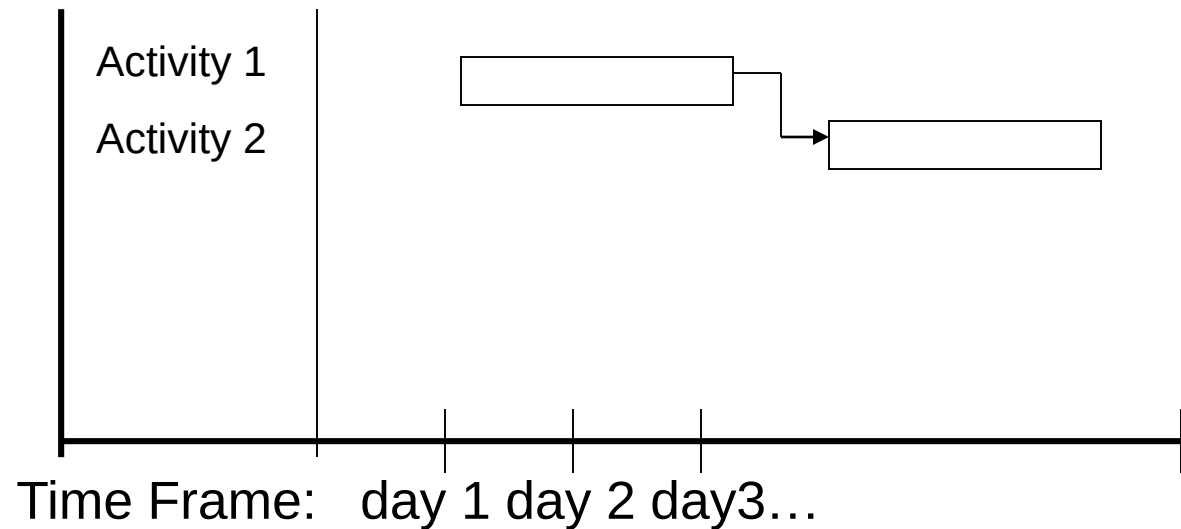
Building a Gantt Chart

- Activities: Create box the length of each activity time duration
 - E.g., activity one is scheduled from day1-day3



Building a Gantt Chart

- Dependencies: Show dependencies between activities with arrows
 - E.g., activity 2 cannot start until activity 1 is complete



Scheduling

A production schedule is the time table that specifies the times at which the jobs in a production department will be processed on various machines.

The schedule gives the starting and ending times of each job on the machines on which the job has to be processed.

Scheduling Example

Suppose there are three jobs in a production department that are to be processed on four categories (types) of machines. We designate the jobs as A, B, and C; and the machine types are designated as M1, M2, M3, and M4.

The operations for job A are designated as A1, A2, A3, and A4. The operations of job B are designated as B1, B2, and B3. Similarly the four operations of job C are designated as C1, C2, C3, and C4.

Scheduling Example (continued)

Each job is characterized by its routing that specifies the information about the number of operations to be performed, the sequence of these operations, and the machines required for processing these operations.

The times required for processing these operations are also required for developing a production schedule.

Scheduling Example - Data

The table on right hand side (RHS) gives the data for this example.

The table gives the machine required for each operation of each job. For example, the first operation of job A, A₁, is processed on machine M₁; second operation, A₂, is processed on machine M₃ and so on.

The operations of all jobs have to follow their processing sequences. For example operation A₃ of job A can not be processed before operation A₂.

The processing time for each operation is also given in this table.

Job	Operation Number	Machine Number	Processing Time (Days)
A	A1	M1	5
	A2	M3	3
	A3	M4	7
	A4	M2	4
B	B1	M2	2
	B2	M3	6
	B3	M4	8
C	C1	M1	4
	C2	M2	6
	C3	M3	8
	C4	M4	2

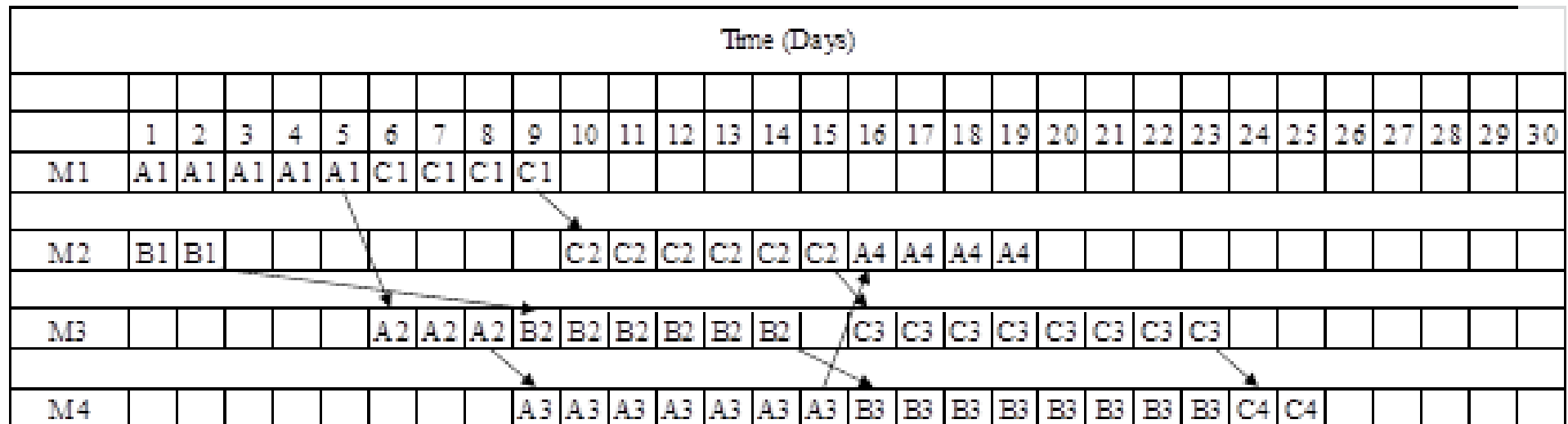
Scheduling Example – Objective Function

The objective is to schedule these jobs so as to minimize the time to complete all jobs. This time is called make-span or the schedule time. We will use the term make-span in this presentation.

Scheduling Example Solution – Gantt Chart

One of the schedules for this example is presented below in the form of a Gantt Chart.

The Gantt chart, for each machine, shows the start and finish times of all operations scheduled on that machine.



Scheduling Example - Alternative schedules

Several alternative schedules can be generated for this example.

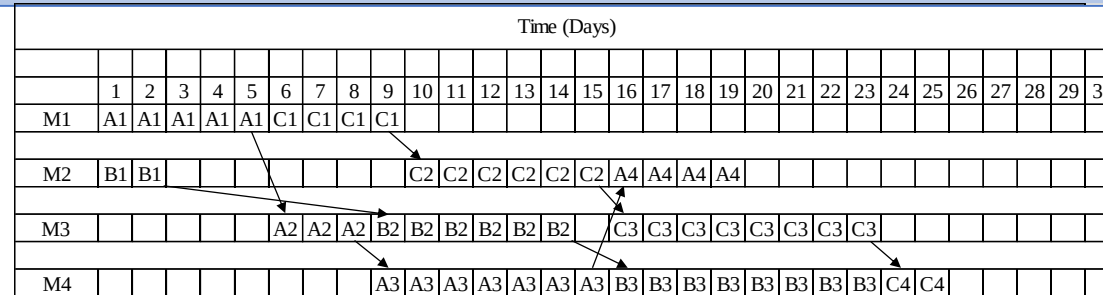
The schedules differ in the order in which the jobs are processed on the four machines. Three of these schedules are:

- The first schedule orders jobs as: A first, then B and then C (A-B-C).
- The second schedule orders jobs as: B first, then A, and then C (B-A-C).
- The third schedule orders jobs as: C first, then A, and then B (C-A-B).

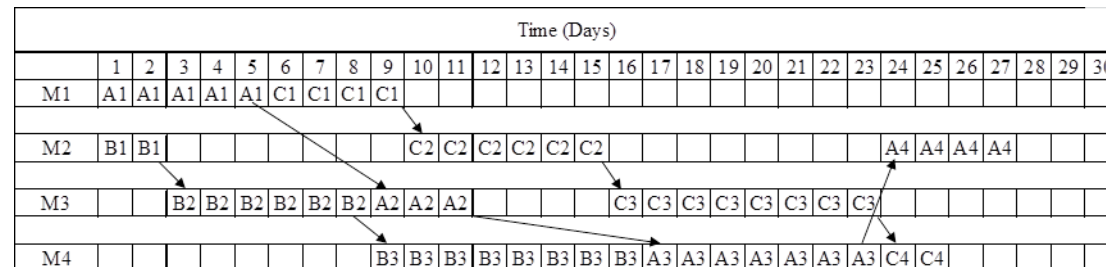
The Gantt charts for these schedules are shown in next slide.

The values of make-span for these three schedules are 25, 27 and 30 days respectively. Schedule A-B-C is the best of these three schedules.

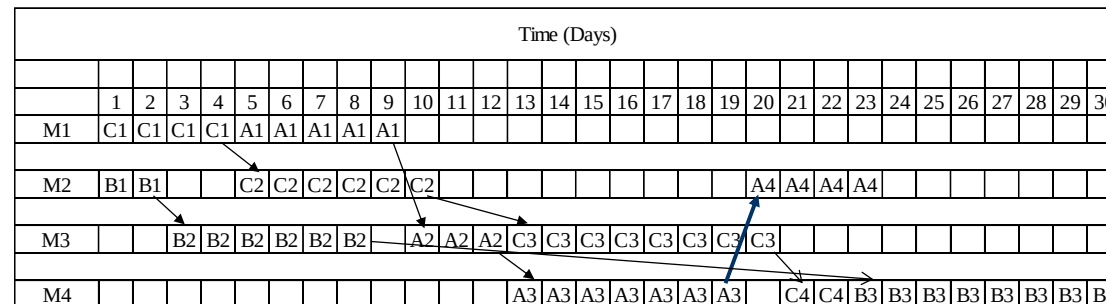
Scheduling Example - Alternative Schedules (continued)



Sequence A-B-C
(Make-span = 25 days)



Sequence B-A-C
(Make-span = 27 days)



Sequence C-A-B
(Make-span = 30 days)

Scheduling Example - Alternative Schedules (continued)

**Is sequence A-B-C the global optimal? Can we find a better sequence than this?
The scheduling techniques attempt to answer these questions.**

It should be mentioned that there are different effectiveness measures of a schedule in different situations. Minimizing make-span is only one of them. We will study other effectiveness measures also.

Scheduling Example - Assumptions

Once a job is started on a machine, its processing can not be interrupted, that is, preemption is not allowed.

The machines are continuously available and will not break down during the planning horizon. This assumption is rather unrealistic but we make this assumption to avoid complexity in discussing scheduling concepts.

A machine is not kept idle if a job is available to be processed.

Also, each machine can process only one job at a time.

INCIDENTS FOR DISCUSSION

- **Springville Fire Department**
- The city of Springville is building a new fire station in their city. The city is expanding and is in need of a second fire station closer to the newer areas of the city to ensure shorter response times. The project manager and the project team have been selected for the project. The team is very interested in selecting the scheduling technique that will be used to follow the project through to completion.

INCIDENTS FOR DISCUSSION

- The project manager, city manager, and chief of the fire department have set the following criteria for the process of selecting the scheduling technique: easy to use, shows durations of tasks, shows milestones, can see the flow of work, can see the sequence of events, can depict which tasks can be undertaken at the same time, and can tell how far tasks are from completion. The city manager favors the Gantt chart, the chief likes PERT, and the project manager prefers CPM.

Questions:

If you were the project manager, which method would you use, and why?