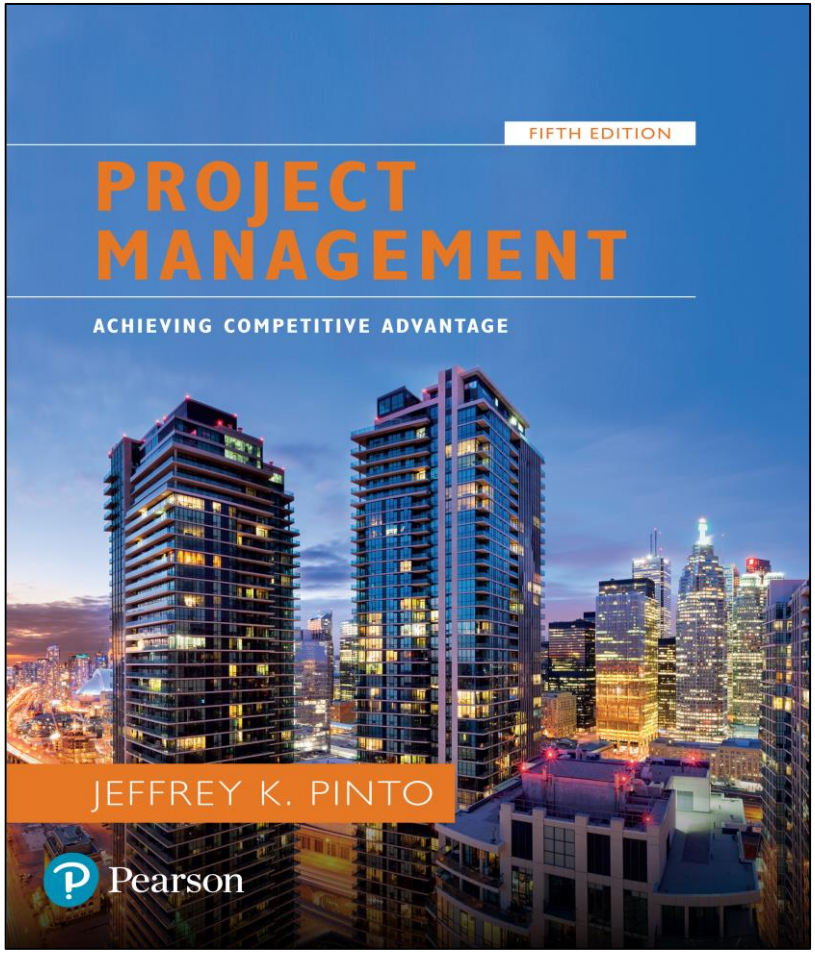
Project Management: Achieving Competitive Advantage

Fifth Edition



Chapter 9

Project Scheduling: Networks, Duration Estimation, and Critical Path

Learning Objectives (1 of 2)

9.1 Understand the importance of project scheduling techniques.

9.2 Understand and apply key scheduling terminology.

9.3 Develop an activity network using Activity-on-Node (AON) technique.

9.4 Perform activity duration estimation based on the use of probabilistic estimating techniques.

Learning Objectives (2 of 2)

9.5 Construct the critical path for a project schedule network using forward and backward passes, determine project slack, and calculate the probability of finishing on time.

PMBoK Core Concepts

Project Management Body of Knowledge (PMBoK) covered in this chapter includes:

1. Plan Schedule Management (PMBoK 6.1)
2. Define Activities (PMBoK 6.2)
3. Sequence Activities (PMBoK 6.3)
4. Estimate Activity Resources (PMBoK 6.4)
5. Estimate Activity Durations (PMBoK 6.5)
6. Develop Schedule (PMBoK 6.6)
7. Control Schedule (PMBoK 6.7)

Project Scheduling

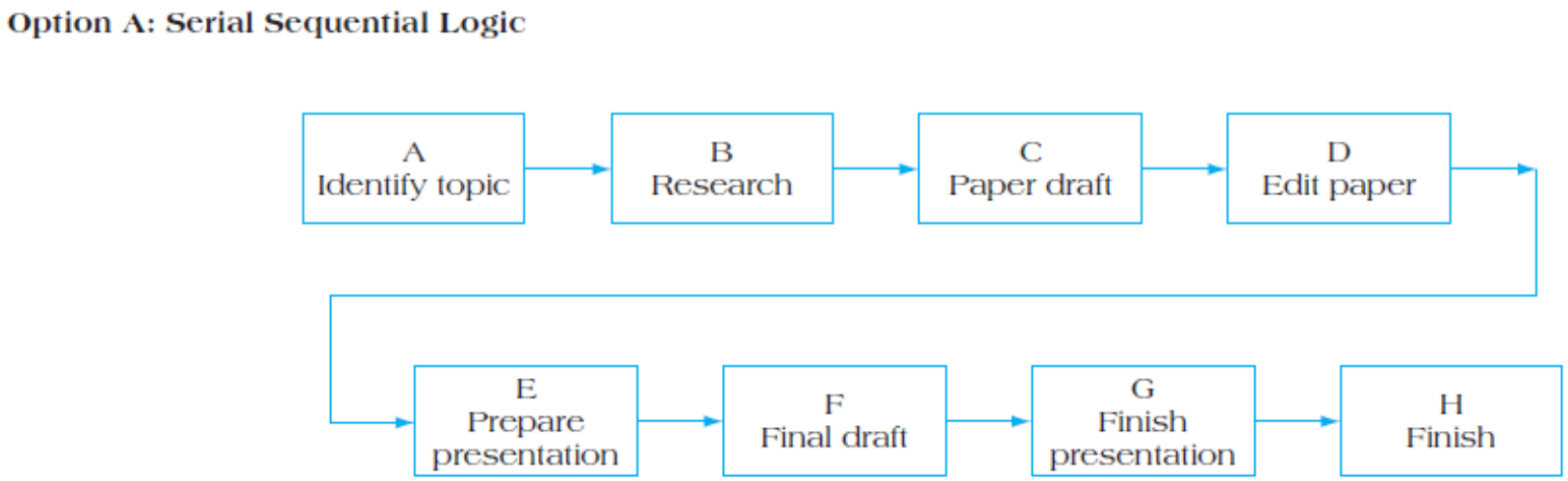
Project scheduling requires us to follow some carefully laid-out steps, in order, for the schedule to take shape. PMBoK states, “an output of a schedule model that presents linked activities with planned dates, durations, milestones, and resources.”

Project planning, as it relates to the scheduling process, has been defined by the PMBoK as:

The identification of the project objectives and the ordered activity necessary to complete the project including the identification of resource types and quantities required to carry out each activity or task.

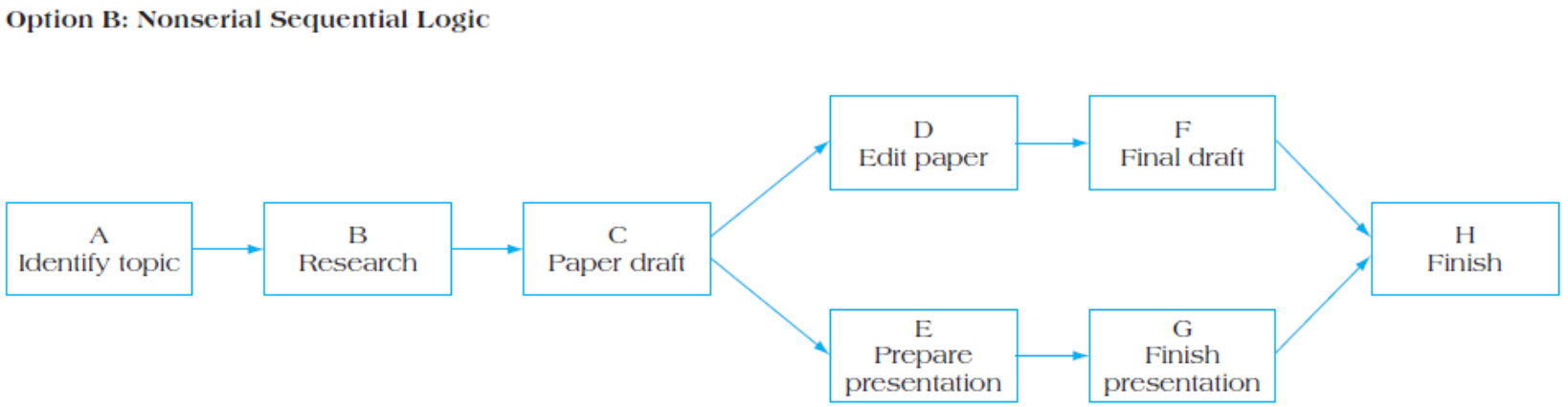
Network Diagram—Serial Sequential Logic

Figure 9.2A Alternative Activity Networks for Term Paper Assignment



Network Diagram – Nonserial Sequential Logic

Figure 9.2B Alternative Activity Networks for Term Paper Assignment



Project Scheduling Terms (1 of 4)

- **Project Network Diagram**: Any schematic display of the logical relationships of project activities.
- **Path**: A sequence of activities defined by the project network logic.
- **Event**: A point when an activity is either started or completed.
- **Node**: One of the defining points of a network; a junction point joined to some or all of the other dependency lines (paths).

Project Scheduling Terms (2 of 4)

- **Predecessors**: Those activities that must be completed prior to initiation of a later activity in the network.
- **Successors**: Activities that cannot be started until previous activities have been completed. These activities follow predecessor tasks.
- **Early start (ES) date**: The earliest possible date the uncompleted portions of an activity can start.
- **Late start (LS) date**: The latest possible date that an activity may begin without delaying a specified milestone.

Project Scheduling Terms (3 of 4)

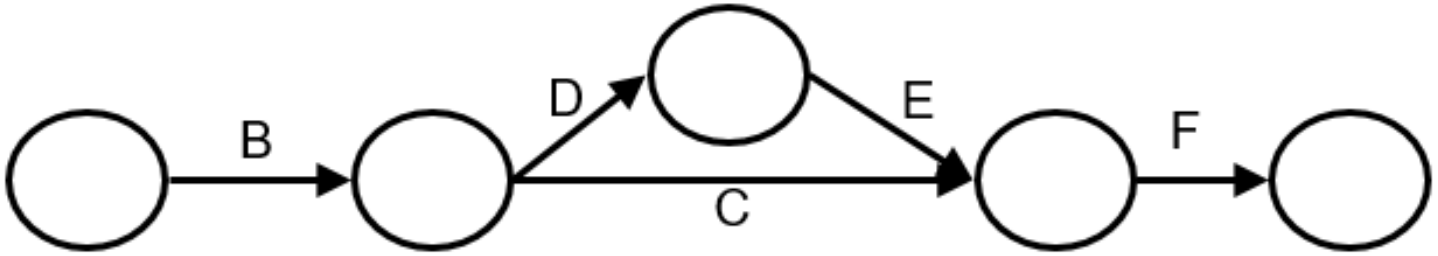
- **Forward pass**: Network calculations to determine earliest start/earliest finish for an activity through working forward through each activity in network.
- **Backward pass**: Network calculations to determine late start/late finish for uncompleted tasks through working backward through each activity in network.
- **Merge activity**: An activity with two or more immediate predecessors.
- **Burst activity**: An activity with two or more immediate successors.

Project Scheduling Terms (4 of 4)

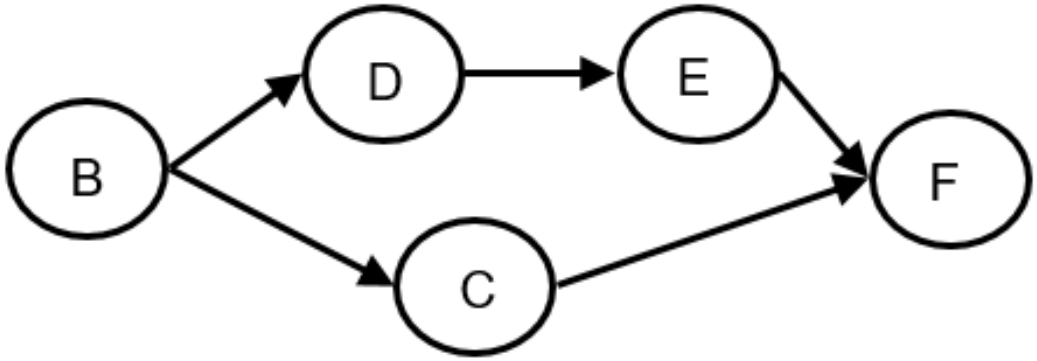
- **Float**: The amount of time an activity may be delayed from its early start without delaying the finish of the project.
- **Critical path**: The path through project network with the longest duration.
- **Critical Path Method**: A network analysis technique used to determine the amount of schedule flexibility on logical network paths in project schedule network and to determine minimum project duration.
- **Resource-limited schedule**: Start and finish dates reflect expected resource availability.

AOA Versus AON

The same mini-project is shown with **activities on arc**…

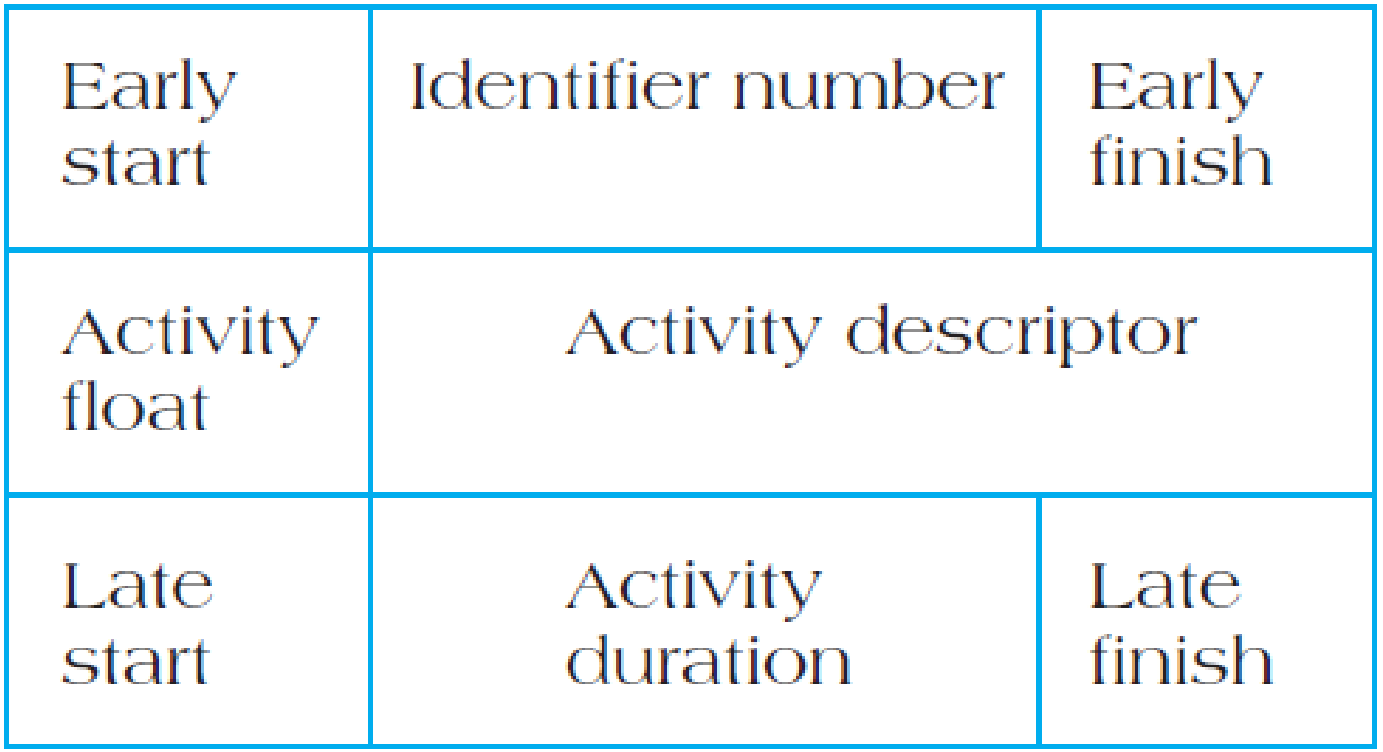


…and **activities on node**.



Node Labels

Figure 9.3 Labels for Activity Node



Serial Activities

Serial activities are those that flow from one to the next, in sequence.

Figure 9.5 Project Activities Linked in Series

Concurrent Activities

When the nature of the work allows for more than one activity to be accomplished at the same time, these activities are called **concurrent**, and **parallel project paths** are constructed through the network.

Figure 9.6 Activities Linked in Parallel (Concurrent)

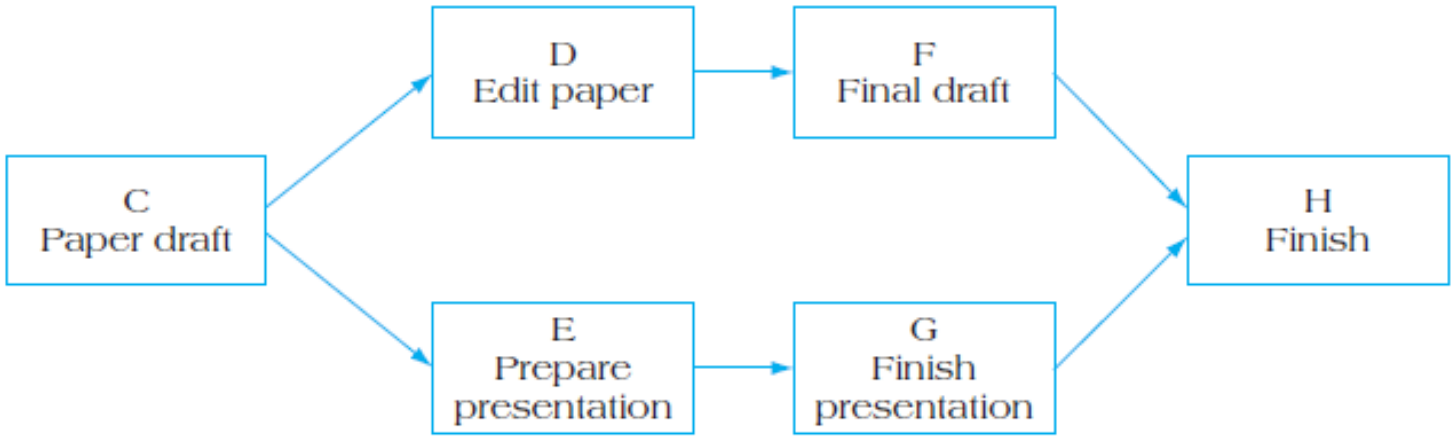


Figure 9.7 Merge Activity

Activity D can only begin following the completion of activities A, B, and C.

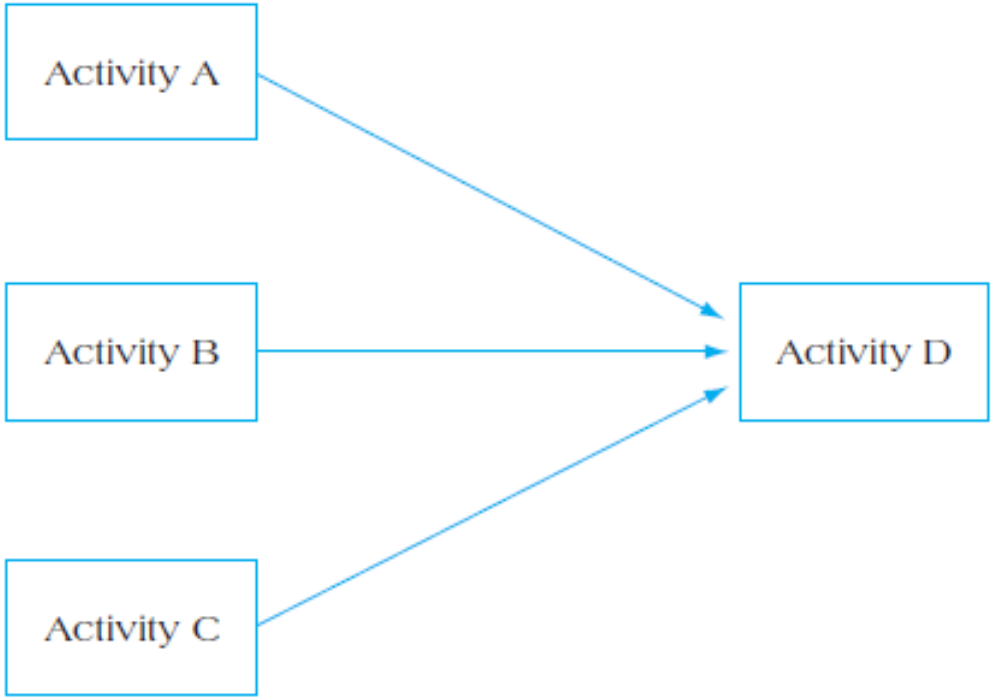
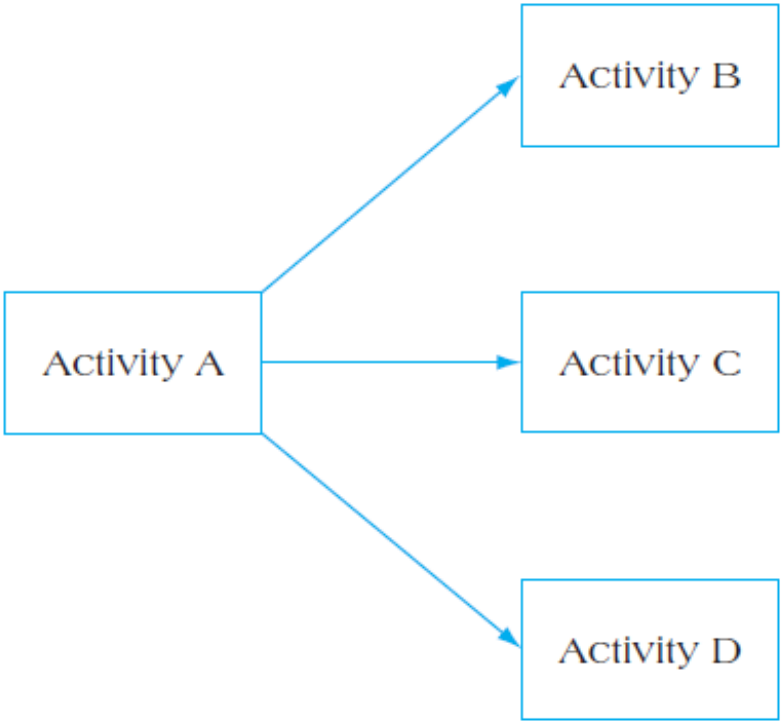


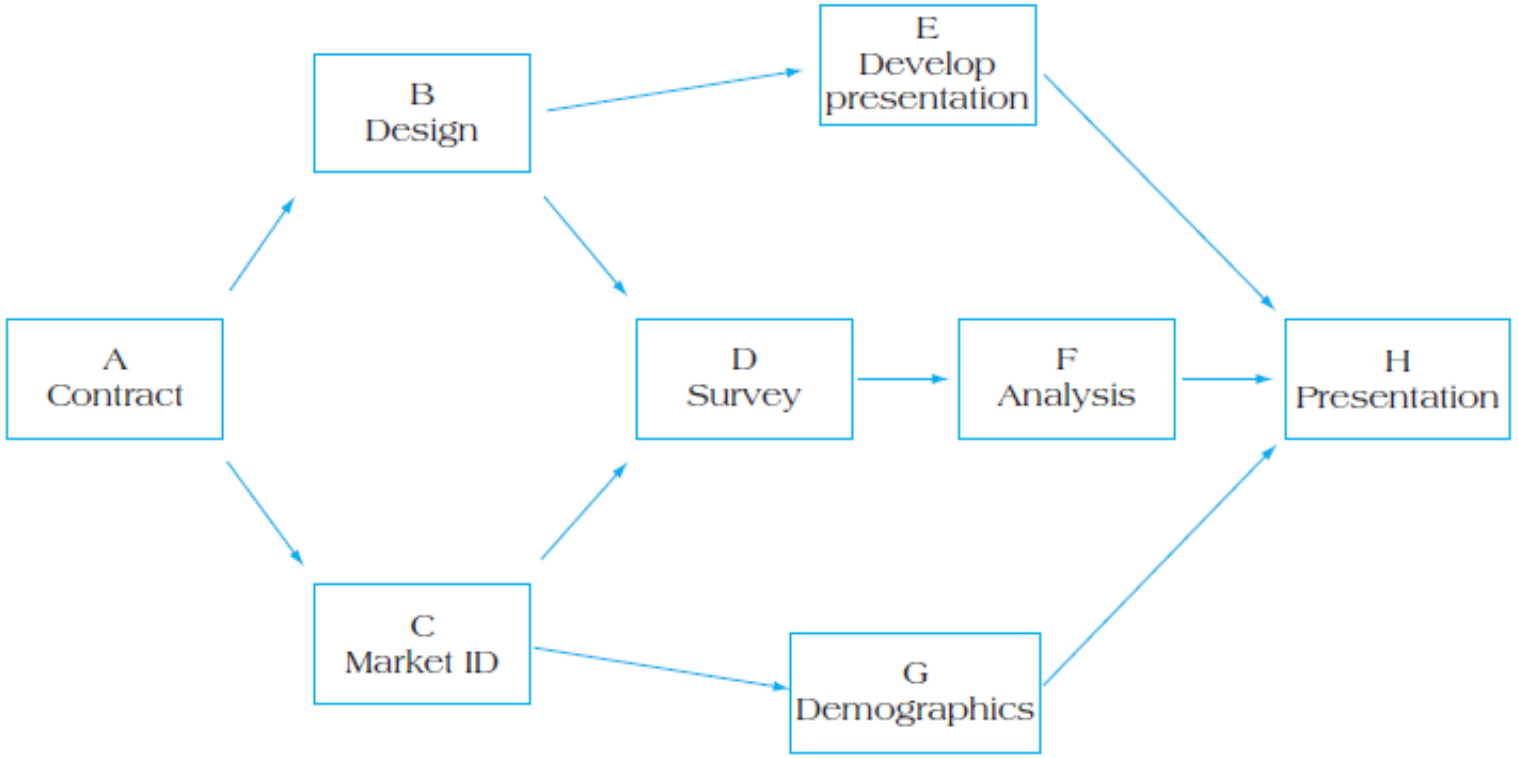
Figure 9.8 Burst Activity

Activities B, C, and D can only begin following the completion of activity A.



Complete Activity Network

Figure 9.10 Complete Activity Network for Project Delta



Duration Estimation Methods

- Experience
- Expert opinion
- Mathematical derivation—Beta distribution
  - Most likely (*m*)
  - Most pessimistic (*b*)
  - Most optimistic (*a*)
- Two assumptions used to convert *m*, *a*, and *b* into time estimates (TE) and variances (s^2) are:

$$\text{Activity Duration} = \text{TE} = \frac{\text{a} + 4m + b}{6} \qquad \text{Activity Variance} = s^2 = \left(\frac{b - a}{6}\right)^2$$

Figure 9.14 Symmetrical (Normal) Distribution for Activity Duration Estimation

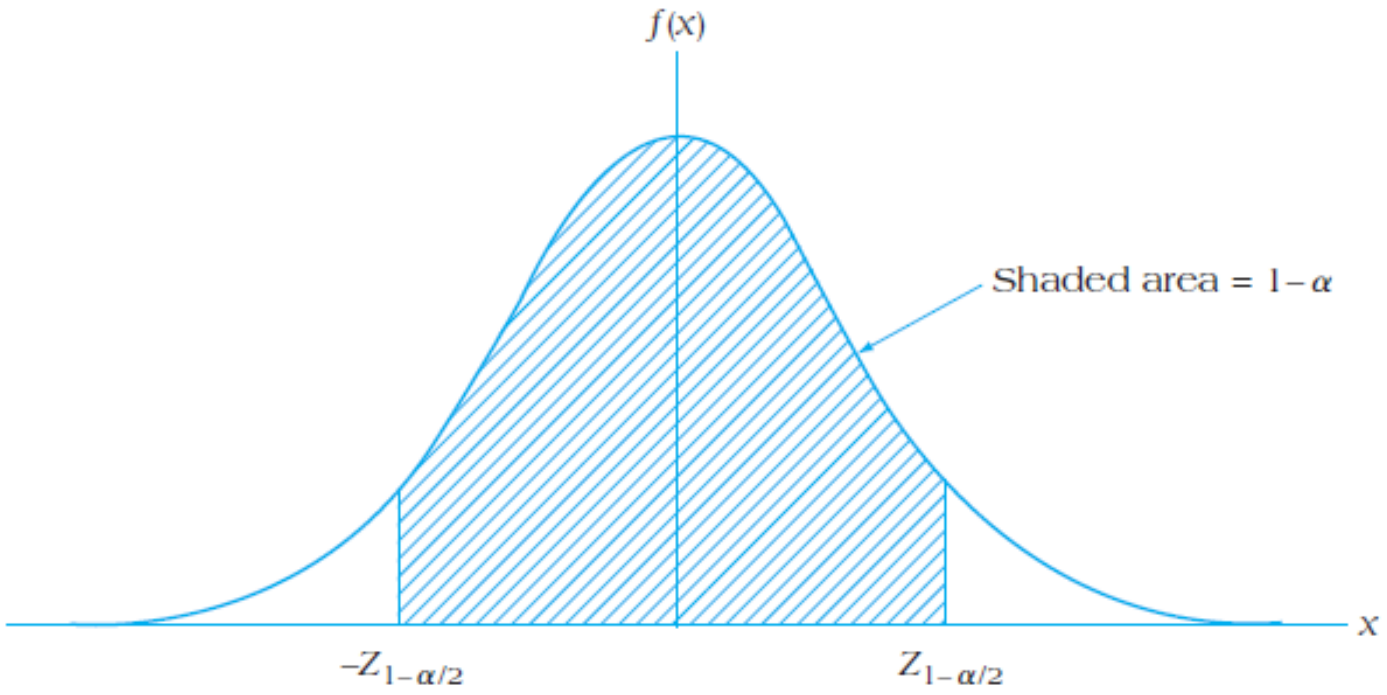
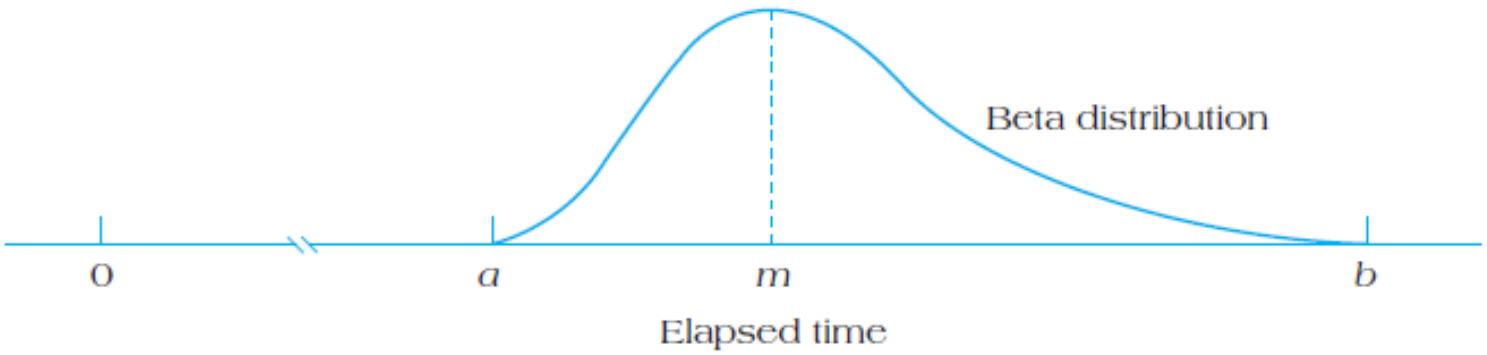


Figure 9.15 Asymmetrical (Beta) Distribution for Activity Duration Estimation



Activity Duration Estimates (1 of 2)

Table 9.2 Activity Duration Estimates for Project Delta

Name: Project Delta

Durations are listed in weeks

Activity	Description	Optimistic	Most Likely	Pessimistic
A	Contract signing	3	4	11
B	Questionnaire design	2	5	8
C	Target market ID	3	6	9
D	Survey sample	8	12	20
E	Develop presentation	3	5	12
F	Analyze results	2	4	7
G	Demographic analysis	6	9	14
H	Presentation to client	1	2	4

Activity Duration Estimates (2 of 2)

Table 9.3 Estimated Project Activity Times Using Beta Distribution

Name: Project Delta

Durations are listed in weeks

Activity	Description	TE (1:4:1 ratio)/6
A	Contract signing	5
B	Questionnaire design	5
C	Target market ID	6
D	Survey sample	12.7
E	Develop presentation	5.8
F	Analyze results	4.2
G	Demographic analysis	9.3
H	Presentation to client	2.2

Constructing the Critical Path

- Forward pass—an **additive move** through the network from **start to finish**
- Backward pass—a **subtractive move** through the network from **finish to start**
- Critical path—the **longest path** from end to end which determines the **shortest project length**

Figure 9.16 Partial Project Activity Network with Task Durations

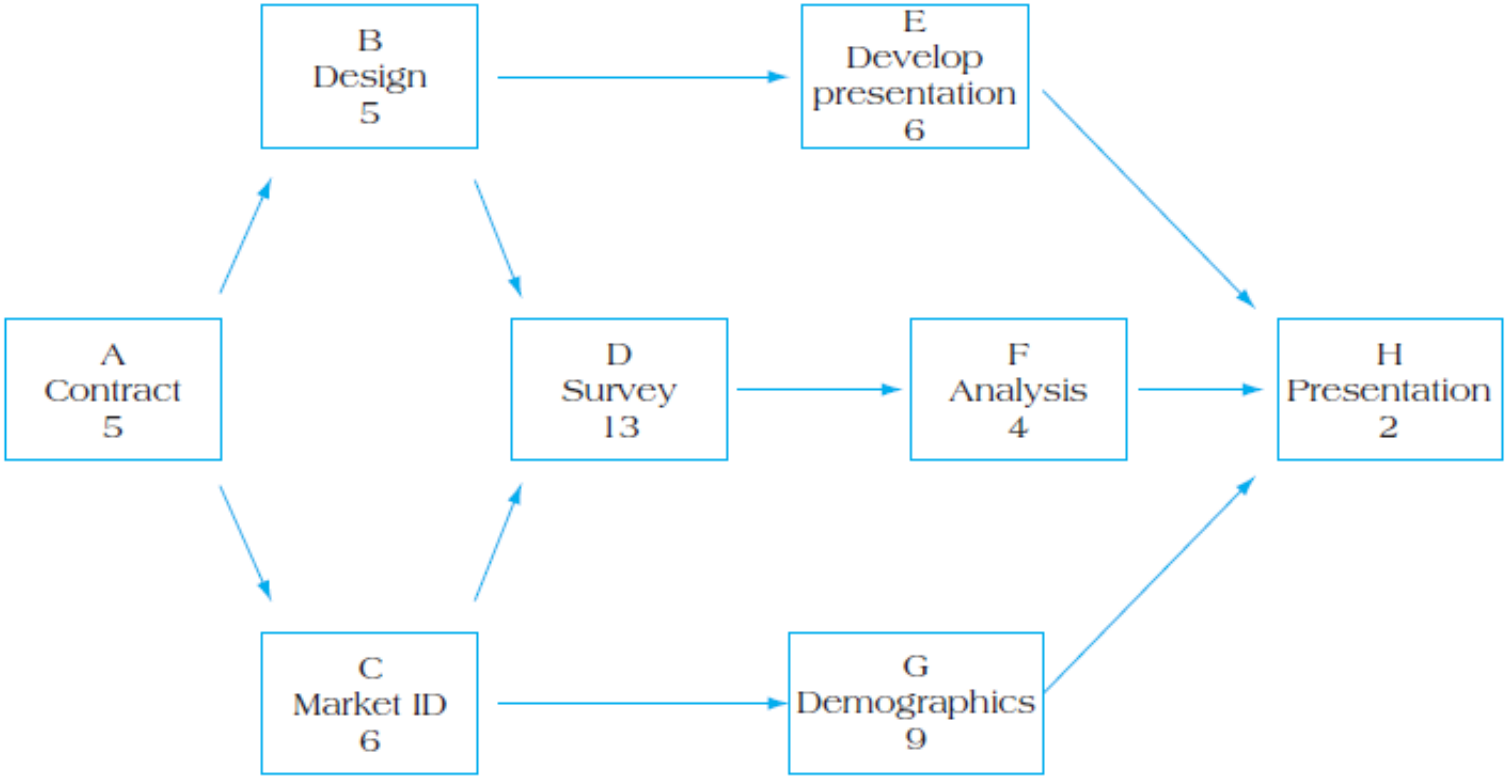


Figure 9.18 Activity Network with Forward Pass

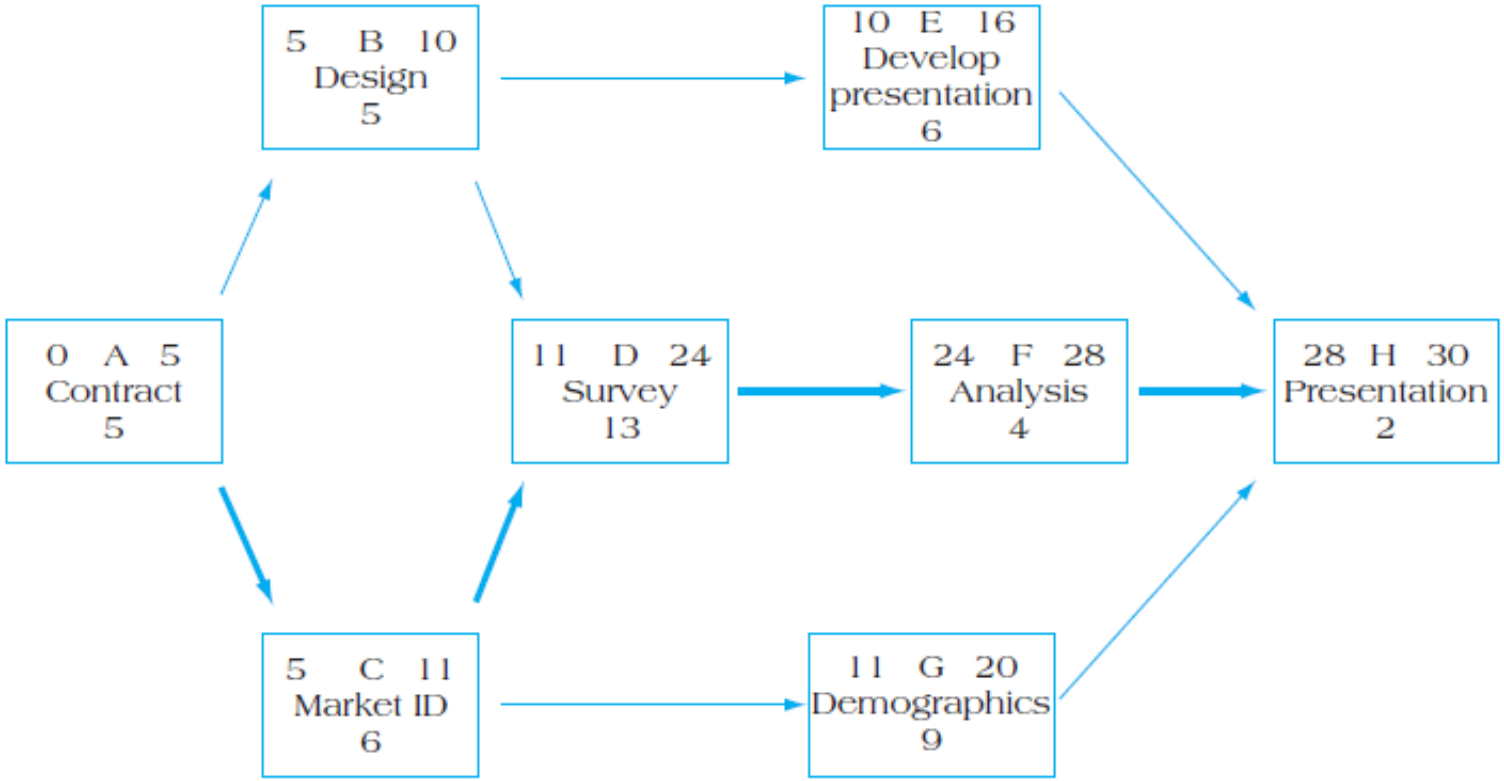


Figure 9.19 Activity Network with Backward Pass

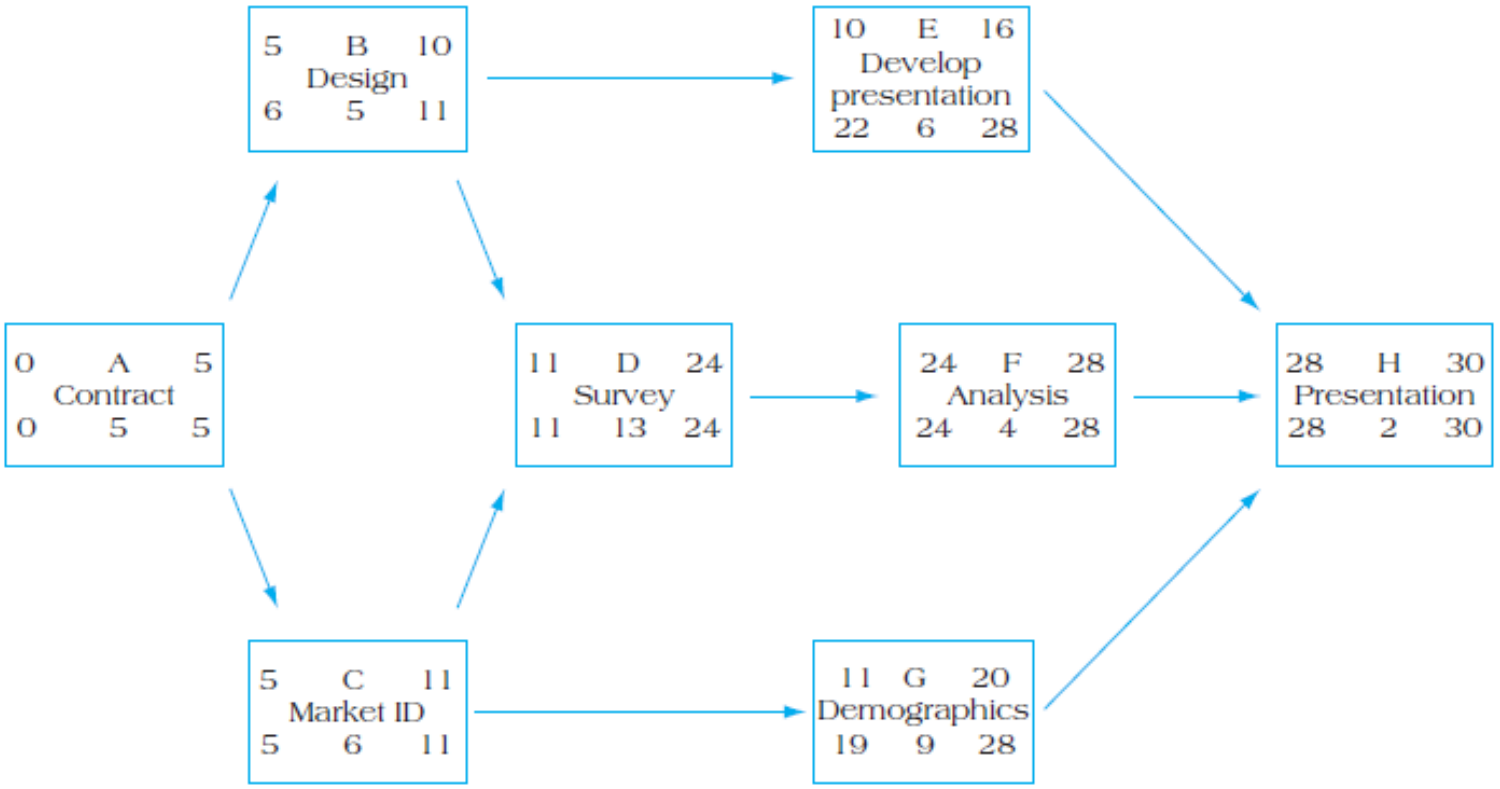


Figure 9.20 Project Network with Activity Slack and Critical Path

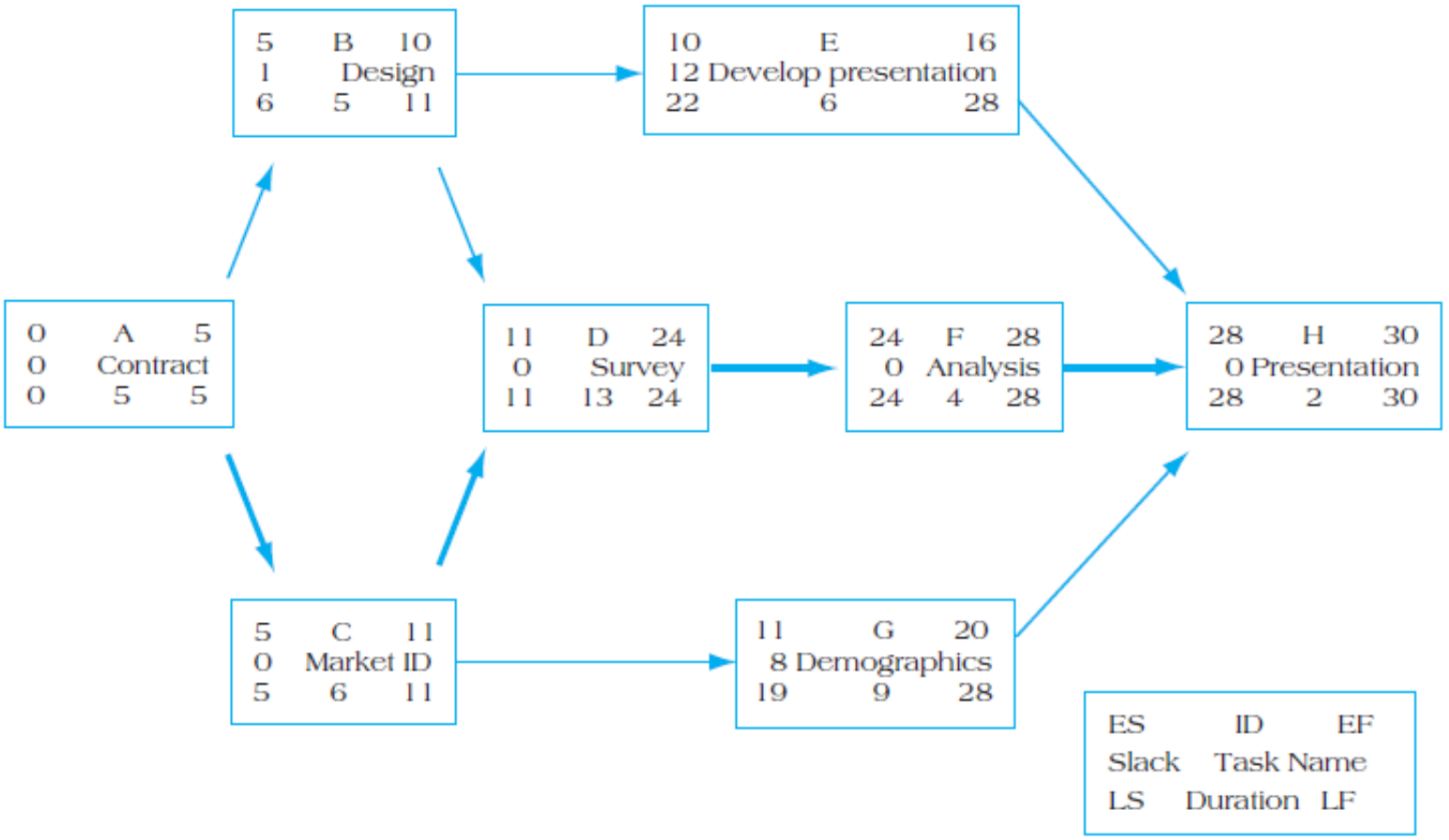


Figure 9.24 AON Network with Laddering Effect

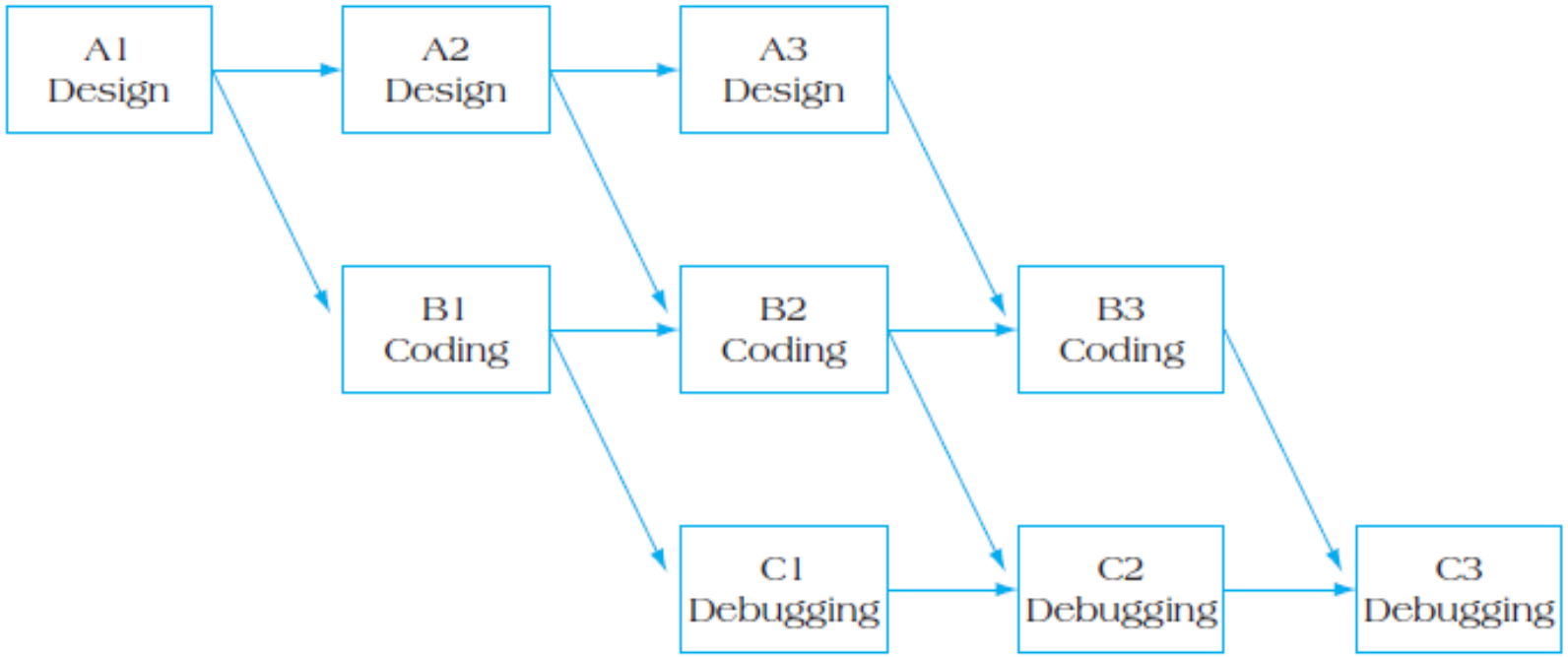
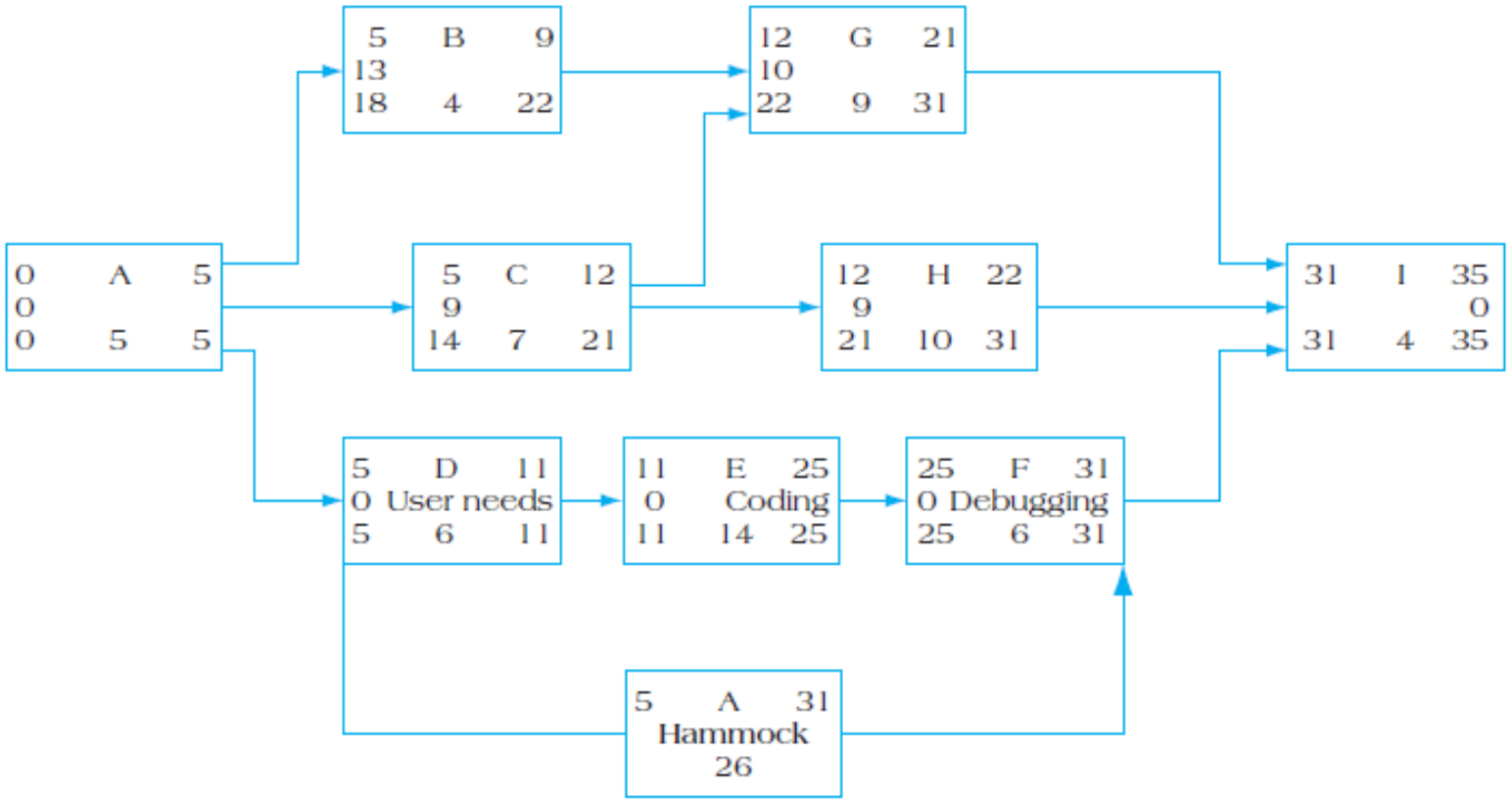


Figure 9.25 Example of a Hammock Activity



Options for Reducing the Critical Path

1. Eliminate tasks on the critical path.
2. Replan serial paths to be in parallel.
3. Overlap sequential tasks.
4. Shorten the duration on critical path tasks.
5. Shorten early tasks.
6. Shorten longest tasks.
7. Shorten easiest tasks.
8. Shorten tasks that cost the least to speed up.

Summary (1 of 2)

1. Understand the importance of project scheduling techniques.
2. Understand and apply key scheduling terminology.
3. Develop an activity network using Activity-on-Node (AON) technique.
4. Perform activity duration estimation based on the use of probabilistic estimating techniques.

Summary (2 of 2)

5. Construct the critical path for a project schedule network using forward and backward passes, determine project slack, and calculate the probability of finishing on time.

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